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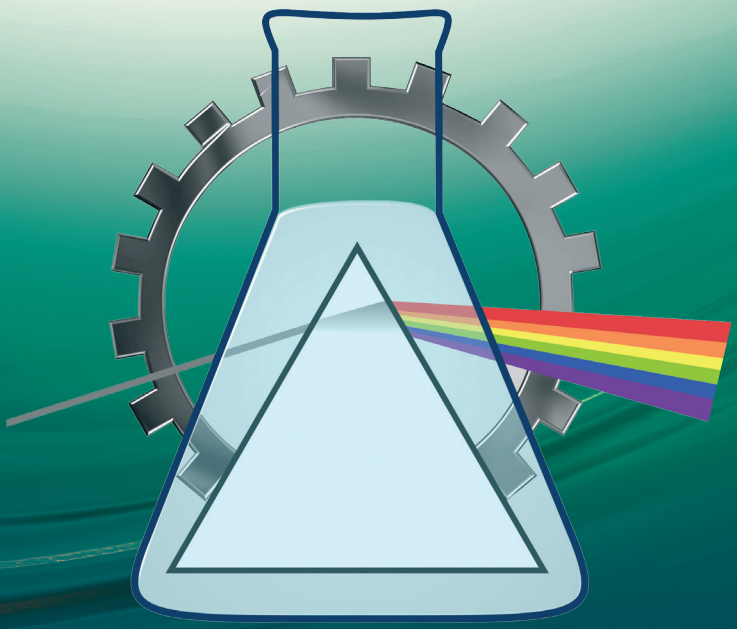
SCIENCE AND INDUSTRY
challenges and opportunities



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ENCAPSULATION OF GREEN TEA LEAVES EXTRACT BY SPRAY DRYING

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Introduction: In recent years, leaves of green tea (*Theae folium* (*Camellia sinensis*, Theaceae)) have been abundantly investigated due to their high content of polyphenolic, especially catechins including epigallocatechin-3-gallate (EGCG), epigallocatechin (EGC), epicatechin-3-gallate (ECG) and epicatechin (EC), shown to possess many health-promoting effects, such as hypoglycemic (anti-diabetic), anticarcinogenic, anti-inflammatory, antimicrobial and antioxidant activities [1]. The stability of bioactive compounds of green tea leaves, otherwise sensitive to environmental factors (such as light, heat, moisture, pH, and oxygen), may be preserved by their encapsulation within a coating material, i.e. their conversion from liquid to dry form, which additionally may enable their controlled release and prolong shelf life. Spray drying (SD) using encapsulating agents such as natural biopolymers from the group of polysaccharides and/or proteins has been widely used for the stated purpose, enabling the production of powders suitable for further usage in the pharmaceutical or food industry [2]. In this study, SD was used for drying green tea leaves extract, with or without the addition of pectin in various concentrations, which was used as an encapsulating agent.

Experimental: *Preparation of extract***:** The extract was obtained by percolation of green tea leaves with 50% (*v/v*) ethanol, (D:E = 1:5), in which the alcohol was evaporated to less than 5%, after which a dry residue of 7% (*m/m*) was determined.
Spray Drying Process: Samples without the addition of pectin (sample A) or with the addition of pectin in ratio of 1:2, 1:1 and 2:1 relative to dry residue (samples B, C and D, respectively) were dried using spray dryer (Labtex ESDTi, Labtex, Hudders eld, UK) with a needle diameter of 0.5 mm, the inlet temperature of 130±1°C, outlet temperature of 65±10°C, pressure of 2.2. bars, pump speed of 4, and airflow of 11. *Technological and Physicochemical Properties of the Microencapsulates:* In the obtained extracts the yield was calculated considering the initial mass of the liquid extract, i.e. the content of dry residue in the extract, the concentration of pectin, and the mass of the obtained dry extract. Flowability was determined based on bulk and tapped density, according to Ph Eur 10.0. The encapsulation efficiency of the marker compounds (EGCG, EGC, ECG, and EC) was determined using an appropriate HPLC method that allowed their quantification in the liquid extract and the resulting powders (spray-dried extracts). Scanning electron microscopy (SEM) was used for visualization of the size and surface morphology of the particles in the dried extracts, while the dissolution of EGCG, EGC, ECG, and EC from the dried extracts was determined in 0.1 M hydrochloric acid (pH = 1.2) at 37 °C.

Results: The powder yield was in the range of 53.50 to 60.63% and was the highest in samples a and C (without pectin and with pectin in ratio 1:1 relative to dry residue,

respectively). The addition of pectin led to a consequent improvement in the flowability of the dried extracts up to a ratio of pectin and dry residue of 1:1 (sample C). A further increase in the proportion of pectin in sample D did not lead to a comparative improvement in flowability. Similarly, in the SEM micrographs of sample a (without added pectin), the presence of particles of uniform size, irregular spherical shape with a wrinkled surface may be detected. With an increase in the proportion of pectin in samples B and C, the appearance of a fraction of spherical particles may be seen, which can be related to the presence of the encapsulating agent. In sample B, the regular spheres are similar in size to the particles of the wrinkled surface, and in sample C, the regular spheres were slightly larger compared to the ones in sample A. In sample D, where pectin content is twice as high compared to the dry residue, the presence of large spherical particles compared to small particles with a wrinkled surface is evident. Encapsulation efficiency was highest in sample C, with the exception of EGC and EC, where the highest encapsulation efficiency was detected in sample B. When it comes to the dissolution of marker compounds, the addition of pectin slowed down the dissolution rate of all tested compounds, and this effect was the most pronounced in sample C (in which the ratio of dry residue and pectin was 1:1), while the further increase of pectin content did not lead to a comparative increase in the dissolution rate of the tested compounds.

Conclusions: Results of the current study singled out the sample in which green tea leaves extract was dried with pectin and in which pectin to dry residue ratio was 1:1 due to the best yield, encapsulation efficiency, and flowability. Also, the slowest release of bioactive compounds was detected in this dry extract, which will be the basis for our further research.

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