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Vegetable proteins

A source of sustainable food ingredients

Vegetable proteins: understanding is the key to using them

With an expected growth of the world population to above 9 billion in 2050, there will be an enormous pressure on the future food production system. Furthermore, side-stream valorisation reduces wastage and enables a profitable use of all raw materials.

Plant proteins are more sustainable than animal proteins and more cost effective. (Partly) replacing animal protein with (new) plant protein ingredients or developing new plant protein-based products may contribute to an efficient use of available proteins.

Over the last decade, the numbers and volumes of vegetable proteins have increased. However, the application of plant proteins is still limited, due to such issues as off-taste/off-flavour, colour, solubility and low techno-functional properties. Functional proteins are still required to have animal properties, such as gelatine, for their broad application range.

The aim of this white paper is to show that by understanding vegetable proteins (from extraction to functionality), it is possible to broaden their application.

Protein fibres for meat alternatives

Consumers are aware of the sustainability issues, but are not necessarily willing to give up the taste or bite that belongs to an animal protein. One example is the bite of meat: many meat alternatives are available on the market, but most of them are not fulfilling the bite experience of meat. Thus their consumption is limited.

Meat alternatives with a bite

Protein fibers produced with NIZO technology have a meat-like texture and mouthfeel: juiciness and bite of meat. The protein fibers are applicable for dairy and vegetable proteins. Read this case

CLSM pictures of protein fibers and macroscopic visualization of a 'burger-like' after cooking

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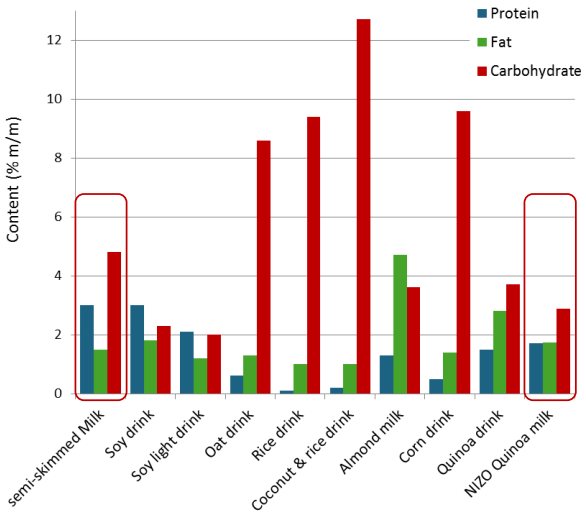
Vegetable protein drinks

Worldwide, the number of people intolerant to gluten and lactose, or allergic to dairy proteins is increasing. Thus, there is a need for alternative drinks to replace for example milk. A number of 'milk analogue' has appeared on the market, such as soy, almond and oat milk. However, this is still a niche market, because a lot of these drinks are still too astringent for people in developed countries.

Quinoa as a source of proteins for 'milk analogue'

Quinoa is recognised as a natural food source with high nutritional value. It is lactose and gluten free. NIZO has developed a well tasting, nutritional balanced Quinoa drink.



This new drink offers a good mouthfeel, and offers the same protein content as other 'milk analogue'. It also offers a much lower carbohydrate content that other vegetable drinks (except soy).

New sources of vegetable proteins

Apart from soy proteins, which have been used for many years in food industry, new sources of vegetable proteins have appeared in the last two decades, such as pea, rapeseed and potato.

Other sources are studied right now for their application in the food industry:

- Proteins from microalgae: Microalgae are harvested for biodiesel production. However, to make the process economically profitable, proteins (as well as other compounds) must be extracted and applied in the food industry.
- Proteins from gluten free starchy seeds: Quinoa, Amaranth and TEFF are good candidates for new sources of vegetable proteins.

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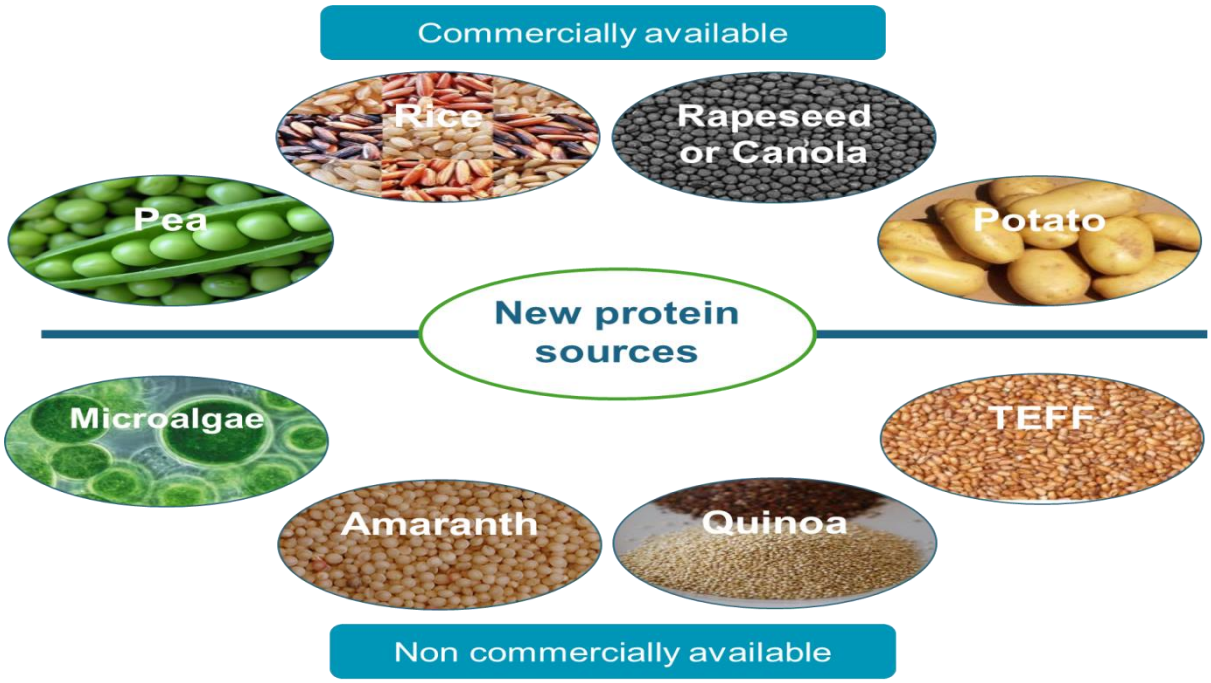

An overview of protein sources.

When investigating new protein sources for potential food applications, several factors must be looked at:

1. Nutritional Value
2. Digestibility of vegetable proteins
3. Organoleptic properties and way to mask it
4. Protein modifications
5. Bioactive peptides
6. Extraction

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1. **Nutritional value:** the amino acid composition of the protein powder. It is important to remember that the requirements for the essential amino acid are different, depending on the consumer target group. NIZO developed tools to search for proteins that have a certain amino acid profile.

Essential amino acid (mg/g)	FAO/WHO* Infant (<6mths)	FAO/WHO* Adults	Whey	Soy	Pea
Histidine	21	15	13	26	25
Isoleucine	55	30	50	49	44
Leucine	96	59	94	82	85
Lysine	69	45	68	63	77
Methionine + cysteine	33	22	34	26	15
Phenylalanine + tyrosine	94	38	128	90	95
Threonine	44	23	68	67	38
Tryptophan	17	6	27	14	8
Valine	55	39	67	50	49

**Target groups and the amount of essential amino acids they require.*

2. **Digestibility of vegetable proteins**: it is important to compare the digestibility of new sources of protein and egg or dairy proteins.

   Right now there are discussions with the FAO (Food and Agriculture Organisation) about the methods to use to determine the protein digestibility:
   - PDCAAS: Protein Digestibility Corrected Amino Acid Score
     - Established method according to AOAC (Association of Official Agricultural Chemists)
     - Measurement in the feces
     - Bioavailability of single amino acids is not taken into account
   - DIAAS: Digestible Indispensable Amino Acid Score
     - True ileum digestibility -> sampling at terminal ileum
     - Measure digestibility for individual essential amino acids
     - Preferably determined in humans > if not possible: pigs > if not possible: rats
     - No established AOAC method yet

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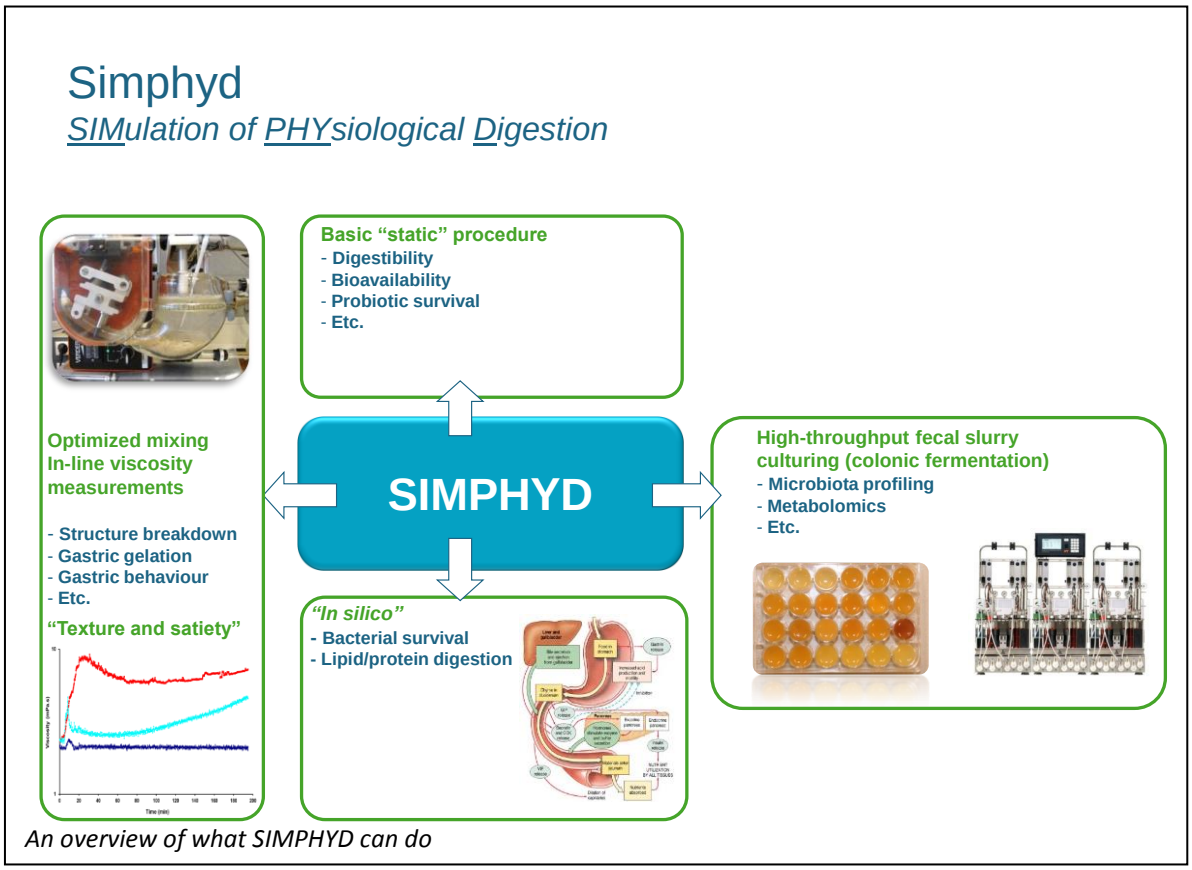
NIZO has developed an *in vitro* test to screen protein digestibility, called SIMPHYD: SIMulated PHYsiological Digestion:



An overview of what SIMPHYD can do

3. New protein sources: organoleptic properties and way to mask it

There are several possible reasons why alternative protein sources often show negative taste and flavour attributes:

- **Volatile compounds (VOCs)**:
  - VOCs are present in most of the seeds (soy, pea, beans,….). They are aldehydes, ketones and alcohols.
  - VOCs are mainly generated by oxidation of unsaturated fatty acids and synthesized by enzymatic reactions
  - The VOC hexanal is responsible for:
    - A beany off-flavour in soy protein isolates
    - A hay-like off-flavour of peas
  - Factors such hydrophobicity of proteins, pH, temperature, ionic strength may influence the retention of VOC to a protein.
  - ***Preventing VOC formation is better than curing.***

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- **Saponins:**
  - Saponins are surface active triterpene glycosides and are present in many plant species (pea, soy, spinach, lupin),
  - Responsible for the bitter taste in peas and soy.
  - ***Dehulling stage is crucial as saponins are concentrated in the hull.***
- **Phenolic compounds:**
  - Non-covalent interactions or covalent binding due to oxidation of phenolic compound to form quinone (alkali condition or via polyphenol oxidase),
  - Lower protein solubility and digestibility,
  - Changes the organoleptic properties (off taste and color).
- **Sugars.**

NIZO has developed tools to study the complex formation between saliva and food products, such as tribology (see example below). These tools have, amongst other things, taught us that the interaction of saliva proteins with some food components results in astringency or a rough feeling:

- Proteins or polyphenols
- Loss of lubrication in the mouth
- Complexes between ingredient and saliva give a rough feeling.

Tribology allows the measuring of lubrication

- Novel application of tribology on food products
- Correlation to sensory attributes
- Related to interaction of product with oral surfaces
- Mimic tongue surface by using pig tongue or PDMS

Based on this knowledge, we have developed tools to limit this complex formation and decrease the astringency of a specific ingredient tested.

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4. Protein modifications

Natural modification is a way to tune protein functionality such as glycation (attachment of sugar moiety), phosphorylation (addition of negative charges) and enzymatic cross-linking (tranglutaminase and tyrosinase). These modifications are aimed at protein solubility as well as the solubility profile, gelling and foaming behaviour and water holding.

An example of enzymatic cross-linking used to replace fat

Fat plays a crucial role in the structure and texture of foods. However, due to the worldwide demand for low fat products, we need to look for fat replacers.

At NIZO, we used enzymatic cross-linking to turn caseins into swollen micelles with enhanced water binding. Furthermore, we designed protein particles that show lubrication behaviour and Pickering stabilisation.

5. Bioactive peptides

Protein hydrolysis is also a way to increase value of a protein ingredient. NIZO has developed a database of bioactive peptides including their bio-effect (antimicrobial peptides, ACE-inhibiting peptides, mood and stress peptides, insulin trophic peptides, etc…).

6. Extraction

Protein extraction is crucial for protein functionality. In order to understand and to tune protein extraction, we need to understand proteins. For example, it is crucial to know if there are any anti-nutritional factors present in the seeds from which proteins are extracted and how to inhibit their action (cracking, heating, etc..). Also, protein extraction from seeds is difficult, because of the presence of polyphenols and their interactions with proteins. These interactions can lead to protein aggregation and precipitation.

By 'knowing how' it is possible to extract highly functional proteins: RuBisCo

RuBisCo is considered to be the most abundant protein in the world as it is present in every green plant.

So wouldn't it be great if we could extract protein from green plants?

This is exactly what we did: we extracted protein from spinach. Our extraction technology resulted in a highly functional protein with an excellent nutritional profile and no green colour.

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How can we help you?
Contact us if you would like:

- To do a QuickScan to explore the functionality of your protein ingredient
- To learn more about various ways to screen a new protein ingredient
- Consultancy on a new ingredient source
- To screen your protein on digestibility using NIZO SIMPHYD
- To do functionality tests
- To know more about proteins and spray-drying.

Contact
We hope this information has been helpful.

Should you have any questions or would like to know more about the application of vegetable proteins, we welcome you to contact Laurice Pouvreau.

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About NIZO food research
NIZO food research is one of the most advanced, independent contract research companies in the world.

We apply our expertise and competitive technologies to support your:

- Innovation (flavour, texture, health)
- Cost reduction (processing efficiency, ingredient replacement & test productions)
- Responsible entrepreneurship (food safety & quality, sustainable processing, evidence based health claims)

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