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

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In recent years, the excessive production of products by the food industries has led to an increased amount of waste. The exploitation and utilization of wastes is the most effective way of dealing with this problem. With the passage of time, the development of know-how and the search of literature, waste utilization has itself become a huge research field on which many researchers have focused. Also, the awareness and demands of the consumer public for biofunctional foods directed the industries to the formation of products, which on the one hand have the necessary nutrients and on the other hand contribute positively to the health of the consumer (Delfanian & Sahari, 2020). The above combination led the attention of the scientific community in the receipt and isolation of biofunctional components from waste, such as polyphenols. Specifically, during the juicing of a certain amount of pomegranate fruit, 37% is waste and specifically 23% refers to the peels and 14% to the seeds of the fruit (de Oliveira et al., 2020). Many researchers turned their interest to the polyphenolic content of pomegranate peels, as it exhibits high antioxidant and antimicrobial activity (Kaderides et al., 2021).

Polyphenols are characterized as unstable combounds and this is the biggest challenge that the industry has to face. This instability is due to various factors, such as the interactions both between the various antioxidant components and with the food components. A determining factor for these interactions is the environment and the conditions prevailing in it (Ioannou et al., 2012). Therefore, the main goal is their proper management. This achievement requires the formulation of a final product capable of maintaining the structural integrity of the phenolic components until the moment of administration - consumption, masking their taste, increasing their water solubility and bioavailability, and accurately transporting them to a physiological target (Mourtzinos & Goula, 2018). Encapsulation, specifically microencapsulation, has been one of the most effective solutions to the above goals.

There are many encapsulation methods used in the food industry with spray drying being the dominant technique (Desai & Park, 2005). One of them is encapsulation by co-crystallization, which has attracted more and more researchers in recent years. It presents competitive advantages over other encapsulation methods as it is a simple and economical method, which offers an alternative solution for the management, protection, and preservation of active ingredients used in industry in powder form (Karangutkar & Ananthanarayan, 2020), it gives improved physicochemical properties in the produced powder (Chezanoglou & Goula, 2021), covers undesirable organoleptic properties of the active ingredient (Alex López-Córdoba et al., 2014), and finally offers a competitive production unit cost, simple construction, easy handling, and portability operations (Alex López-Córdoba et al., 2015). The main mechanism of the method is based on the modification of the crystalline structure of sucrose, from perfect to imperfect and irregular crystals, resulting in the formation of a porous matrix in which a second active ingredient is encapsulated and protected (López-Córdoba and Navarro, 2018).

The aim of this study is the effective encapsulation of the pomegranate peel's phenolic extract into the sucrose matrix. In a previous work it was observed through a comparison of three different experimental designs, Central composite design (CCP), Box-Behnken design (BB), and 2-level factorial design (F) that from the three examined parameters: 1) the solid's concentration of the phenolic extract, Xs (°Brix), 2) the dry extract-sucrose ratio, E/S (g/g), and 3) the encapsulation temperature, T (°C), only the dry extract to sucrose ratio affected statistical significantly the co-crystallization efficiency in all three experimental designs. For this reason, it was considered necessary to study further parameters in the effectiveness of the method. In the present research study, it was examined whether the rate of change of encapsulation temperature, the rate of change of moisture evaporation, and the type of stirrer during co-crystallization, affect the efficiency of the method and the physicochemical properties moisture content (MC), hygroscopicity (H), solubility (S), bulk density (BD), color (L*, a*, b*), antioxidant capacity (AA) of the co-crystallized powder. Regarding the rate of temperature change and evaporation, their profile was studied by taking values at specific time intervals and at different final encapsulation temperatures and then they were interpreted with the help of a mathematical model as constants, which were two of the three independent variables of the considered CCP experimental design. The third parameter is the type of agitator, where it is necessary to study whether it can be expressed quantitatively based on the Reynolds number.

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