Designing an Electrophoretic Separation System for Oleosomes and Proteins

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Oilseeds play a significant role in establishing more sustainable food production with their high oil and protein content, as both can be utilized as plant-based functional ingredients. Currently, an intensive oil extraction process is applied to extract oil, which degrades the quality of both oil and proteins. To take full advantage of oilseed compounds, a gentle process is needed that will sustain the quality of both oil and proteins. The present work aims to design an electrophoretic separation process that enables us to recover intact oleosomes and proteins from the seeds following a mild alkaline extraction. Rapeseed is used as a model oilseed. The electrophoretic separation is based on differences in the electrophoretic mobilities of the compounds. Rapeseed oleosomes and proteins exhibit significantly different electrophoretic mobility at pH ? 6, yet both are negatively charged at this pH range. The separation can be achieved by imposing a counter-current hydrodynamic flow at a rate that is between the electrophoresis rate of oleosomes and proteins. Thus, the compounds with higher mobility, oleosomes, are retained by the electric field and the compounds with lower mobility, proteins, go along with the flow. To theoretically prove the principle, the separation was modelled using the Nernst-Planck equation, and to demonstrate the principle, a PDMS-based microfluidic system was built that allows direct observation of the movement of oleosomes and proteins under a fluorescent microscope at varying electric field strengths and flow velocities. Both the modeling and the experimental studies indicated migration of oleosomes and proteins can be steered changing the electric field strength and the flow velocity. Certain combinations of the electric field strength and the flow velocity resulted in separation of oleosomes and proteins. A further increase either in the electric field strength or the flow velocity, however, hinders the separation, as both oleosomes and proteins move in the same direction. Overall, the conducted research revealed theoretically and experimentally the designed electrophoretic separation system is accomplishable, and it can be a novel path to separate oleosomes and proteins.