Gentle Drying of Sensitive Food Products

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Natural extracts are of special interest for the food industry. They are often gained by extraction using conventional solvents followed by solvent separation and powderization, because solvent free and powderous products are desired. Therefore the most common techniques applied in production are spray and freeze drying. These techniques offer the possibility for high quality powder production but also are characterized by high energy consumption and the risk of oxidation.

In this investigation a product-gentle drying process for natural food products (called PGSS-Drying) will be presented. The process uses the solvent power of supercritical gases for the removing solvents in a continuous process step. No long extraction times like in batch extraction processes are needed. The solution or dispersion to be dried is continuously mixed (often in a static mixer) under pressure with a supercritical gas (mostly carbon dioxide) and depressurized over a nozzle into a spray tower – the solution is atomized and fine droplets are formed. The drying is achieved through a combined extraction and CO_2-driven flash evaporation. The condensation of solvent drops in the spray tower has to be avoided by adequate choosing the right spray tower conditions (e.g. temperature and pressure). By changing the amount of gas used and spray tower conditions the properties of the generated particles can be changed (e.g. in shape, size, porosity and residual moisture). By using a multi-component dispersion encapsulations of liquids are possible. Typically low to moderate temperatures are used in the spray tower (30-60°C), so that temperature sensible substances can be dried in a product-gentle way.

The versatility of the described process has been demonstrated over the last years with many different systems as e.g green tea extract. Dry and free flowing powders were achieved. The presented investigation focused on process design, possibilities and costs. Particles with different morphologies, generated via PGSS-Drying are shown in figure 1.

Green tea is a widely consumed beverage throughout the world and is produced from non-fermented leaves of Camelia Sinensis. Traditionally, green tea leaves are extracted with water. To form solid products, these aqueous products have to be dried. Due to the high amount of antioxidants (catechines) present and their reported health benefits, it is an interesting system to investigate. The main focus of the investigation is how to avoid antioxidant degradation during solvent removal.

The work was separated into two major sections, firstly optimization of the extraction process and secondly, optimizing of the drying process.

Optimization of the extraction process

Comparing different temperatures from 20 °C to 80 °C for conventional extractions with water, the optimal temperature was found to be 80 °C. Changing the ratio of raw material to solvent, ratio m(GT):m(H_2O) = 1:50 achieved the highest amount of epigallocatechin gallate (5.51%) after 15 min extraction. At the same time, the highest amounts of epicatechin (2.54%) and epicatechin gallate (1.89 %) were obtained. From the experiments it can be seen that a higher ratio of water to green tea at the same temperature and mixing time results in a higher yield of extraction and also the highest amount of extracted components.

Increasing extraction time does not have such a significant effect on the amount of polyphenols extracted. Results were compared for 60 °C and 80 °C. It can be seen that at 60 °C, the polyphenol content in the extract remains constant from 60 to 120 minutes of extraction. On the other hand, at 80 °C, the amounts of EC and ECG, start to decrease slightly after 15 min of extraction. One of the reasons is the temperature sensitivity of polyphenols and increased oxidation occurring at higher temperatures.

Comparing different solvents at different temperatures, methanol was found to be the best solvent, as can be seen by the highest amount of extracted polyphenols. Surprisingly high amounts of EGCG (5.02%), EC (2.50%) and ECG (1.80%) were extracted already at 20 °C. The second best solvent is water, followed by ethanol, which had the lowest results.

In addition, different mixtures of ethanol-water at 80 °C were investigated and it was found that extraction with pure water leads to a yield of 26.62%, while the addition of an equal amount of ethanol to the water further increases the yield to 33.72 %. This mixture was found to be the optimum, according to the amount of extracted EGCG (6.91%) and also with regard to the highest yield. Using pure ethanol the obtained yield was 15.71%.

Optimizing of the drying process

For the further processing of samples with PGSS Drying, water was used as a solvent, with a ratio of 1:10 according to the raw material. Extractions were performed at 60 °C and 80 °C, extraction time was set to 15 min. A ratio of 1:10 was used due to the limitations of the pilot plant.

Comparing extracts dried by different processes (figure 2), PGSS was found to be better, according to the higher amounts of extracted polyphenols. Furthermore water residue in extracts dried with PGSS (5.09%) was lower than with vacuum drying (8.82%) and it was below the 8 % limit which is necessary in order to prevent polyphenol oxidation.

Summary

As can be gathered from the presented results, PGSS is a promising technique for the drying of temperatures and oxygen sensitive substances. The process is carried out at low temperatures and in complete inert atmospheres.

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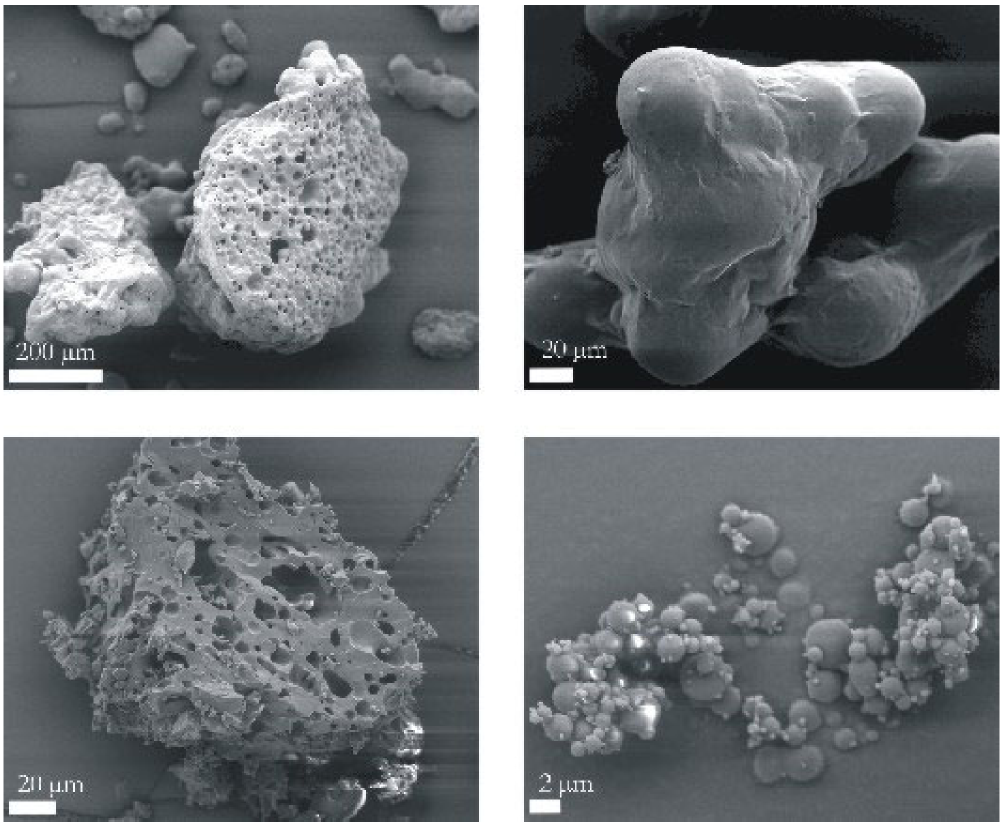

Figure 1: Particles dried using the PGSS-Drying process

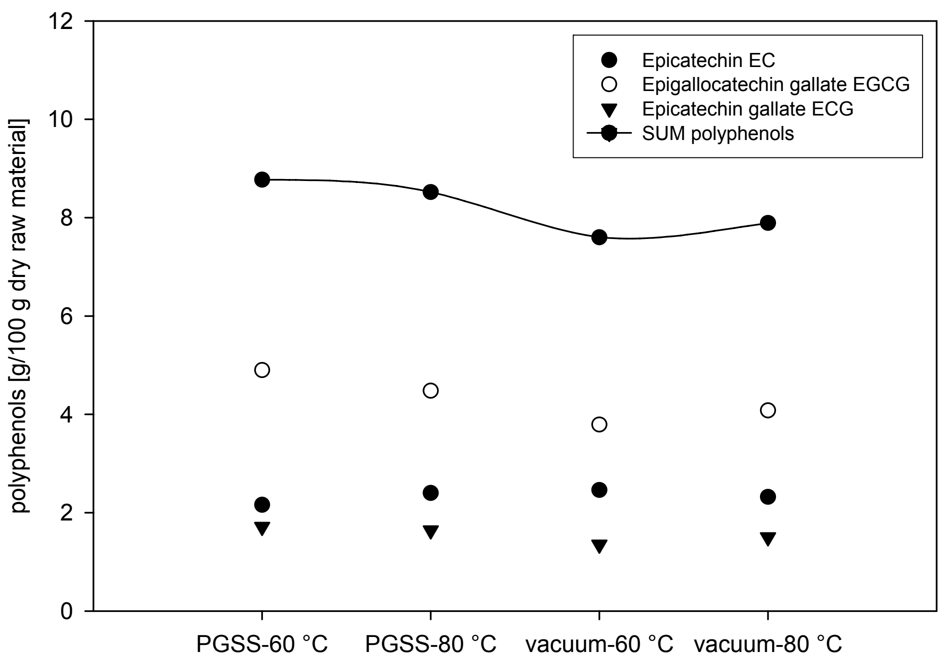

Figure 2: Plot showing polyphenol content in extracts dried with vacuum and PGSS (60 °C and 80 °C indicate temperatures at which extractions were performed)