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Engineering of bioaerogels as key ingredients in the development of functional foods to deliver health through diet

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Background

Bioaerogels are food-grade materials with high porosity, low density, and high surface area. These properties make aerogels optimal **candidates as functional ingredients** [1]. In this context they could be exploited to (i) **load** and **protect** bioactives [2]; (ii) develop **fat-replacers** [3]; (iii) **incorporate air** in foods. These features suggest that aerogels could be optimal candidates as functional ingredients which could be used for food (i) ***Enrichment****, i.e.* addition of foods with healthy compounds and (ii) ***Clearing/lightening,*** *i.e.* reduction and/or removal of unhealthy components (e.g., saturated fat, salt and sugar).

Bioaerogels are prepared by removing water from an aqueous polymeric gel, while maintaining the original network structure. This is typically obtained by water substitution with ethanol followed by supercritical-CO_2 drying. Although aerogels have been prepared from both proteins (e.g., egg and milk proteins) and polysaccharides (e.g., carrageenan, starch) (4,5), very few studies are currently available on the possibility to use **plant proteins** (6,7) or **cellulose** to prepare food-grade aerogel. Such biopolymers would offer a range of advantages, including **increased sustainability** (these polymers can be obtained from food waste upcycling) and **nutritional value** (e.g., gut protection function of cellulose, bioactive peptides released from proteins), as well as **suitability for specific dietary regimes** (e.g., vegans).

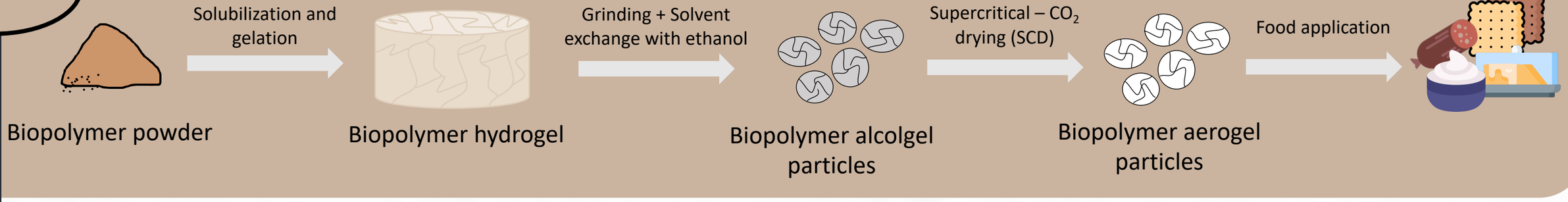
Aim

The aim of the present PhD project is to fill the knowledge gaps on bioaerogels to enable their application as sustainable functional food ingredients to deliver health through diet

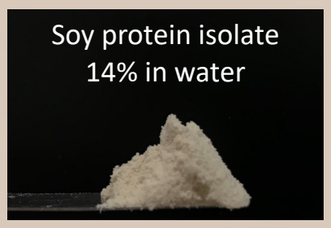
Expected activities

Activity \ Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Development of bioaerogels																								
a. Identification of biopolymer sources																								
c. Assessment of biopolymer gelling capacity																								
d. Aerogel production and characterization																								
2. Use of bioaerogels as functional ingredients in real food matrices																								
b. Evaluation of bioaerogels compatibility with food																								
c. Development of strategies to control aerogel porosity																								
c. Prototyping foods containing bioaerogels																								
d. Assessment of nutritional functionality																								
Mobility period																								
Bibliographic research																								
Paper preparation																								
Thesis development																								

Approach

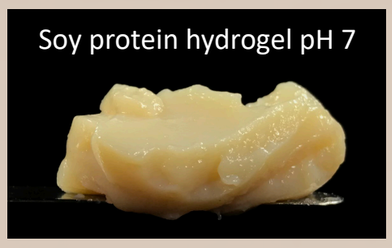


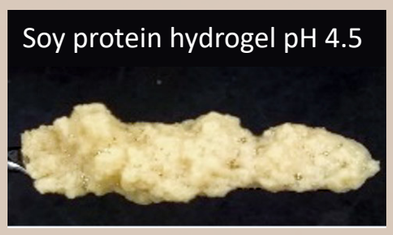
Application of the approach to soy protein



Soy proteins are the vegetable proteins mostly used to replace animal ones

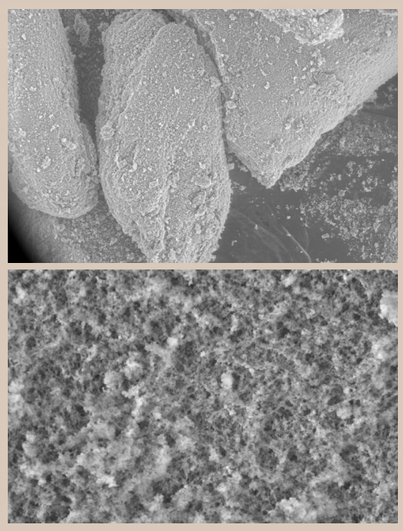
Solubilization and gelation





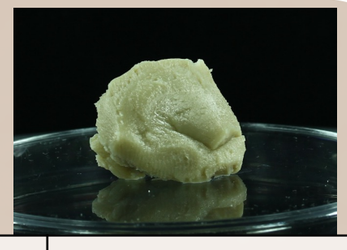
According to the pH, self-standing strong gel or microgels were obtained

Grinding + Solvent exchange + SCD



Soy protein aerogel particles with high porosity (>70%), high internal surface area (60-140 m^2/g), and low density (0,20-0,30 g/cm^3) were obtained

Fat replacer development



Soy	Aerogels after oil absorption		
Sample	Content (%)	OHC ($g_{oil}/g_{aerogel}$)	G' x 10^3 (Pa)
Isolate	37	0,58 ± 0,03	Granular structure
Aerogel pH 7	69	2,23 ± 0,14	34,1
Aerogel pH 4.5	72	2,52 ± 0,04	467,4

Aerogelation significantly improves soy protein oil structuring ability and OHC, probably due to process-induced modification to protein structure, including increased porosity and exposure of hydrophobic groups

Conclusions

By selecting proper concentration and pH, it is possible to engineer food-grade aerogels based on soy proteins

Soy protein aerogels might be interesting functional ingredients due to their oil-structuring ability

References:

1) C. A. García-González, et al., *Molecules,* 24, 1815, 2019.
2) A. Ubeyitogullari, O. N. Ciftci, *International Food Research Journal,* 123, 27-35, 2019.
3) S. Plazzotta, et al., *Polymers,* 13, 4063, 2021.
4) L. Manzocco, et al., *Food Hydrocolloids*, 122, 107117, 2022.
5) S. Plazzotta, *Food Hydrocolloids*, 96, 1-10, 2019.
6) D. J. Andlinger, et al., *Food Hydrocolloids,* 112, 106305, 2021.
7) V. Santos-Rosales, et al., *Molecules, 24,* 871, 2019