High-Voltage Plasma Treatment of Hemp Proteins: Unravelling Structure–Function Relationships

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BACKGROUND

Why Hemp Meal?

- Complete AA Profile
- Good Digestibility
- Sustainability
- Free From Allergens
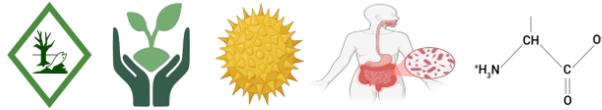
☑ Fundamental hub of Hemp seed processing
☑ Manitoba rank 3rd with 14% of Canada's Hemp
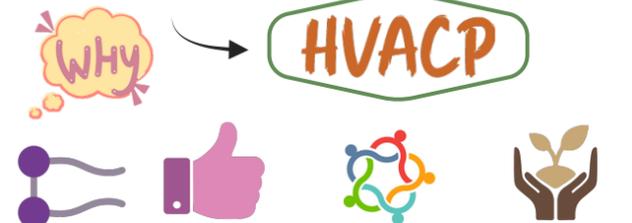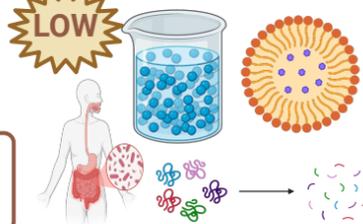
✗ Poor solubility, weak functional properties

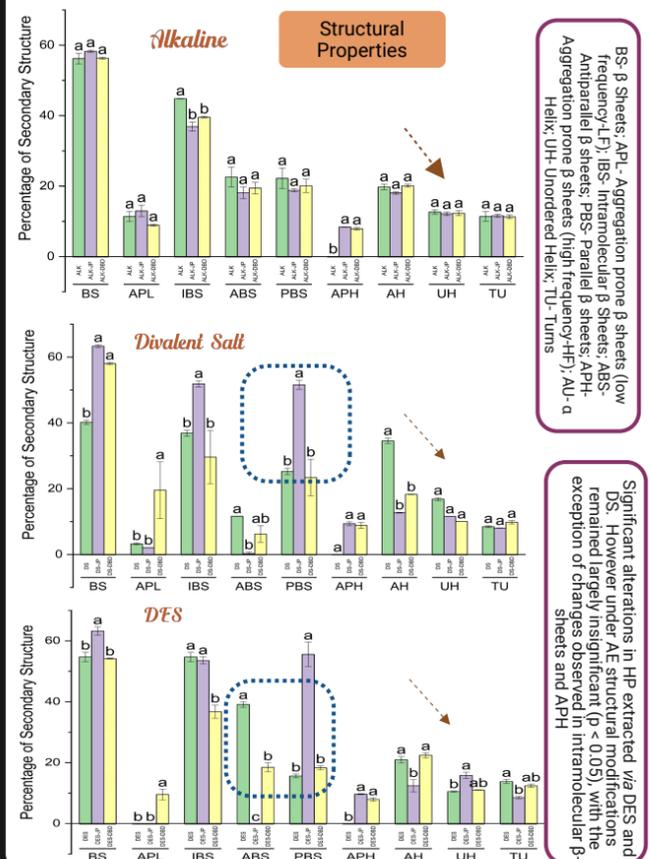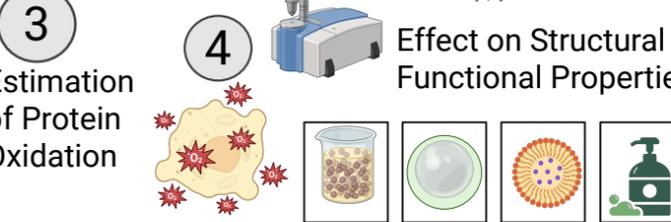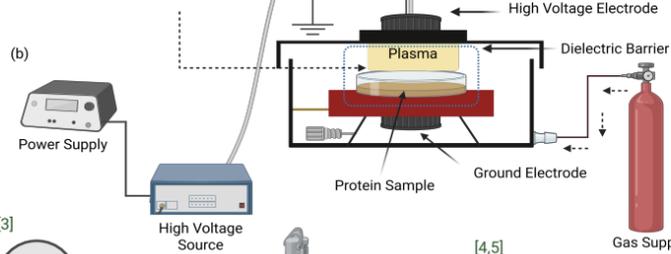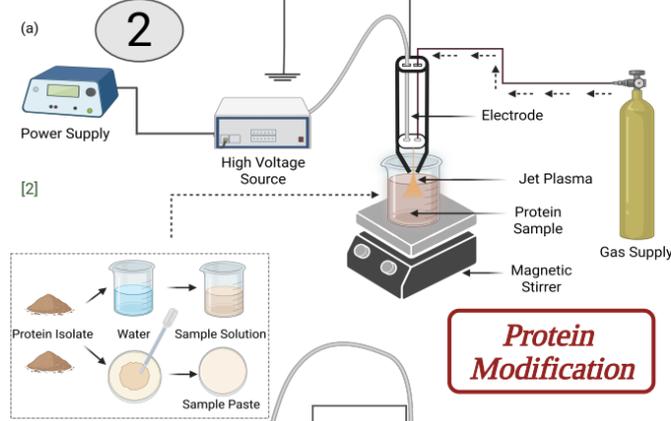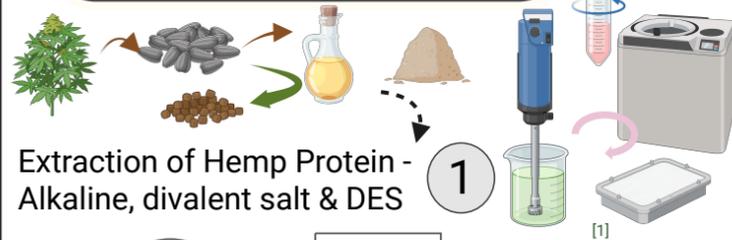✓ Protein Modification to enhance applicability in diverse food systems

OBJECTIVES

- To extract protein from Hemp Meal
- To develop HVACP-based processing
- To explore the dual functionality of HVACP
- To understand the effects of HVACP modification on digestibility & bioaccessibility

RATIONALE
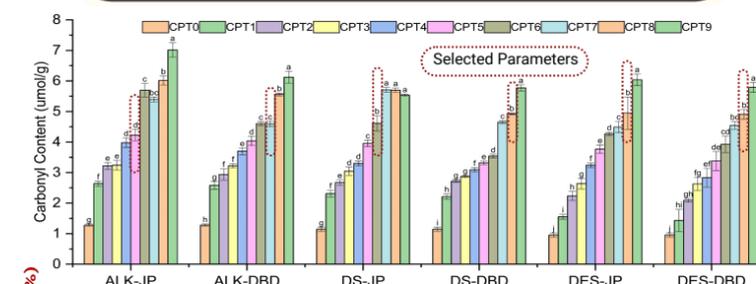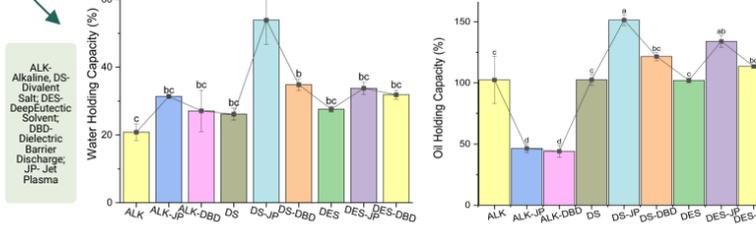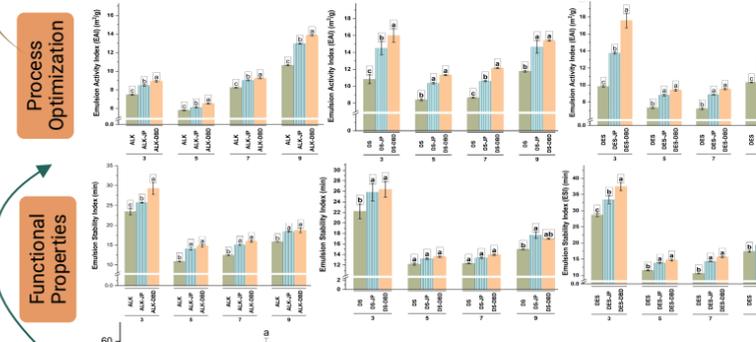
The major limitation of using Hemp Meal Protein.....

Strategy

LOW → PROTEIN MODIFICATION → WHY → HVACP

METHODOLOGY

1 Extraction of Hemp Protein - Alkaline, divalent salt & DES

2 (a) Power Supply — High Voltage Source — Electrode — Jet Plasma — Protein Sample — Magnetic Stirrer — Gas Supply

Protein Isolate — Water — Sample Solution — Sample Paste

Protein Modification

(b) Power Supply — High Voltage Source — High Voltage Electrode — Plasma — Dielectric Barrier — Protein Sample — Ground Electrode — Gas Supply

3 Estimation of Protein Oxidation

4 Effect on Structural & Functional Properties

INDUSTRY RELEVANCE & APPLICATIONS

→ Clean label & non thermal modification
→ Scalable & energy efficient
→ Precise tailoring of protein properties for targetted applications
→ Eco friendly and consumer aligned profile
→ Convert agri based food to value added food ingredients

Energy → Metabolic responses

RESULTS & DISCUSSION

- Alkali Extraction: Sample : Water – 1:15 (w/v), pH – 10, Isoelectric pH - 6
- Salt Extraction: Sample : Solution – 1:10 (w/v), NaCl : MgCl₂ - 1:3, 0.8 M Salt Solution
- DES Extraction: Water Content : 40%, ChCl : Gly Molar Ratio – 1:2 (w/w), Extraction Time – 1h, Solid : Liquid – 1:12 (w/w)

Structural Properties

BS- β Sheets; APL- Aggregation prone β sheets (low frequency-LF); IBS- Intramolecular β Sheets; ABS- Antiparallel β sheets; PBS- Parallel β Sheets; APH- Aggregation prone β sheets (High frequency-HF); AH- Helix; UH- Unordered Helix; TU- Turns

Significant alterations in HP extracted via DES and DS. However under AE structural modifications remained largely insignificant (p < 0.05), with the exception of changes observed in intramolecular β-sheets and APH
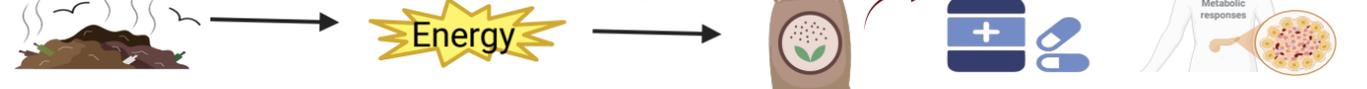
Process Optimization

Functional Properties

ALK- Alkaline, DS- Divalent Salt; DES- DeepEutectic Solvent; DBD- Dielectric Barrier Discharge; JP- Jet Plasma

Solubility (%)

	CPT0	CPT1	CPT2	CPT3	CPT4	CPT5	CPT6	CPT7	CPT8	CPT9
ALK-JP	9.83±0.14d	9.86±0.04c	10.68±0.12c	11.21±0.17c	11.98±0.03b	13.30±0.11a	13.29±0.14a	12.54±0.13b	12.62±0.03ab	12.27±0.26ab
ALK-DBD	9.83±0.14c	10.67±0.14c	11.00±0.14de	11.64±0.09d	13.11±0.14c	13.58±0.02bc	13.91±0.22b	14.00±0.21b	15.43±0.08a	14.77±0.25a
DS-JP	10.45±0.17f	10.79±0.16f	11.88±0.29e	12.65±0.09e	13.00±0.14cd	13.46±0.13c	14.50±0.25b	14.66±0.36b	15.52±0.13a	12.94±0.37cd
DS-DBD	10.60±0.14f	11.67±0.14e	11.96±0.36e	12.95±0.25d	13.25±0.19d	14.07±0.14c	14.12±0.17bc	14.39±0.06bc	15.33±0.25a	14.81±0.10ab
DES-JP	10.29±0.13f	10.75±0.11ef	11.17±0.10e	12.10±0.12d	13.62±0.16bc	13.89±0.17c	13.89±0.17c	14.63±0.14a	14.21±0.16ab	14.21±0.16ab
DES-DBD	10.29±0.13g	10.40±0.21f	11.52±0.10f	12.66±0.48e	12.84±0.28de	13.43±0.34cd	14.03±0.38bc	14.54±0.35b	15.43±0.24a	14.41±0.33b

Conclusion

HVACP enhanced solubility & emulsification of Hemp proteins with DBD (Dielectric Barrier Discharge) outperforming JP (Jet Plasma). **Optimal conditions varied by extraction method** balancing solubility & minimal oxidation. **Structural unfolding** improve functionality. **Improved functionality** support HVACP's potential in functional food applications

FUNDING

References