Ultrasonic assisted extraction of plant proteins from lupin and split pea

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Abstract

There is a rising trend in consumption of vegan products with ingredients of plant origin. Legumes are characterized by high protein content and can be utilized for the production of plant protein isolates or concentrates that can improve the functional and nutritional quality of such food products. In the current study, a green extraction technology, Ultrasonic Assisted Extraction (UAE), is investigated regarding the isolation of proteins from lupin and split peas and is compared to Conventional Alkaline Extraction (CAE). Water (pH=9.5) is used as extraction solvent. The processing parameters, including ratio of raw material to solvent, ultrasonic power, extraction time and extraction temperature are investigated in order to determine the optimal extraction conditions. The extraction efficiency is determined via Bradford Analysis; the extracted protein fractions are, also, evaluated regarding their water and oil holding capacity and their solubility. The results demonstrate that UAE extraction is a sustainable approach for the extraction of plant proteins, that achieves reduction of extraction time and improvement of extraction efficiency; the optimal extraction conditions are determined as follows: ultrasonic power 750 W, raw material:solvent ratio 1:10, extraction time 10 min.

Introduction

Nowadays, a rapid increase in human population is observed and as a result, a significant increase in the need for food. The eating habits of the average person are mainly based on the consumption of meat and its derived products, which results in the excessive exploitation of land, water and energy resources of the planet[1]. As a result, the greenhouse effect is intensified and the cycle of nitrogen and phosphorus is disrupted[2]. At the same time, overconsumption of meat can be related to serious problems in human health, such as cardiovascular diseases, colon cancer and even mortality[3]. Therefore, substituting and replacing meat and finding alternative protein sources are increasingly necessary.

A particularly important alternative source of proteins are legumes, as they show a high protein content and their consumption shows significant advantages in human health[4]. They contain bioactive elements, such as galacto-oligosaccharides, and are known for their anti-cancer and antioxidant effects, their contribution against obesity and diabetes, as well as for reducing LDL cholesterol[5]. They are also particularly beneficial for intestinal health, since they act as probiotics. Especially, lupin and split pea have a high content in proteins and are not allergenic foods.

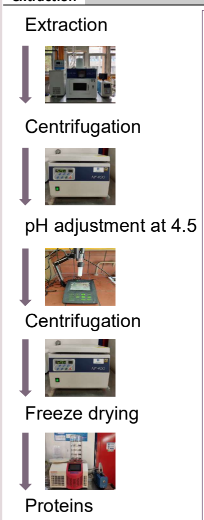
The aim of this work is to produce alternative proteins from split pea and lupin by optimizing the extraction procedure, using an environmentally friendly Ultrasound assisted extraction. The optimum extracts are evaluated for their Water and Oil holding capacity and their Particle Size Distribution.

Materials & Methods

Extraction of Proteins:

Table 1: Extraction parameters for the recovery of proteins from lupin and split pea

Method	Solution	Temperature (°C)	Solid: Solvent ratio	Extraction time (min)	Ultrasound power (W)
Alkaline extraction	Deionized water pH=9.5	25	1:10, 1:15, 1:20	30, 45, 60	-
Ultrasound assisted extraction			1:10, 1:15	5, 10, 20	450, 750



Extraction efficiency (EE): Determined with Bradford method, by calculating the absorption in a UV photometer at 595 nm, using albumin as a standard[6].

Particle Size Distribution: Determined using a Laser diffraction particle size analyzer (Microtrac S3000/S3500 Series), with methanol as dispersant.

Water and oil holding capacity: Protein extract is mixed with water or sunflower oil. The samples are centrifuged and the supernatant is removed and weighted. The mass difference of the initial amount of water or oil with that of the supernatant, corresponds to the amount of oil or water that binds the extract.

Results

Extraction Efficiency (EE):

The results of EE of alkaline extraction and UAE are presented in the tables below. As the extraction time and the solid to solvent ratio increase, an increase in the EE of legumes is observed.

Table 2: EE of alkaline extraction

Solid to solvent ratio	Extraction time (min)	EE (%) Split pea	EE (%) Lupin
1:10	30	8.93	20.76
1:10	45	9.80	23.54
1:10	60	11.47	21.99
1:15	30	9.86	19.89
1:15	45	9.68	20.82
1:15	60	11.88	24.65
1:20	30	8.20	24.37
1:20	45	3.87	21.60
1:20	60	8.37	26.49

Table 3: EE of UAE

Extraction time (min)	Power (W)	EE (%) (1:10 ratio) Split pea	EE (%) (1:15 ratio) Split pea	EE (%) (1:10 ratio) Lupin	EE (%) (1:15 ratio) Lupin
5	450	9.87	7.17	27.19	31.19
10	450	10.82	9.94	28.96	35.37
20	450	11.02	12.72	30.25	32.50
5	750	8.75	7.17	29.06	32.12
10	750	12.87	11.85	31.61	30.69
20	750	15.11	14.19	33.85	33.08

The protein content of the extracts is presented in the charts below:

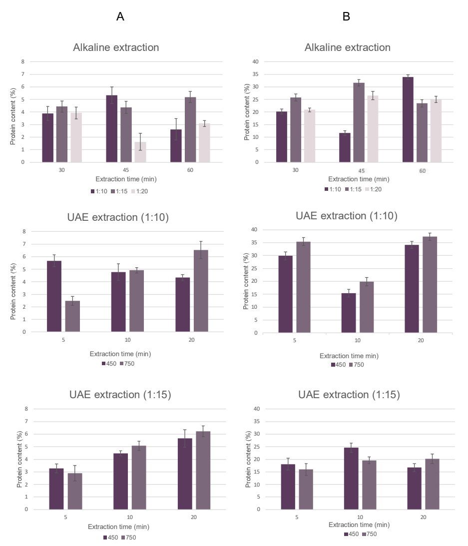


Figure 1: Protein content (mg protein/g extract) Alkaline extraction, UAE for A. Split pea B. Lupin

The evaluation of optimum extracts is presented below:

Water (WHC) and Oil (OHC) holding capacity:

Table 4: WHC, OHC

Method	WHC (g/g)		OHC (g/g)	
	Split pea (45 min)	Lupin (60 min)	Split pea (45 min)	Lupin (60 min)
Alkaline extraction (1:10)	1.033	1.056	13.142	9.831
UAE (1:10, 450 W, 5 min)	3.164	1.625	11.685	11.444

Particle Size Distribution:

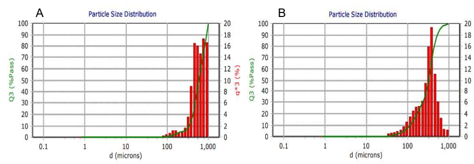


Figure 2: Particle size distribution of split pea A. alkaline extraction, B. Ultrasound assisted extraction

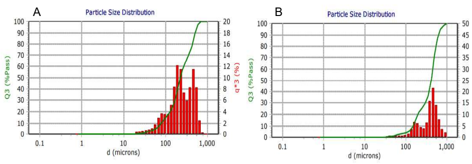
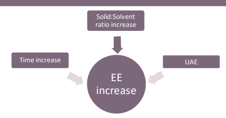


Figure 3: Particle size distribution of lupin A. alkaline extraction, B. Ultrasound assisted extraction

Table 5: Average diameter of split pea and lupin particles (mm)

	Split pea	Lupin
Alkaline extraction	345.2	268.8
Ultrasound assisted extraction	323.9	398.8

Conclusions



- In alkaline extraction, the EE is higher for solid:solvent ratio of 1:15 for split pea and 1:20 for lupin. In UAE 1:10 ratio gave better results for split pea, while in the case of lupin 1:15 ratio exhibited higher efficiency. UAE requires a smaller ratio of solid:solvent, as well as lower quantities of solution.
- UAE was successful as extracts with higher protein content were observed in shorter times.
- The adoption of UAE can have a positive impact in terms of the environmental footprint of the process, but also in terms of cost.
- The extracts obtained under the influence of ultrasound showed a wider diameter of their particles.
- UAE leads to increased values in WHC and OHC.
- Proteins with WHC = 1.49 – 4.72 g/g are more usable for applications in the food industry.

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