# Natural food ingredients from quince peel: Towards a "zero-waste" production system

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## Introduction

The resources on our planet are finite and limited. Nonetheless, more and more waste is being produced worldwide. In this sense, it is essential to acquire circularity and "zero waste" approaches to move from the current environmentally unsustainable agri-food system to a more sustainable practice. Quince is the yellow fruit of the deciduous tree *Cydonia oblonga* Mill. This fruit has an intense aroma, flavor and acidity, but most varieties are too sour and astringent to be eaten raw, so it is usually processed into marmalade and many other food products, mostly sweets, through processes that discard the peel as a by-product. Therefore, this work was carried out to promote the upcycling of quince peel into valuable food ingredients following a "zero waste" approach. Thus, it was intended to optimize the extraction of compounds of interest to the food industry using the response surface methodology (RSM).

## Methodology

Quince peels supplied by local farmers from Bragança, Portugal, were lyophilized and reduced to a fine powder. A 20 run RSM-coupled central composite rotatable design, combining five levels of time (1–119 min), temperature (25–95°C) and ethanol proportion (0–100%) (Table 1) was implemented for optimizing the extraction of soluble solid extracts (SSE) and malic acid (MA) from quince peel, while simultaneously obtaining fiber concentrate extracts (FCE). A flowchart of the steps involved in the extraction is shown in Fig. 1.

**Table 1.** Levels of the independent variables used in the experimental design.

| Independent variables | Symbols | Units | Variable levels | | | | |
|---|---|---|---|---|---|---|---|
| | | | -1.68 | -1 | 0 | 1 | +1.68 |
| Time | *t* | min | 1 | 25 | 60 | 95 | 119 |
| Temperature | *T* | °C | 26 | 40 | 60 | 80 | 94 |
| Ethanol proportion | *S* | %, *v/v* | 0 | 20 | 50 | 80 | 100 |

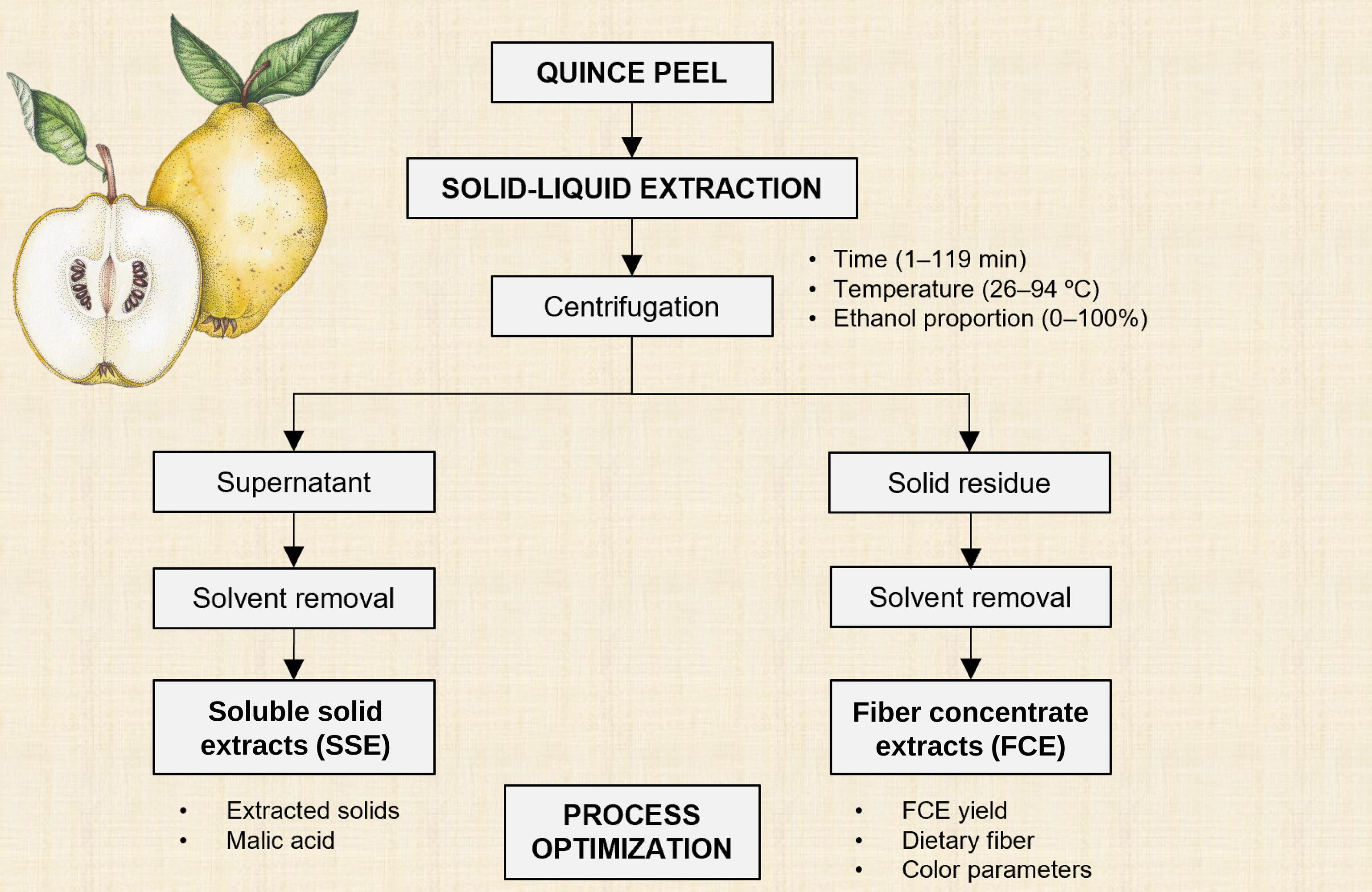


**Fig. 1** Flowchart of the steps involved in the preparation of soluble solid extracts (SSE) and fiber concentrate extracts (FCE) from quince peel and responses considered for process optimization by RSM.

The SSE and FCE yields were determined gravimetrically. Malic acid, which has been used as a food preservative, was identified and quantified by ultra-fast liquid chromatography with photodiode array detection (UFLC-PDA).[1] The dietary fiber (DF) content of the FCE was determined by an enzymatic-gravimetric method (AOAC 985.29) and their color was measured with a portable colorimeter.[2,3]

### References

1. A.L. Vara, J. Pinela, M.I. Dias, et al. Foods 9 (**2020**) 1522.
2. AOAC International. Official Methods of Analysis of AOAC International, 20$^{th}$ Ed, Gaithersburg, MD, USA, **2016**.
3. R. Rocha, J. Pinela, R.M.V. Abreu, et al. Processes 8 (**2020**) 1447.

## Results and discussion

The extraction process was significantly affected by the three independent variables and the models constructed by fitting the results in Table 2 to a polynomial equation were validated based on statistical criteria and used to predict optimal extraction conditions.

**Table 2.** Malic acid (MA) content in the soluble solid extracts (SSE) and dietary fiber (DF) content and color parameters (*L**, *a** and *b** values and RGB color) of the fiber concentrate extracts (FCE) obtained with the 20 runs of the experimental design.

| Run | Experimental domain | | | Dependent variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *t* (min) | T (°C) | *S* (%) | MA (%) | SSE yield (%) | FCE yield (%) | DF (%) | *L** | *a** | *b** | RGB color |
| 1 | 25 | 40 | 20 | 6.43 | 58.55 | 43.66 | 57.84 | 59.66 | 7.48 | 21.22 | |
| 2 | 95 | 40 | 20 | 4.59 | 59.12 | 43.08 | 56.78 | 56.75 | 7.50 | 21.14 | |
| 3 | 25 | 80 | 20 | 6.43 | 57.89 | 42.11 | 64.44 | 37.24 | 6.85 | 13.97 | |
| 4 | 95 | 80 | 20 | 6.63 | 53.24 | 46.76 | 62.65 | 35.62 | 5.44 | 11.59 | |
| 5 | 25 | 40 | 80 | 0.59 | 50.31 | 51.90 | 57.27 | 55.88 | 7.20 | 20.91 | |
| 6 | 95 | 40 | 80 | 0.79 | 54.12 | 51.59 | 58.66 | 56.02 | 7.62 | 21.57 | |
| 7 | 25 | 80 | 80 | 4.32 | 50.59 | 49.41 | 57.73 | 59.51 | 7.92 | 21.57 | |
| 8 | 95 | 80 | 80 | 6.18 | 47.30 | 52.70 | 57.53 | 58.60 | 8.14 | 19.93 | |
| 9 | 1 | 60 | 50 | 3.95 | 48.36 | 51.64 | 57.21 | 58.35 | 6.52 | 21.61 | |
| 10 | 119 | 60 | 50 | 5.07 | 48.62 | 50.25 | 58.64 | 56.80 | 6.31 | 20.41 | |
| 11 | 60 | 26 | 50 | 2.90 | 67.09 | 39.82 | 59.83 | 51.76 | 6.81 | 22.31 | |
| 12 | 60 | 94 | 50 | 6.97 | 59.19 | 40.81 | 65.55 | 34.09 | 8.51 | 20.18 | |
| 13 | 60 | 60 | 0 | 6.06 | 49.69 | 49.18 | 55.33 | 55.90 | 7.43 | 21.07 | |
| 14 | 60 | 60 | 100 | 1.63 | 34.47 | 65.53 | 52.46 | 70.62 | 6.63 | 22.25 | |
| 15 | 60 | 60 | 50 | 4.60 | 49.69 | 50.31 | 59.95 | 54.21 | 7.49 | 21.30 | |
| 16 | 60 | 60 | 50 | 4.72 | 51.82 | 48.18 | 58.11 | 56.62 | 7.71 | 21.39 | |
| 17 | 60 | 60 | 50 | 5.37 | 53.32 | 46.68 | 59.35 | 56.42 | 6.91 | 20.79 | |
| 18 | 60 | 60 | 50 | 4.57 | 51.73 | 48.27 | 57.86 | 57.30 | 7.22 | 21.29 | |
| 19 | 60 | 60 | 50 | 4.75 | 49.46 | 50.54 | 57.94 | 58.92 | 7.05 | 21.40 | |
| 20 | 60 | 60 | 50 | 5.41 | 52.03 | 47.97 | 60.48 | 58.33 | 7.20 | 21.54 | |

The SSE yield was promoted by lower temperatures and ethanol proportions, while MA was better extracted at higher temperatures for longer processing times (Fig. 2). In turn, the FCE had opposite yields to the SSE. However, the highest yields of FCE were not in agreement with their DF content. The highest DF values were recorded in FCE obtained at high temperatures and medium-low ethanol proportions (Fig. 2); and only these two independent variables significantly impacted its recovery, through linear, quadratic and also interactive effects. Furthermore, the lighter FCE were those with the highest yields.

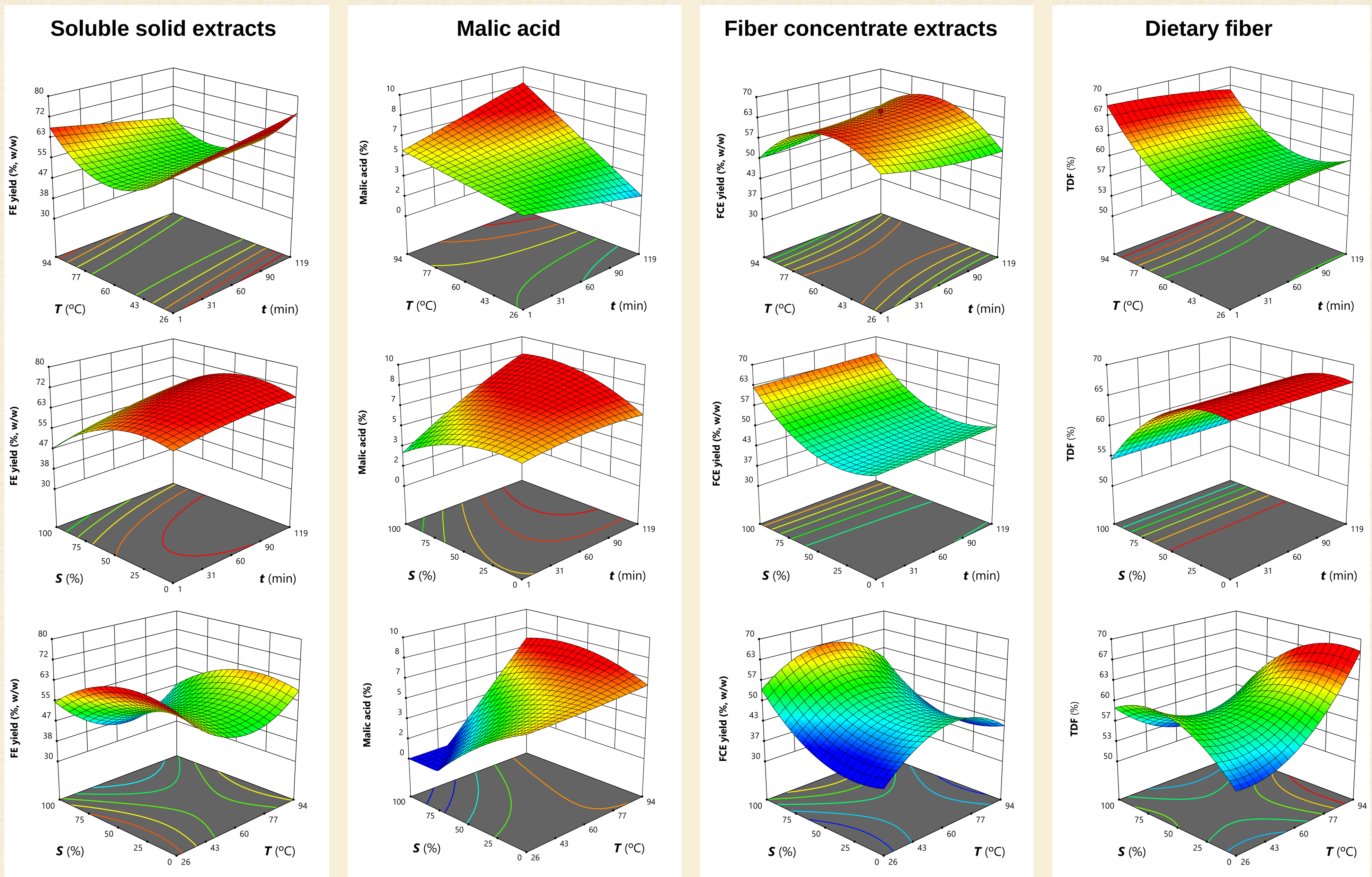


**Fig. 2** Response surface plots of the effects of the independent variables on the extraction of soluble solid extracts (SSE), malic acid (MA), fiber concentrate extracts (FCE) and dietary fiber (DF) from quince peel. In each 3D plot, the excluded variable is fixed at its optimum value.

## Conclusion

Overall, this study demonstrated that quince peel can be totally upcycled into natural food ingredients with potential to be used as food bioactives, preservatives or fortifiers.

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