Functional properties of mild fractionated soy protein as related to the processing pH

Yu Peng, Natalie Kersten, Konstantina Kyriakopoulou, Atze Jan van der Goot
Food Process Engineering Group, Wageningen University & Research, the Netherlands

Introduction

With rapid population growth, sustainable food production is highly required worldwide. Partially replacing animal proteins with plant proteins is a promising approach. Traditional fractionation processes of plant-based materials target to high purity of components, such as protein isolates. However, such fractionation processes consumes large amount of water and organic solvent reducing the sustainability of plant protein production.

In this study, soybean was selected as raw material because of its popularity in the market. We focused on an alternative mild fractionation, which is based on aqueous fractionation process with some modifications, such as the omission of oil extraction and several washing steps. We believe that mild fractionation can be a potential solution for further increasing the sustainability of plant-based products and by modifying fractionation parameters such as the pH we can achieve protein rich fractions of different functionalities.

Soy protein based food

Objective

Our objective is to obtain soy protein fractions (SPFs) by an alternative mild fractionation process, and understand how the processing pH influences the functional properties of SPFs for various applications.

Approach

Mild fractionation process was used to produce SPFs, while different processing pH (3.5, 4.5, 5.5, 6.5 and 7.5) was performed instead of neutralization step during process.

Full-fat Soy Flour (FFSF)

Protein solubilization pH 8- 9

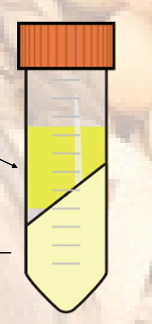
Centrifugation

Oil-rich cream layer

Fibre-rich pellet

Without de-fatting step using organic solvent

Protein precipitation pH 4.5 – 5



Mixing with water

Without washing step using lots of water

pH adjustment 3.5 – 7.5

Drying

The SPFs obtained under different processing pH were evaluated with:

- Chemical composition
- Microstructure (SEM)
- Nitrogen solubility index (NSI) and water holding capacity (WHC)
- Particle size distribution (Mastersizer)
- Viscoelastic properties (Closed Cavity Rheometer, CCR)

Results

- Chemical composition

Table 1 Composition of the SPFs, commercial SPI, and full-fat soy flour (mean value ± standard deviation (n=3), dry basis)

	Protein (N × 5.7)	Oil	Ash	Carbohydrate	Protein yield (%)
Full-fat soy flour	37.0 ± 1.1	21.8 ± 0.4	6.7 ± 0.7	34.5 ± 2.2	-
Commercial SPI	83.3 ± 0.7	0.0 ± 0.0	3.4 ± 0.0	13.3 ± 0.7	-
SPFs	85.3 ± 6.2	2.3 ± 0.0	2.1 ± 0.1	10.3 ± 6.3	55.8 ± 6

- NSI & WHC

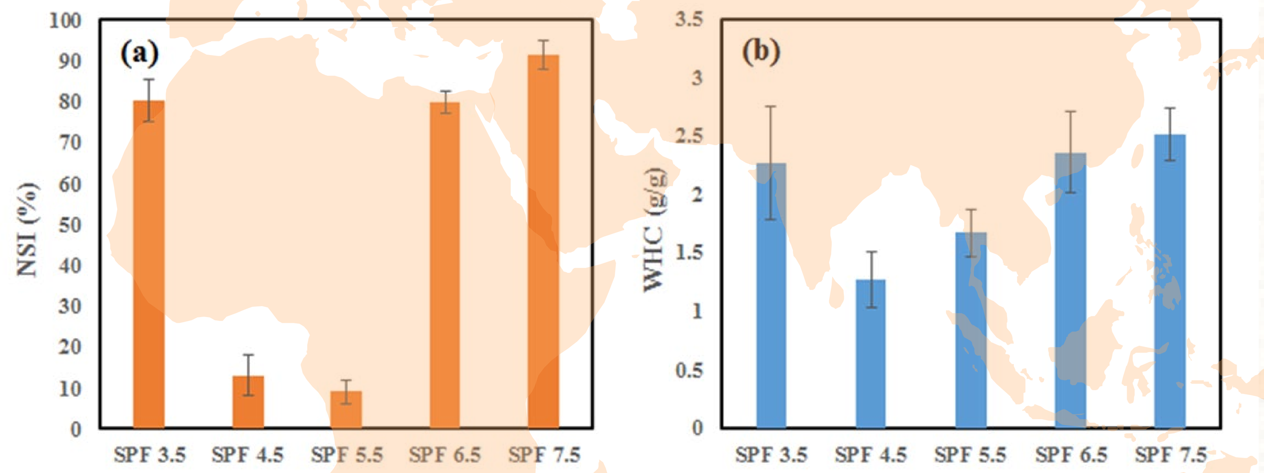


Fig. 1 (a) NSI and (b) WHC of all the SPFs.

The plots of NSI and WHC values against the processing pH resulted in characteristic U-shaped curves.

The lowest values of NSI and WHC occurred at processing pH around the isoelectric pH (pI) of soy protein. The NSI and WHC of SPF increased dramatically when adjusting the processing pH away from pI in both sides. The processing pH can influence the protein's net charge and conformation, which could lead to the exposure or burial of the water binding sites of the proteins, thus to different properties regarding NSI and WHC

- Morphology & particle size distribution

SPFs adjusted at pH 4.5 and 5.5 formed powdery texture after drying and exhibited larger particle size upon hydration. The texture of SPFs gradually transformed into flaky shape when the processing pH away from isoelectric point of 4.8 in both sides, and particle size decreased.

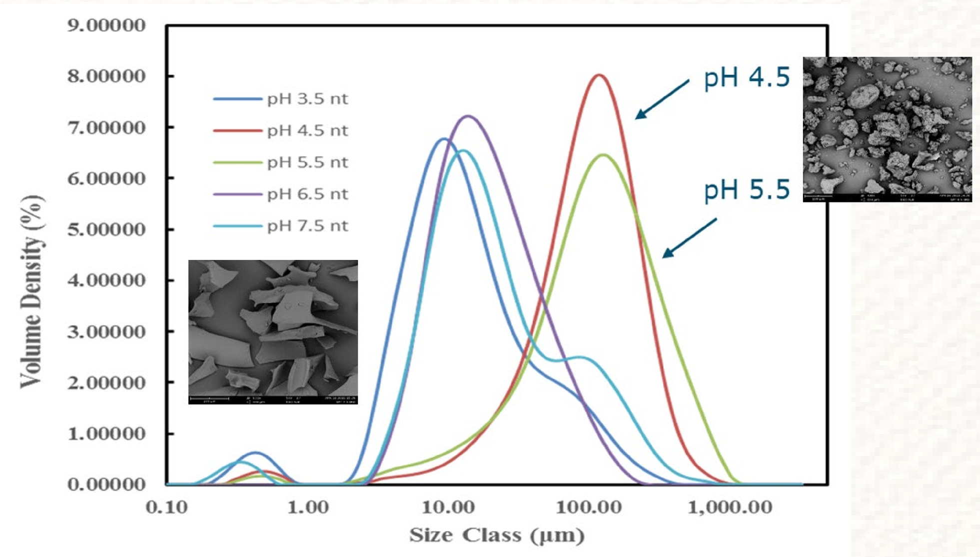


Fig. 2 SEM images and particle size distribution of all the SPFs

- Viscoelastic properties

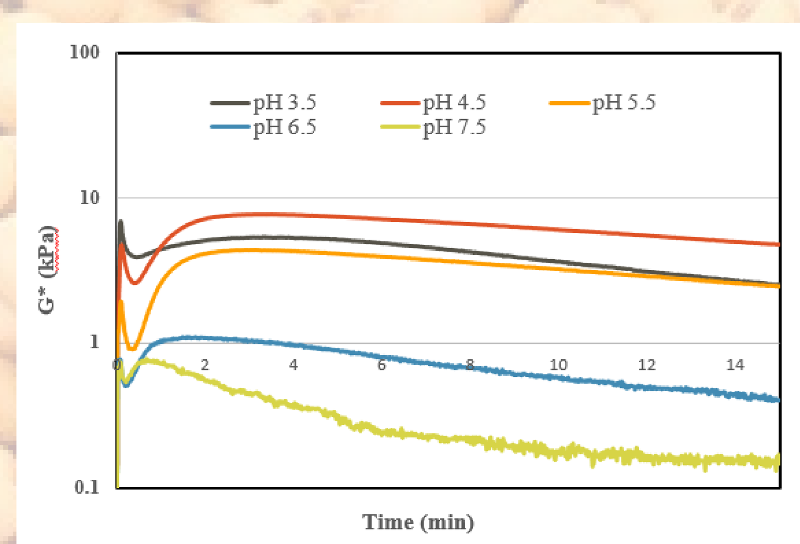


Fig. 3 complex modulus (G*) measured as a function of time at 140 °C of SPFs processed at different pH

SPFs were mixed with full-fat soy flour (FFSF) to exam the potential for meat analogue application. Similar trends were detected in the G*curve of all the SPF/FFSF blends, an apparent valley showed up in the first 2~3 min followed by a retarded steady-state creep. SPF 4.5/FFSF blend and SPF 5.5/FFSF had higher G* while the SPF 7.5/FFSF blend had the lowest one.

Conclusion

- Mildly fractionated SPFs showed higher protein and oil content as compared to commercial SPI.
- The processing pH altered the functionalities (NSI and WHC) and morphology of the SPFs and two clusters could be distinguished: one close and one away from the pI.
- We recommend to adjust the processing pH based on the requirement on the functional properties of multiple soy-based products, avoiding over-processing due to post-treatment modifications.

Department of Food Process Engineering
Wageningen University & Research

Yu Peng (PhD candidate)
Email: yu1.peng@wur.nl