Electrophoretic recovery of oleosomes and proteins from rapeseed

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Introduction

Background: Rapeseed is a promising source of oil and protein with their large annual production (70 mT/year).[1] For future application, both oleosomes and proteins should be extracted with a sustainable, resource efficient method.[2]

Problem: Aqueous extraction is currently not efficient since separating the oleosomes and proteins requires substantial quantities of chemicals, water and energy.[2,3]

Solution: Oleosomes and proteins are charged compounds with various size. Thus, an electric driving force into the extraction process can improve the resolution between oleosome and proteins.

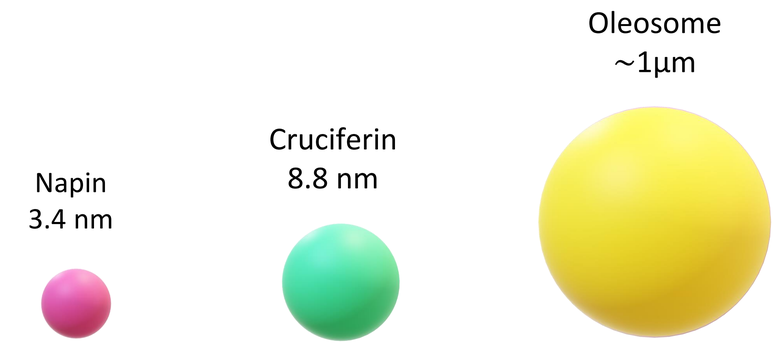

Figure 1: Schematic representation of the compounds in interest.

For electrophoretic resolution, the electrophoretic mobility must be sufficiently different. It depends on charge and size of the compounds, and environmental factors such as pH and ionic strength.[4]

Objective

This project aims to develop a scalable, continuous and electric field assisted separation method for separation of oleosomes and proteins from oilseeds to make the fractionation more efficient and sustainable.

Results – Electrophoretic Mobility

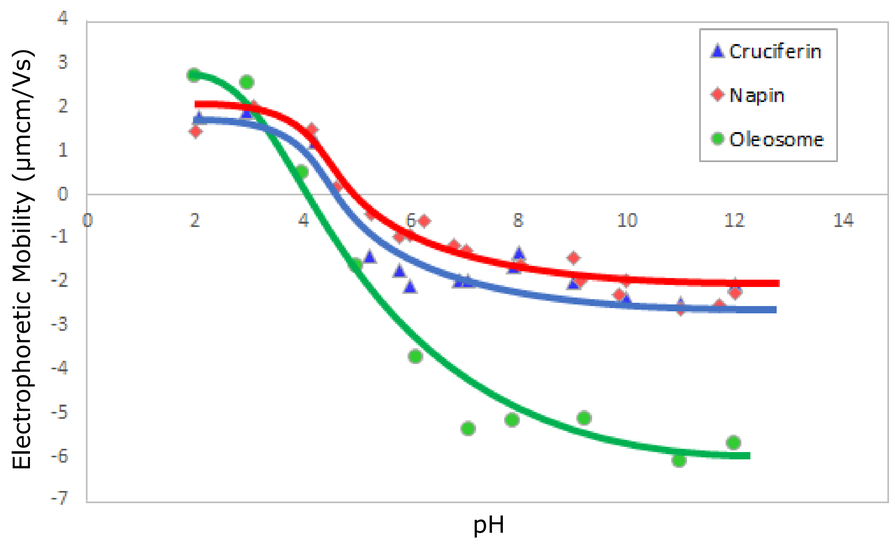

Figure 2. Electrophoretic mobility of oleosomes and proteins at pH 2 – 12.

The electrophoretic mobility of the oleosomes is significantly larger than that of the proteins at all pH > 5 ($p < 0.05$). The electrophoretic mobilities of cruciferin and napin differ from each other at pH 5 – 7 ($p < 0.05$).

Process Design

- Balancing electrophoretic migration and hydrodynamic flow can separate components having different electrophoretic mobility.

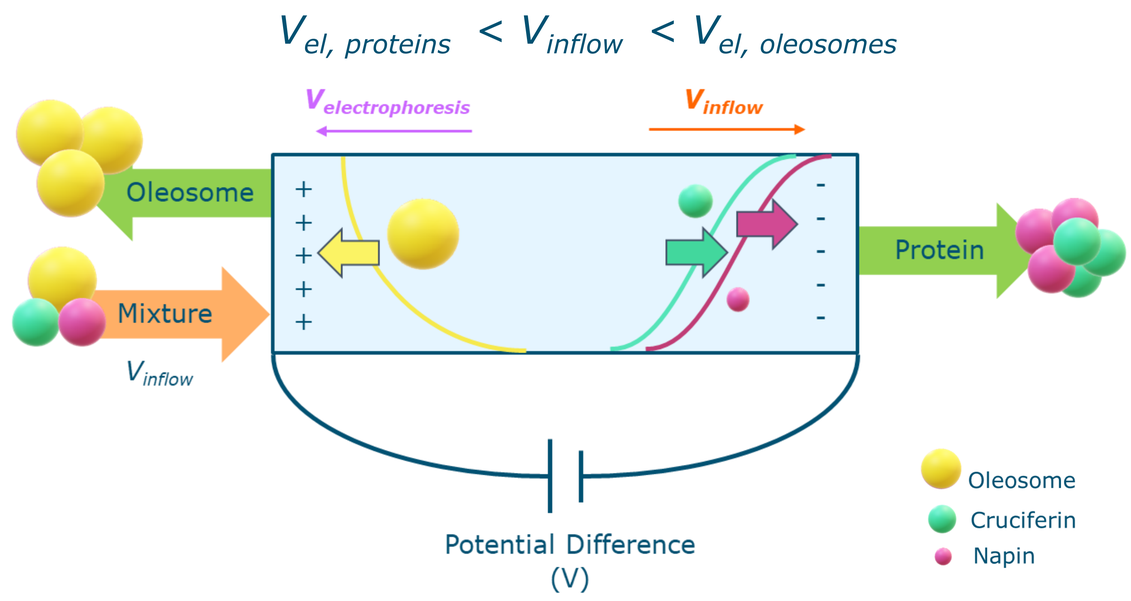

Figure 3: Designed continuous electrophoretic separation process for oleosomes and proteins.

Results - Modelling

The Nernst-Planck equation describes the transport of diluted compounds taking into account diffusion, electrophoresis and convection, and was used to estimate the distribution of oleosomes and proteins in the separation channel.

$$N_i = -Đ_{i4}\frac{dc_i}{dz} - Đ_{i4}\frac{c_i z_i F}{RT}\frac{d\Phi}{dz} + c_i u_4;\ \ i = 1 \dots 3$$

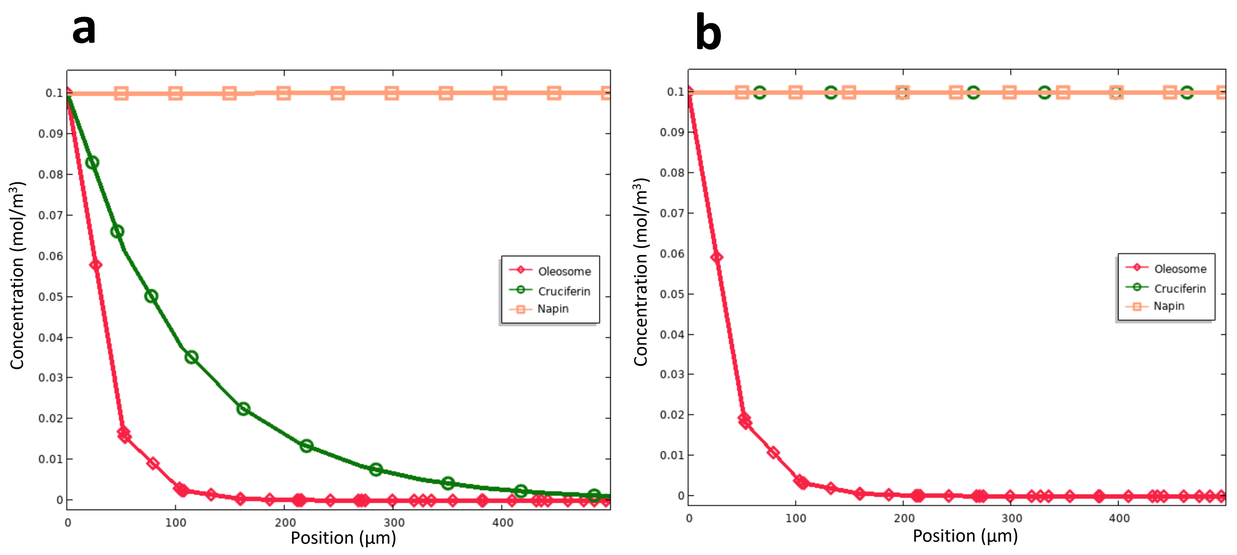

Figure 4: The concentration of oleosomes and proteins throughout the separation channel. Electric field: 1V/cm and a) V_{inlet} = 1.5 µm/s b) V_{inlet} = 5 µm/s.

Conclusions

- A continuous electrophoretic separation system can separate oleosomes and proteins, and even different types of proteins.
- A stronger higher electric field allows larger flow rates and larger throughputs.

Acknowledgements

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References: [1] USDA. Oilseeds: World Markets and Trade, 2020; [2] Nikiforidis, C. V. (2019), Advances in colloid and interface science, 274, 102039; [3] Guzmán, M. J. R. (2020), Doctoral Dissertation, WUR; [4] Srinivas, P. R. (2012), Protein Electrophoresis (pp. 23-28), Humana Press, Totowa, NJ.

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