Encapsulation of pomegranate peel extract in sucrose matrix by co-crystallization

E. Chezanoglou, A.M. Goula

Department of Food Science and Technology, School of Agriculture, Forestry and Natural Environment, Aristotle University, 541 24 Thessaloniki, Greece
Keywords: food waste, pomegranate peel, phenolic extracts, encapsulation, co-crystallization
Presenting author email: chezanog@agro.auth.gr, athgou@agro.auth.gr

In recent years, overproduction of foods increased the amount of waste. Specifically, during the juicing of pomegranate, for every 100 kg of fruit, 37 kg of waste is generated, of which 23 kg refer to the peels and 14 kg to the seeds (de Oliveira *et al*, 2020). Many researchers have turned their attention to the polyphenolic content of pomegranate peels, as it is characterized by high antioxidant and antimicrobial activity (Kaderides *et al*, 2021).

However, polyphenols are considered as unstable compounds and this is the biggest deterrent to their use in the food industry. This instability is due to several factors such as interactions between antioxidants and food ingredients and existence of unsaturated bonds in the molecular structure of phenolic compounds (Cilek *et al*, 2012). As a result, polyphenols are sensitive to light, heat, pH, water, and enzymatic activities (Zeng *et al***,** 2011). In addition, the most remarkable obstacles to the application of phenolic extracts in the food industry are their low water solubility, their rapid release in the food matrix, the instability after their exposure to environmental conditions, their loss of color and aroma due to oxidative degradation, their low oral and gastrointestinal absorption due to low pH values and the presence of enzymes in the respective areas, their short shelf life, and their rapid excretion from the body (Esfanjani *et al*, 2018; Fang and Bhandari, 2010).

All of the above, led the food industry to seek a solution that would improve shelf life and stability of phenolic extracts. Encapsulation and specifically microencapsulation is one of the most effective solutions to this issue. In particular, it enhances their protection from the prevailing environmental conditions, increases their shelf stability, covers their undesirable taste, controls their dispersion, and enriches the product with phenolic compounds (Delfanian and Sahari, 2020).

There are various encapsulation methods used in the food industry over time (Desai and Park, 2005). One of them is co-crystallization method, which is mainly used in the pharmaceutical industry, whereas its use in the food industry is limited (Maunli *et al*, 2005). However, it has competitive advantages over other encapsulation methods, such as direct conversion of the encapsulated core material from liquid state to dry powder without additional drying (Desai and Park 2005), improved physicochemical properties of the co-crystallized products (Karangutkar and Ananthanarayan, 2020), low cost, and flexibility (Sardar and Singhal, 2013).

The principle of co-crystallization method 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). The main steps of the method include heating and stirring of the supersaturated sucrose syrup, addition of the active compound, and cooling of the co-crystallized powder.

The aim of this study is the effective encapsulation of pomegranate peel phenolic extract in the matrix of sucrose by co-crystallization utilizing three different experimental designs: 2-level Factorial Design (2^n), Central Composite Design (CCD), and Box-Behnken Design (BBD), from which the one with the higher predictive ability is selected. The examined parameters are the temperature (125-140°C) at which the phenolic extract is incorporated into the sucrose matrix, the solids concentration of the extract (30-60°Brix), as well as the ratio of dry extract to sucrose (0.1-0.7 g/g). The formed powders are analyzed for their physicochemical properties, moister content, hygroscopicity, solubility, bulk density, and color. Furthermore their antioxidant activity and encapsulation efficiency are evaluated.

References

1. Cilek, B., Luca, A., Hasirci, V., Sahin, S., & Sumnu, G. (2012). Microencapsulation of phenolic compounds extracted from sour cherry pomace: effect of formulation, ultrasonication time and core to coating ratio. *European Food Research and Technology*, *235*(4), 587–596.
2. Delfanian, M., & Sahari, M. A. (2020). Improving functionality, bioavailability, nutraceutical and sensory attributes of fortified foods using phenolics-loaded nanocarriers as natural ingredients. *Food Research International*, 109555.
3. de Oliveira, F. L., Arruda, T. Y. P., da Silva Lima, R., Casarotti, S. N., & Morzelle, M. C. (2020). Pomegranate as a natural source of phenolic antioxidants: a review. *Journal of Food Bioactives*, *9*, 10–22.

4. Desai, K. G. H., & Jin Park, H. (2005). Recent developments in microencapsulation of food ingredients. *Drying Technology*, *23*(7), 1361–1394.
5. Esfanjani, A. F., Assadpour, E., & Jafari, S. M. (2018). Improving the bioavailability of phenolic compounds by loading them within lipid-based nanocarriers. *Trends in Food Science & Technology*, *76*, 56–66.
6. Fang, Z., & Bhandari, B. (2010). Encapsulation of polyphenols–a review. *Trends in Food Science & Technology*, *21*(10), 510–523.
7. Kaderides, K., Kyriakoudi, A., Mourtzinos, I., & Goula, A. M. (2021). Potential of pomegranate peel extract as a natural additive in foods. *Trends in Food Science & Technology*, *115*, 380–390.
8. Karangutkar, A. V., & Ananthanarayan, L. (2020). Co-crystallization of *Basella rubra* extract with sucrose: Characterization of co-crystals and evaluating the storage stability of betacyanin pigments. *Journal of Food Engineering*, *271*, 109776.
9. López Córdoba, A., & Navarro, A. (2018). Physicochemical properties and stability of sucrose/glucose agglomerates obtained by cocrystallization. *Journal of Food Process Engineering*, *41*(8), e12901.
10. Maulny, A. P. E., Beckett, S. T., & Mackenzie, G. (2005). Physical properties of co-crystalline sugar and honey. *Journal of Food Science*, *70*(9), 567–572.
11. Sardar, B. R., & Singhal, R. S. (2013). Characterization of co-crystallized sucrose entrapped with cardamom oleoresin. *Journal of Food Engineering*, 117(4), 521–529.
12. Zheng, N., Bucheli, P. & Jing, H., 2009. Effects of casein- and whey protein–dextran conjugates on the stability of bog bilberry anthocyanin extract. *International Journal of Food Science and Technology*. *44*, 1452–1458.