Valorization of pomegranate peels by co-crystallization of their extract: factors affecting the efficiency

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INTRODUCTION

Pomegranate is a fruit that belongs to the genus *Punica*, while the most well-known species is *Punica granatum* L. (Usha et al., 2020). Pomegranate peel represents the 20–50% of the total fruit, is retained as a by-product after the juicing process, and is an important source of bioactive components, mainly phenolics. However, polyphenols are considered as unstable compounds and this is the biggest deterrent to their use in the food industry. Encapsulation techniques are one of the most effective solutions to this issue. One of them is the co-crystallization process, which has a limited number of applications in the food industry. The mechanism is based on the modification of the crystalline structure of sucrose from perfect to imperfect and irregular crystals, leading to the formation of a porous matrix, in which a second active ingredient is incorporated and protected (López-Córdoba and Navarro 2018). Co-crystallization is an economic and simple method which improves the physicochemical properties of the co-crystallized products.

The purpose of this work is the successful encapsulation of pomegranate peel phenolic extract into a sucrose matrix by the co-crystallization method.

MATERIALS AND METHODS

Encapsulation of pomegranate peel extract using and comparing three different experimental designs

Experimental design	Number of experiments
Central composite design (CCP)	20
Box-Behnken design (BB)	15
Two level factorial design (F)	8

Table 1. Number of experiments of each experimental design.

Table 2. Minimum and maximum value of each examined variable.

Variable	Low	Max
Solids concentration on feed (Xs, °Brix)	30	60
Dry extract to sucrose ratio (E/S, g/g)	0.1	0.7
Temperature (T, °C)	125	140

Dried pomegranate peels

Co-crystallization technique

Co-crystallized powder with pomegranate peel extract

Differential scanning calorimeter (DSC)

Characterization of co-crystallized powder in optimal conditions
(*Xs* = 60 °Brix, *E/S* = 0.591 g/g, *T* = 140 °C)

DSC

- 2–10 mg of the samples (pure sucrose, co-crystallized sucrose, co-crystallized sucrose with the active ingredient at optimal conditions) were placed in hermetically sealed aluminum tablets (Perkin-Elmer Pyris 1)
- An empty aluminum tablet was used as a control.
- The evaluation was performed in the range of 25–250 °C with a heating rate of 10 °C/min in a nitrogen atmosphere with a flow of 20 mL/min.

Total phenolic content

- The samples (crude and encapsulated extract) were placed in hermetically sealed bottles and stored in an oven (Memmert model BE 500, Schwabach, Germany) with controlled temperature and absence of light for 40 days.
- Every 2-3 days, an amount was taken from each sample to measure total phenolic content.

RESULTS AND DISCUSSION

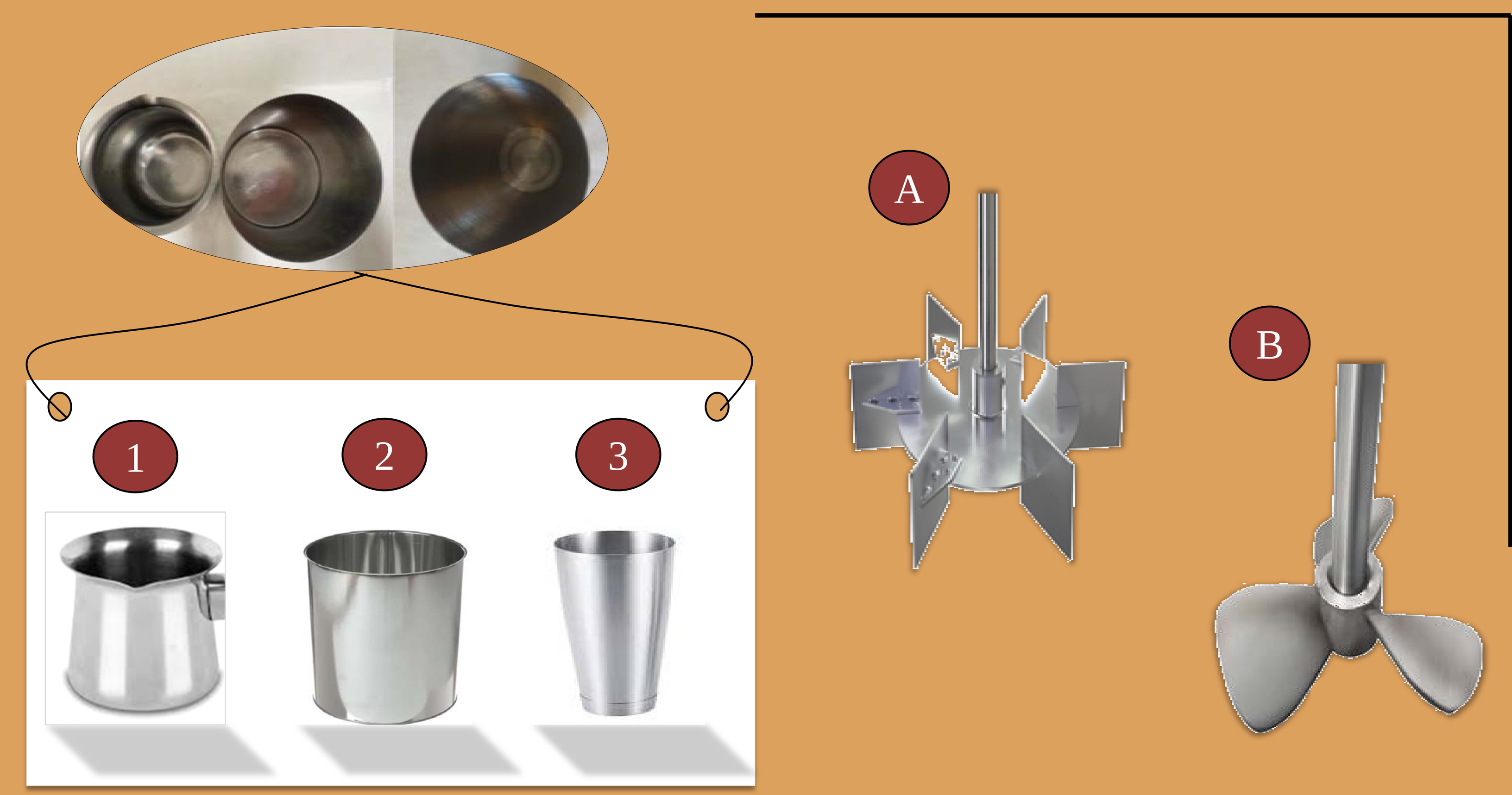

Fig. 1. Choice of metallic vessel and agitator type, A) three-bladed marine propeller B) six-bladed disc turbine.

Table 3. Geometric features of three different metallic vessels.

Vessel	Geometric features			
	Height (cm)	Thickness (cm)	Diameter (cm)	Bottom shape
1	8.0	0.80	6.8	Curved
2	11.5	0.15	10.5	Flat
3	11.2	0.15	5.0	Flat

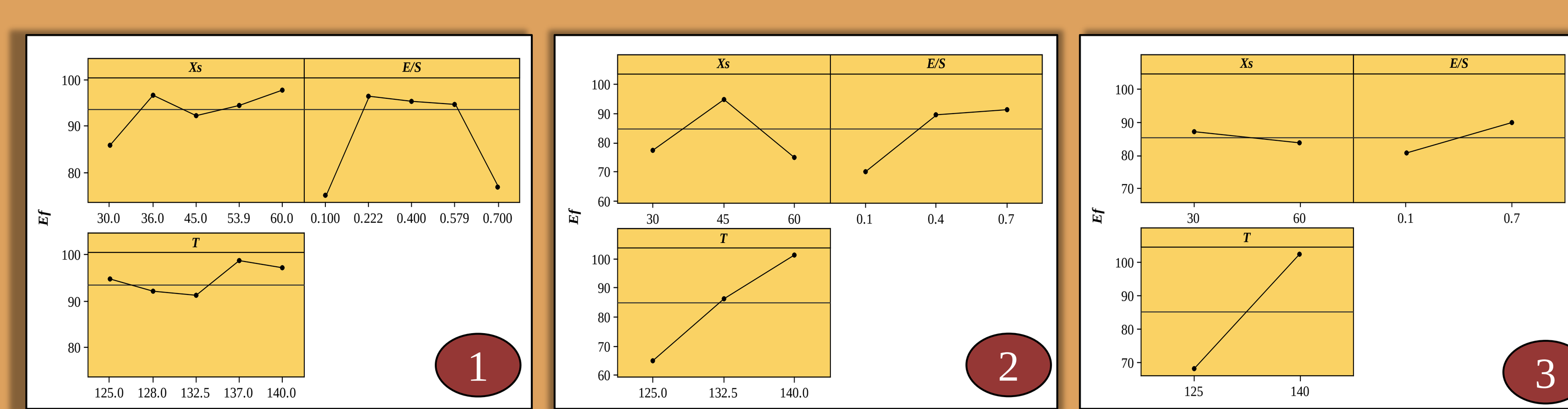

Fig. 2. Main effects plots for the influence of feed solids concentration (*Xs*, °Brix), dry extract to sucrose ratio (*E/S*, g/g), and temperature (*T*, °C) on encapsulation efficiency (*Ef*, %) (1: CCP, 2: BB, 3: F).

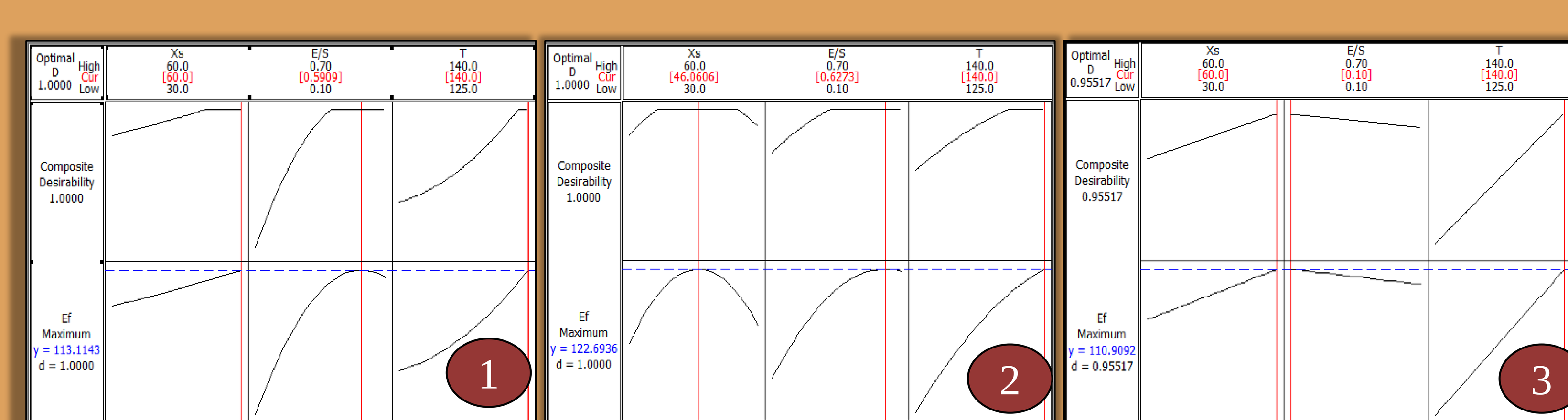

Fig. 3. Optimum conditions for maximizing encapsulation efficiency (*Ef*, %) (1: CCP, 2: BB, 3: F).

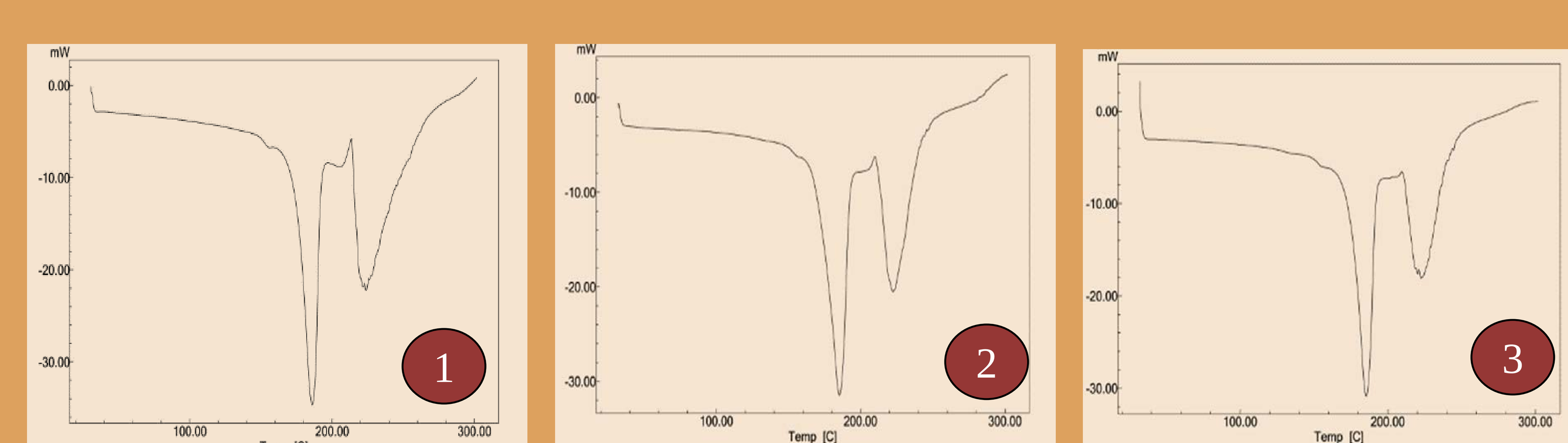

Fig. 4. DSC thermograms of (1) pure sucrose, (2) co-crystallized sucrose, and (3) co-crystallized sucrose with the active ingredient at optimum conditions.

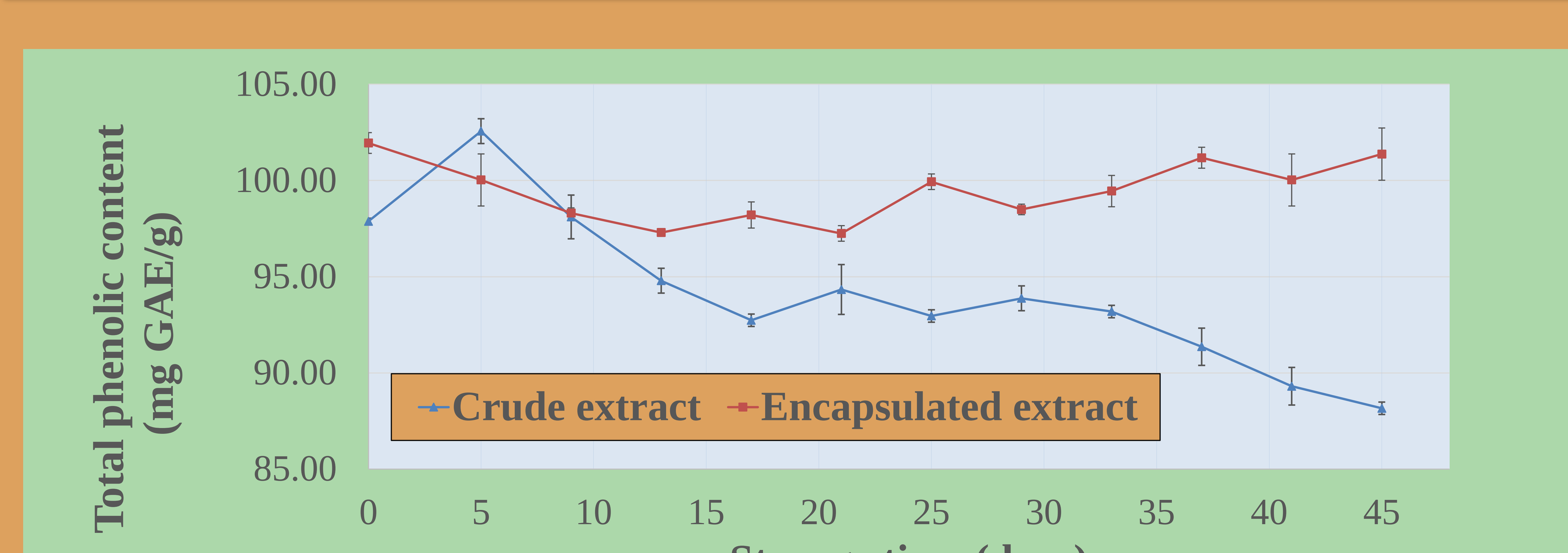

Fig. 5. Total phenolic content (mg GAE/g) of crude and encapsulated extract (at optimum conditions) during storage at 60 °C.

REFERENCES

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