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Characterization and Functionality of Corn Germ Proteins

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NCAUR Where the future is Created

INTRODUCTION

Corn and Biofuels

- Current fuel energy situation has increased demands for both corn and ethanol
- More co-products from corn processing expected to be added to an already-saturated market
- Continuing need to identify and develop novel uses for corn co-products to increase value

Corn germ

- Comprises 12% of total weight of normal dent corn and provides ca. 29% of corn protein **[1]**
- Albumins and globulins account for more than 75% of germ proteins
- Proteins - favorable amino acid balance and high nutritional quality **[1]**
- Corn germ protein flour - used as extender, emulsifier, and stabilizer in ground meats because of functional properties **[2]**
- Primary use is in animal feeds
- Component of corn gluten feed, which sells for $125/ton
- High nutritional quality and functional properties are desirable for higher-value end-uses

OBJECTIVES

- Develop economical methods for extracting corn germ proteins
- Evaluate the functional properties of recovered germ proteins
- Identify potential applications of proteins extracted from corn germ

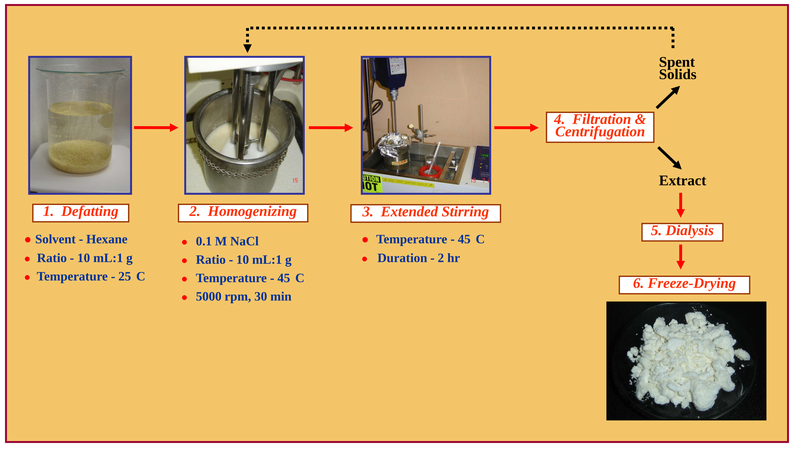
MATERIALS

- Moisture - 49.8 %
- Crude Fat - 36.0% (db)
- Crude Protein - 13.8% (db)

- Moisture - 2.9 %
- Crude Fat - 36.2% (db)
- Crude Protein - 14.0% (db)

METHODOLOGY

EXTRACTION OF PROTEIN



Proximate Analyses

- Moisture - AOCS Ba 2a-38 **[3]**
- Crude protein (%N x 6.25) - AOCS Ba 4e-93 **[3]**
- Crude oil - AOCS Ba 3-38 **[3]**

SDS-PAGE

- Method: Wu and Hojilla-Evangelista **[4]**
- Sample amount - 4 mg protein/mL in 500 µL of sample buffer *[42 nM Tris-HCl (pH 6.8), 2% SDS, 7% glycerol, 4.4% β-mercaptoethanol, 5M urea].*
- Mixture was heated in a boiling-water bath for 5 min.
- Sample load volume - 15 µL
- Gel - Bis-Tris NuPAGE pre-cast 4-12% gradient gel (Invitrogen Corp., Carlsbad, CA).
- MW standards - Pre-stained broad range SDS-PAGE protein standards *(6.5 -196 kDa)*
- System - Novex XCell II Mini Cell system (Novex, San Diego, CA); NuPAGE MES-SDS running buffer *(SDS, Tris, and 4-morpholinoethane sulfonic acid).*

Protein Functionality Tests

Solubility

- Method: Balmaceda *et al.* **[5]**
- Sample concentration - 10 mg protein/mL
- pH levels - 2.0, 4.0, 5.5, 7.0, 8.5, and 10.0
- Protein analysis - combustion method

Foaming properties

- Method: Myers *et al.* **[6]**
- Sample concentration - 10 mg protein/mL
- Determined at pH 7.0
- Foam capacity - volume (mL) of foam produced in 1 min; foam stability - % foam remaining after standing for 15 min.

Protein Functionality Tests (continued)

Emulsifying properties

- Method: Wu *et al.* **[7]**
- Emulsion preparation - 6 mL sample solutions (1 mg protein/mL) + 2 mL corn oil; hand-held homogenizer operated at high setting (20,000 rpm) for 1 min.
- Calculated emulsification activity index (EAI, in m^2/g) and emulsion stability index (ESI, in min.)

Water-holding capacity (WHC)

- Method: Balmaceda *et al.* **[5]**, modified
- Sample amount - 40 mg protein/mL
- Buffer - 0.01 M phosphate buffer, pH 7
- Samples in capped tubes shaken on a platform shaker for 15 min
- Samples heated for 60 min in a water-bath set at 60°C, then cooled in tap water for 30 min.
- Determined water held per gram protein

RESULTS

Protein Extraction Efficiencies

Sample	Treatment	Crude Protein % (db)	Extraction Efficiency %
Wet Germ	None	22.5	-
Wet Germ	0.1 M NaCl, 45 C	14.9	33.8
Wet Germ	+ Multifect GC CX	12.6	43.9
Finished Germ	None	24.6	-
Finished Germ	0.1 M NaCl, 45 C	16.5	32.9
Finished Germ	+ 2% SDS + 2-ME	9.9	59.8
Finished Germ	+ Multifect GC CX	15.7	36.2
Finished Germ	+ Bromelain (2%)	16.2	34.1
Finished Germ	+ Papain (2%)	16.6	32.5

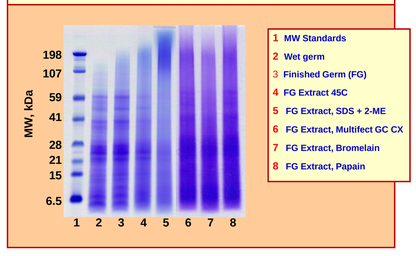
RESULTS

Moisture, Oil, and Protein Contents

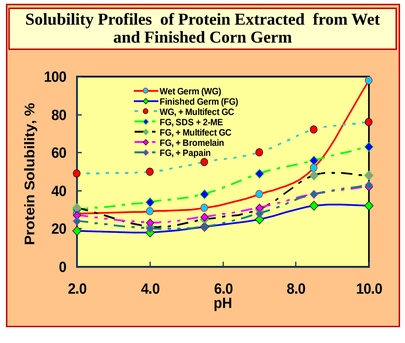
Sample	Moisture %	Crude Fat % (db)	Crude Protein % (db, ffb)
Wet Germ	5.5	0.9	22.5
Spent Solids	12.2	7.2	14.9
Freeze-dried Protein Extract (B)	1.1	10.6	30.2
Freeze-dried Protein Extract (M)	1.8	16.5	27.8
Finished Germ	6.8	2.3	24.6
Spent Solids	9.6	4.0	16.8
Freeze-dried Protein Extract (B)	5.0	9.0	31.3
Freeze-dried Protein Extract (S)	2.1	15.4	27.4
Freeze-dried Protein Extract (M)	2.4	11.5	32.4
Freeze-dried Protein Extract (B)	2.1	7.4	32.3
Freeze-dried Protein Extract (P)	0.8	6.2	33.8

B: Basic method, 0.1 M NaCl only
S: 0.1 M NaCl + SDS + 2-ME
M: 0.1 M NaCl + Multifect GC CX
B: 0.1 M NaCl + Bromelain
P: 0.1 M NaCl + Papain

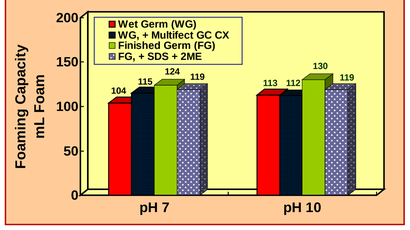
SDS-PAGE Results: Corn Germ Proteins Extracted at Various Conditions



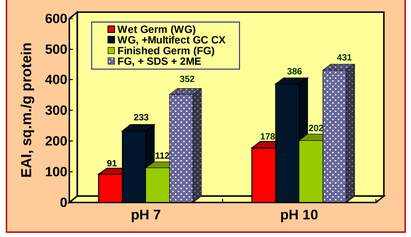
Solubility Profiles of Protein Extracted from Wet and Finished Corn Germ



Foaming Capacities of Proteins Extracted from Wet and Finished Corn Germ



Emulsifying Capacities of Proteins Extracted from Wet and Finished Corn Germ



Other Functional Properties of Proteins Extracted from Wet and Finished Germ

Protein Source	Foam Stability % remaining foam		Emulsion Stability Index min.		WHC g water/ g protein
	pH 7	pH 10	pH 7	pH 10	pH 7
Wet Germ	10	9	15	78	2.2
Wet Germ (+ Multifect GC CX)	0	2	32	97	1.7
Finished Germ (FG)	3	84	25	138	3.5
FG (+ SDS + 2-ME)	93	92	0	0	8.1

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