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Applicability of product-driven process synthesis to separation processes in food

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Aim of the project

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The aim of this project is to fractionate and utilize a concentrated by-product (okara) from the soy milk production.

Main focus:

- Separation and purification of isoflavones from the okara
- Development of a sustainable, economic, and mild separation process
- Use and extension of the product-driven process synthesis (PDPS) methodology, including a process in which the food matrix plays an important role in separation

Introduction – Okara / soy milk production

+H_2O

14kg
+ steam

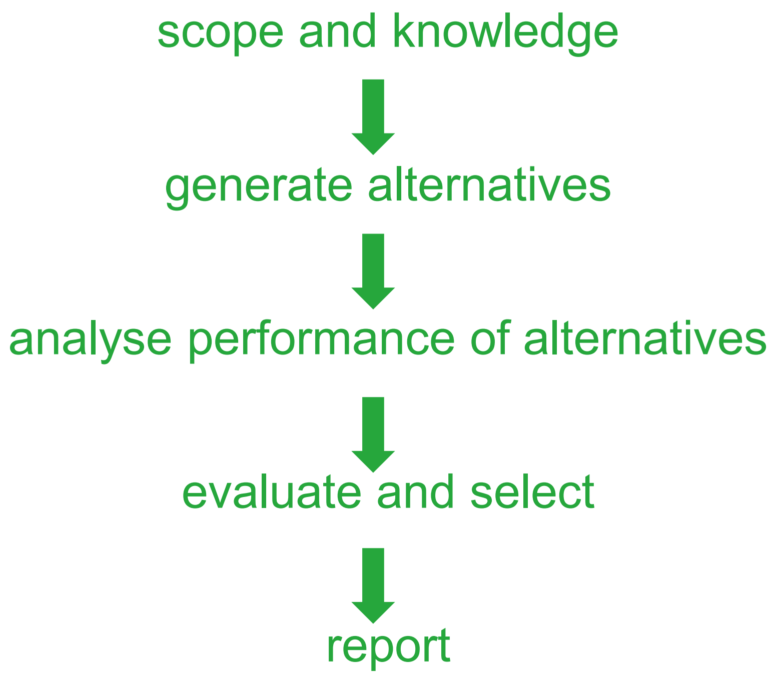
ASC-50 SoyCow

Water	**~80%**
Carbohydrates	
(insoluble DF)	~50% db
Proteins	~30% db
Lipids	~15% db
Isoflavones	***~0.1% db***

Introduction – PDPS

- Process synthesis approaches are well matured for chemical products
- Gap in application for food products
  - Microstructure of more importance
- Extended for food industry based on hierarchical decomposition of problem

Level	Description
0	Framing
1	Consumer wants
2	Product function
3	**Input/output**
4	**Task network**
5	**Mechanism and operational window**
6	Multiproduct integration
7	Equipment selection or design
8	Multi product-equipment integration



Application – PDPS for separation processes in food

- Application shown for ice-cream, mayonnaise, bouillon
  - Microstructure of end product (output) important
- Application for separation of isoflavones from okara
  - Microstructure of starting product (input) important

Chemical process (separation tasks)

Building food structure (mixing, preserving)

Decomposing food structure (separation tasks)

- Separation process leads to impurities and uncertainties in the streams
  - Increased number of task networks
  - More experimental work necessary at an earlier stage
  - Different tasks necessary ➡ extension of the methodology

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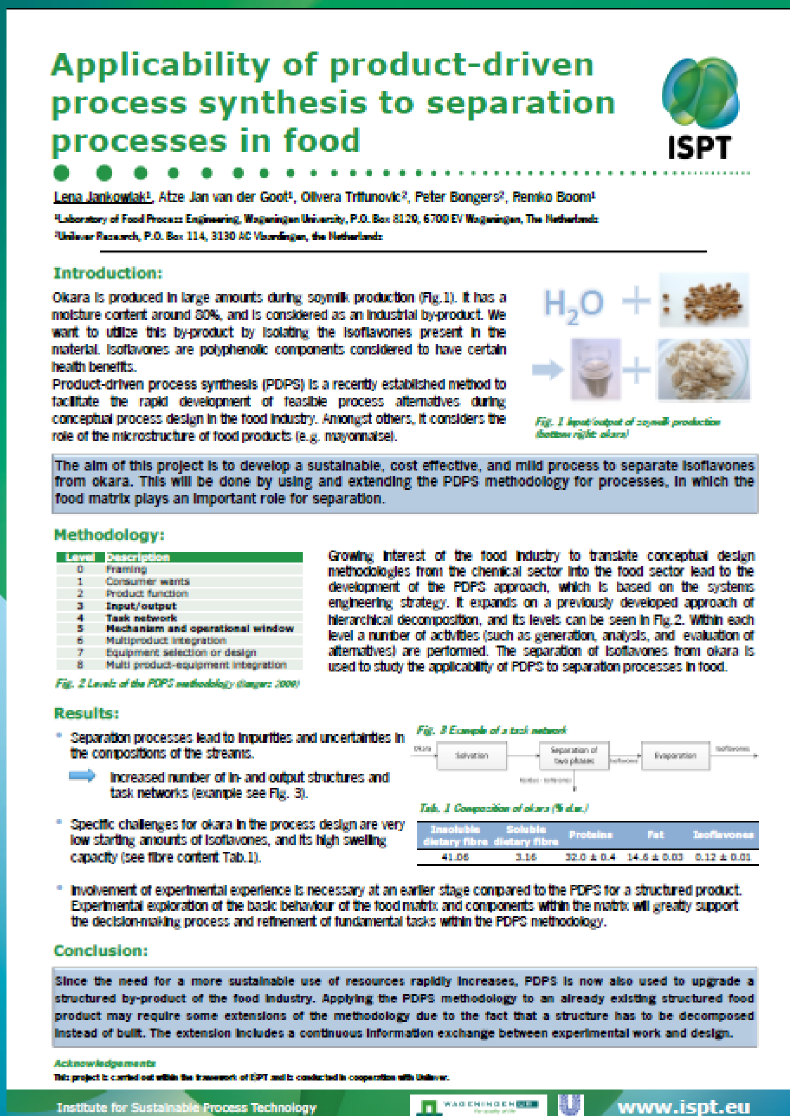

Applicability of product-driven process synthesis to separation processes in food

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Introduction:

Okara is produced in large amounts during soymilk production (Fig.1). It has a moisture content around 80%, and is considered as an industrial by-product. We want to utilize this by-product by isolating the isoflavones present in the material. Isoflavones are polyphenolic components considered to have certain health benefits.

Product-driven process synthesis (PDPS) is a recently established method to facilitate the rapid development of feasible process alternatives during conceptual process design in the food industry. Amongst others, it considers the role of the microstructure of food products (e.g. mayonnaise).

Fig. 1 Input/output of soymilk production (bottom right: okara)

The aim of this project is to develop a sustainable, cost effective, and mild process to separate isoflavones from okara. This will be done by using and extending the PDPS methodology for processes, in which the food matrix plays an important role for separation.

Methodology:

Level	Description
0	Framing
1	Consumer wants
2	Product function
3	**Input/output**
4	**Task network**
5	**Mechanism and operational window**
6	Multiproduct integration
7	Equipment selection or design
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Fig. 2 Levels of the PDPS methodology (Bongers 2009)

Growing interest of the food industry to translate conceptual design methodologies from the chemical sector into the food sector lead to the development of the PDPS approach, which is based on the systems engineering strategy. It expands on a previously developed approach of hierarchical decomposition, and its levels can be seen in Fig.2. Within each level a number of activities (such as generation, analysis, and evaluation of alternatives) are performed. The separation of isoflavones from okara is used to study the applicability of PDPS to separation processes in food.

Results:

- Separation processes lead to impurities and uncertainties in the compositions of the streams.
  - ⇨ Increased number of in- and output structures and task networks (example see Fig. 3).
- Specific challenges for okara in the process design are very low starting amounts of isoflavones, and its high swelling capacity (see fibre content Tab.1).
- Involvement of experimental experience is necessary at an earlier stage compared to the PDPS for a structured product. Experimental exploration of the basic behaviour of the food matrix and components within the matrix will greatly support the decision-making process and refinement of fundamental tasks within the PDPS methodology.

Fig. 3 Example of a task network

Tab. 1 Composition of okara (% d.w.)

Insoluble dietary fibre	Soluble dietary fibre	Proteins	Fat	Isoflavones
41.06	3.16	32.0 ± 0.4	14.6 ± 0.03	0.12 ± 0.01

Conclusion:

Since the need for a more sustainable use of resources rapidly increases, PDPS is now also used to upgrade a structured by-product of the food industry. Applying the PDPS methodology to an already existing structured food product may require some extensions of the methodology due to the fact that a structure has to be decomposed instead of built. The extension includes a continuous information exchange between experimental work and design.

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Thank you

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