HIGH-POWER ULTRASOUND FOR EFFICIENT EXTRACTION OF A HIGH-QUALITY LUPIN PROTEIN FRACTION: A SUSTAINABLE APPROACH FOR FOOD INDUSTRY APPLICATIONS

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INTRODUCTION

Global population is growing rapidly, which results in an increased demand for protein sources. Lupin flour (LF) has emerged as a valuable source of high-quality protein, offering significant potential for food industry applications. However, conventional protein isolation methods are highly intensive in terms of time, water and chemicals, highlighting the need for more sustainable alternatives.

AIM

This study explores the use of high-power ultrasound (HPU) for the extraction of lupin protein concentrate (LPC), while evaluating its impact on the concentrate techno-functional properties.

MATERIALS AND METHODS

LF extractions were conducted for 9 min using water and ethanol-water (1:4 v/v) as solvents under both mechanical stirring (952 rpm) and HPU (sonotrode, 24 kHz) at temperatures of 30 and 60°C. After centrifugation, supernatants were adjusted (pH 4.7) to precipitate solubilized proteins, which were then centrifuged, freeze-dried and stored (-26°C).

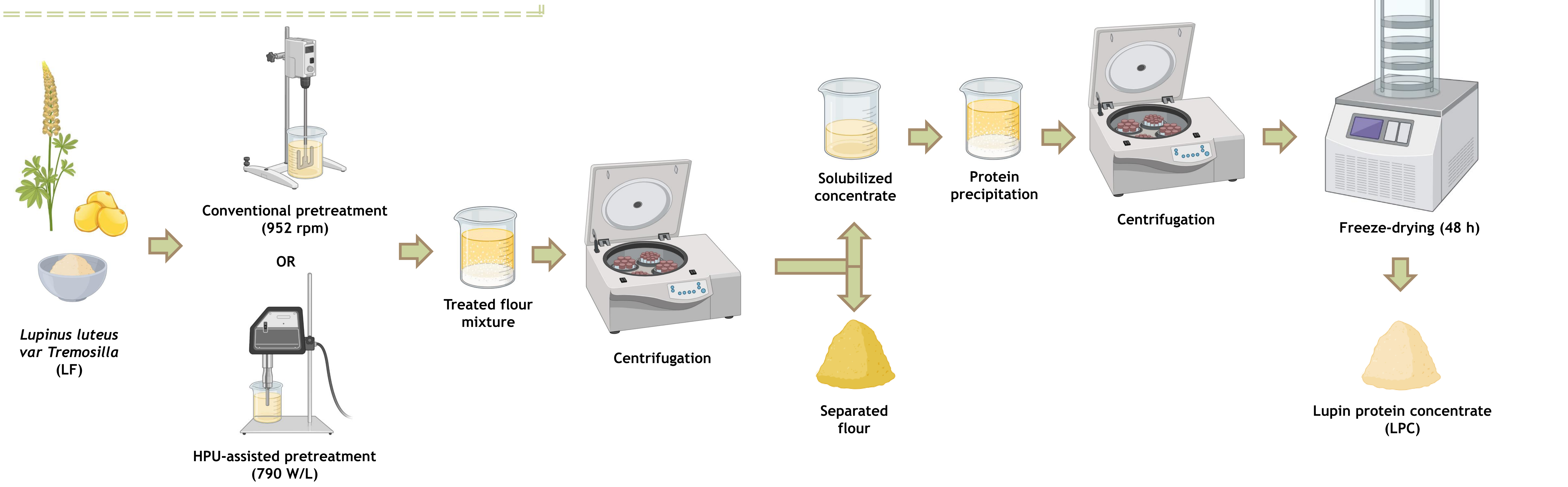

Figure 1. Scheme of flour pretreatment.

Finally, protein content, protein yield and techno-functional properties like water and fat absorption index and foaming and emulsifying properties of LPC were determined.

RESULTS

Table 1. Protein content (PC), protein yield (PY), water (WAI) and fat (FAI) absorption indexes, foaming capacity (FCA) and stability (FS) and emulsifying activity index (EAI) and stability (ESI) of lupin protein concentrates (LPC).

Solvent	T (ºC)		PC (g/g LPC)	PY (g/g LF)	WAI (g/g)	FAI (g/g)	FCA (%)	FS_{1h} (%)	FS_{2h} (%)	EAI (m^2/g)	ESI (min)
Water	30	HPU	62.7±0.6^{b}	16.5±1.1^{ab}	1.69±0.01^{e}	2.15±0.12^{c}	110.1±2.9^{a}	79.0±6.1^{a}	68.8±2.9^{a}	21.4±1.5^{a}	136.6±5.5^{a}
	60		67.3±2.2^{a}	15.1±1.0^{ab}	2.24±0.12^{bc}	2.54±0.26^{b}	91.2±4.3^{c}	61.2±3.8^{b}	41.1±2.5^{d}	16.0±1.4^{c}	108.3±2.5^{b}
Ethanol-water	30	no-HPU	67±0.5^{a}	15.8±1.2^{ab}	2.51±0.09^{a}	3.19±0.01^{a}	93.0±1.2^{c}	59.9±1.0^{b}	46.6±0.9^{c}	16.2±2.0^{c}	101.5±7.6^{c}
		HPU	63.2±0.3^{b}	17.1±0.5^{a}	1.96±0.01^{d}	2.74±0.17^{b}	103.9±1.8^{b}	76.2±3.1^{a}	50.1±0.8^{b}	16.1±2.5^{c}	108.7±4.8^{b}
	60	no-HPU	62.9±0.2^{b}	9.1±0.8^{c}	2.46±0.05^{ab}	3.28±0.02^{a}	52.0±2.1^{d}	37.4±2.0^{c}	21.3±1.4^{e}	16.4±0.4^{c}	43.6±3.2^{e}
		HPU	64.9±0.1^{ab}	14.4±0.3^{b}	2.16±0.17^{cd}	2.72±0.08^{b}	40.4±2.9^{e}	28.8±4.1^{d}	9.3±1.1^{f}	18.5±0.2^{b}	54.9±3.0^{d}

Values are presented as average ± SD. Different lowercase letters in columns indicate significant differences (p<0.05).

Table 2. Effect of pretreatment variables on protein content (PC), protein yield (PY), water (WAI) and fat (FAI) absorption indexes, foaming capacity (FCA) and stability (FS) and emulsifying activity index (EAI) and stability (ESI) of lupin protein concentrates (LPC).

	HPU	Temperature	Solvent
PC	x	x	x
PY	+26%	-23%	x
WAI	-17%	+11%	x
FAI	-17%	x	+15%
FCA	x	-38%	-28%
FS_{1h}	x	-39%	-26%
FS_{2h}	x	-52%	-44%
EAI	x	x	x
ESI	+10%	-39%	-35%

+, denotes a significant (p < 0.05) increase; -, denotes a significant (p<0.05) decrease; x, denotes not significant effect (p>0.05). Percentages (%) were calculated from average values of LSD intervals (ANOVA, 95%) between sonicated and unsonicated samples (HPU factor), 60 and 30 °C (temperature factor) and ethanol-water and water (solvent factor).

- LPC exhibited average values of 65 g/100 g for protein content and 19 g/100 g for protein yield, with significant (p<0.05) variations influenced by extraction variables.
- HPU exhibited the highest protein yields (avg. > 26%) while preserving techno-functional properties, including water and fat absorption, foaming capacity and emulsifying activity.
- Increasing temperature from 30 to 60ºC and the use of ethanol-water solvent led to significant (p<0.05) reductions in most techno-functional traits.

CONCLUSIONS

These findings highlight that LPC can be produced by a cost-effective and simple method, while maintaining excellent techno-functional properties, making it a competitive alternative to other plant-protein sources.

Moreover, HPU application represents a promising approach for large-scale industrial applications, reducing energy consumption through low temperature operations and minimizing the use of solvents, thereby aligning with sustainability goals in food processing.

ACKNOWLEDGEMENTS

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Lupin flour (LF) has emerged as a valuable source of high-quality protein, offering significant potential for food industry applications. However, conventional protein isolation methods are highly intensive in terms of time, water and chemicals, highlighting the need for more sustainable alternatives. This study explores the use of high-power ultrasound (HPU) for the extraction of lupin protein concentrate (LPC), while evaluating its impact on the concentrate techno-functional properties. LF extractions were conducted for 9 min using water and ethanol-water (1:4 v/v) as solvents under both mechanical stirring (952 rpm) and HPU (sonotrode, 24 kHz) at temperatures of 30 and 60°C. After centrifugation, supernatants were adjusted (pH 4.7) to precipitate solubilized proteins, which were then centrifuged, freeze-dried and stored (-26°C). Resulting LPC exhibited average values of 65 g/100 g for protein content and 19 g/100 g for protein yield, with significant ($p<0.05$) variations influenced by extraction variables. HPU exhibited the highest protein yields (avg. > 26%) while preserving techno-functional properties, including water and fat absorption, foaming capacity and emulsifying activity. However, increasing temperature from 30 to 60ºC and the use of ethanol-water solvent led to significant ($p<0.05$) reductions in most techno-functional traits. These findings highlight that LPC can be produced by a cost-effective and simple method, while maintaining excellent techno-functional properties, making it a competitive alternative to other plant-protein sources. Moreover, HPU application represents a promising approach for large-scale industrial applications, reducing energy consumption through low temperature operations and minimizing the use of solvents, thereby aligning with sustainability goals in food processing.