United States Department of Agriculture
Agricultural Research Service

Effects of Cooking and Screw-Pressing on Functional Properties of *Cuphea* Seed Proteins

Mila P. Hojilla-Evangelista[1] and Roque L. Evangelista[2]

[1]Plant Polymer Research and [2]New Crops & Processing Technology
National Center for Agricultural Utilization Research
Peoria, Illinois, USA

INTRODUCTION

There is great interest in developing the *Cuphea* plant as an alternate source of industrial oil. Its seed produces 16-42% oil that is rich in medium-chain fatty acids (MCFA) and triglycerides (MCT), specifically lauric and capric acids (1, 2). These MCFAs and MCTs are used in detergents, cosmetics, lubricants, and fuels. The current commercial sources of MCFAs and MCTs are the tropical oilseeds (coconut and palm oils).

***Cuphea* Plant and Seeds**

Photos courtesy of Dr. W. Phippen, Western Illinois Univ.

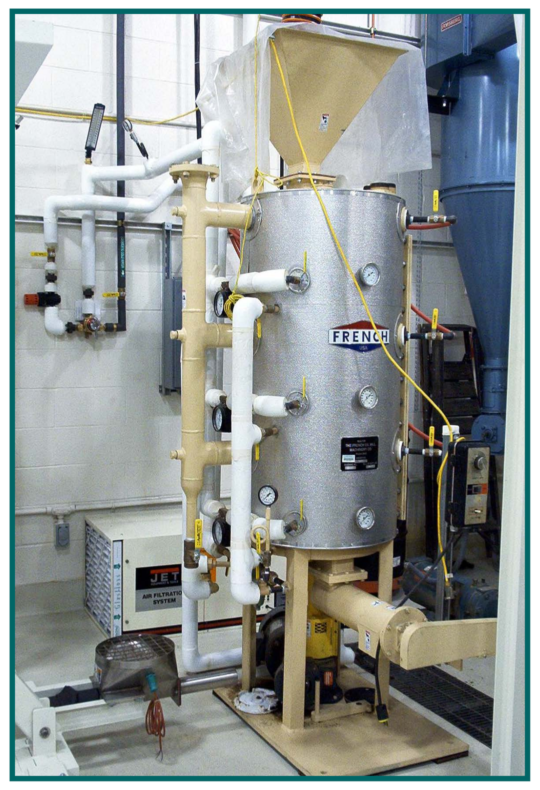
Cuphea seed also contains about 25% crude protein (dry basis), which means that protein-rich co-products will be generated by oil processing. Currently, little information is available on *Cuphea* proteins. Scientists at NCAUR recently completed pioneering studies that determined the soluble classes, amino acid compositions, and electrophoretic profiles of *Cuphea* proteins.

Objectives

The present study:

- Determined the effects of the oil processing conditions on the functional properties of *Cuphea* proteins
- Evaluated the potential of *Cuphea* proteins for value-added uses

French Laboratory Seed Conditioner

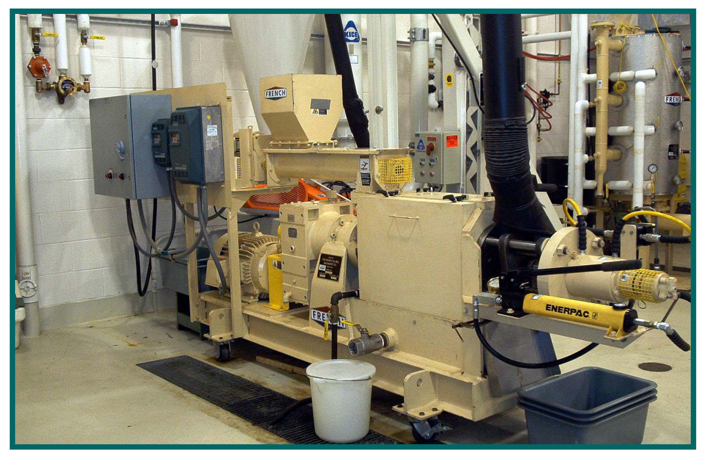


METHODOLOGY

Materials. This study used *Cuphea* seeds from 2003 harvest in Central Illinois. Seeds were flaked to 0.01 in. thickness by using a Roskamp flaking mill.

Cooked flakes were obtained by heating the flaked seeds to 180°F in the seed conditioner, and holding at this temperature for 0 (C1), 45 (C2), or 90 min. (C3). Press cakes were obtained after oil extraction by screw-pressing.

French Laboratory Screw Press



Proximate Analyses. Unprocessed *Cuphea* seeds, cooked flakes, and press cakes were ground into ca. 30-mesh particle size by using a coffee grinder for 2 min. Moisture, crude protein (%N x 6.25), and crude oil contents of the samples were determined by using AOCS standard methods Ba 2a-38, Ba 4e-93, and Ba 3-38, respectively (3).

Protein Functionality Tests. Ground *Cuphea* seeds (control), cooked flakes, and press cakes were first defatted by 5-6 cycles of hexane extraction at 25°C until residual oil content was < 0.5% (db).

Solubility. Solubilities of samples (10 mg protein/mL) were determined at pH 2.0, 4.0, 5.5, 7.0, 8.5, and 10.0 using the method of Balmaceda et al. (4). Protein content analysis was by the Dumas combustion method.

Foaming properties. Foam capacity and stability of samples (10 mg protein/mL) were determined at pH 10.0 by following exactly the procedure described by Myers et al. (5). Foam capacity was the volume (mL) of foam produced in 1 min. Foam stability was expressed as the % foam remaining after standing for 15 min.

Emulsifying properties. Emulsification activity index (EAI, in m^2/g) and emulsion stability index (ESI, in min.) were determined by using the method of Wu et al. (6). Emulsions were prepared by homogenizing mixtures of 6 mL sample solutions (1 mg protein/mL) and 2 mL corn oil with a hand-held homogenizer operated at high setting (20,000 rpm) for 1 min.

RESULTS

Proximate Composition. The *Cuphea* seed contained substantial amounts of crude oil and protein (Table 1). Moisture contents of the flaked seeds decreased significantly when they were held for longer periods in the seed conditioner, as would be expected (Table 1). This observation also held true for the corresponding press cakes. Heating the flaked seed to 180°F (0 min holding) caused a marked reduction in the oil and protein contents (Table 1). However, among the heated samples (flakes and press cakes), only slight decreases in the amounts of oil and protein were noted.

Table 1. Partial Composition of Ground *Cuphea* Seeds, Cooked Flakes and Pressed Cake

Sample	Moisture %	Crude Protein % (db)	Crude Oil % (db)
Cuphea seeds	6.53	20.80	31.50
Flakes, cooked 0 min (C1)	6.80	17.40	20.28
Flakes, cooked 45 min (C2)	4.70	17.38	19.52
Flakes, cooked 90 min (C3)	2.30	16.63	19.24
C1 Press cake	5.53	23.16	8.30
C2 Press cake	3.25	21.58	7.41
C3 Press cake	2.07	21.07	8.96

Protein Solubility. Protein in the control *Cuphea* seeds had poor solubility (10%) at pH 4-7, but at pH 2 and 10, its solubility was 57 and 88%, respectively (Fig. 1). The almost 90% solubility of *Cuphea* seed proteins at alkaline pH was markedly greater than that of soybean flour protein (55-60%) used in a different study. This finding also implies that *Cuphea* seed proteins may have some use in applications having alkaline environments, such as wood adhesives. Because the greatest solubility was observed at pH 10, the other functional properties were evaluated at this pH.

Solubility profiles of proteins from cooked flakes (Fig. 1) showed that simply heating the flaked seeds to 180°F (0 min holding) resulted in 50-60% reduction in soluble proteins. Holding for 45 min resulted in less than 5% soluble proteins at pH 2-7 and 37% soluble proteins at pH 10. Holding for 90 min gave solubilities that were slightly less than those of flakes held for 45 min.

The amounts of soluble proteins from press cakes recovered from flakes held for 45 and 90 min. decreased even further at all pH levels (Fig. 2). The solubility profile of the press cake produced from flakes with 0 min holding did not show a similar reduction.

Foaming Properties. *Cuphea* seed proteins did not produce much foam (Fig. 3) and the foam collapsed quickly. Cooking the flakes greatly improved the foaming capacity of the protein, especially at 0 min. holding time (Fig. 3). Proteins from the press cake still had greater foam capacity than the protein from untreated ground seeds, which further showed the beneficial effects of heating on foaming ability. However, all samples had very poor foam stabilities. Foams collapsed immediately after forming.

Emulsifying Properties. The control *Cuphea* seed proteins showed excellent emulsifying activity at pH 10 (Fig. 4). Heating the flaked seeds (in the conditioner and screw press) reduced EAI values by 20-35%. The greatest reduction (51%) was observed in flakes held for 45 min in the conditioner.

Emulsions from *Cuphea* seed proteins were fairly stable (Fig. 5) and had ESI values that were similar to that observed for soybean protein. Holding the flakes for 45 min in the cooker increased the ESI value by 53% (Fig. 5). All other heat-treated samples had ESI values that did not differ much from that of the control.

Fig. 1. Solubility Profiles of Ground *Cuphea* Seeds and Flakes Cooked at Various Times

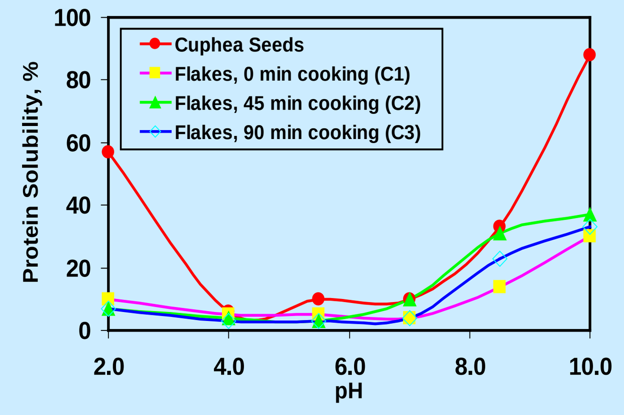


Fig. 2. Solubility Profiles of Ground *Cuphea* Seeds and Press Cakes from Various Cooked Flakes

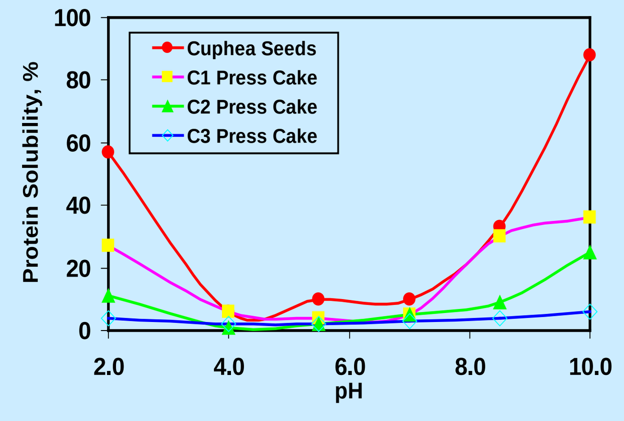
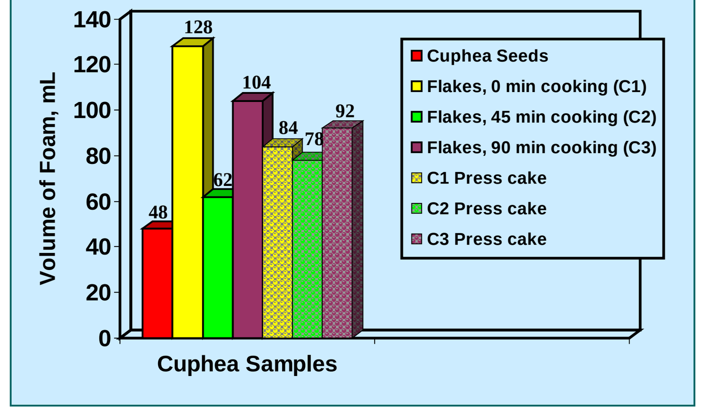


Fig. 3. Foaming Capacities at pH 10 of Ground *Cuphea* Seeds, Cooked Flakes and Press Cakes



Acknowledgment

We thank Debra Stamm and Jeff Forrester of NCAUR for their assistance in the preparation and analyses of samples.

Fig. 4. Emulsifying Activities at pH 10 of Ground *Cuphea* Seeds, Cooked Flakes and Press Cakes

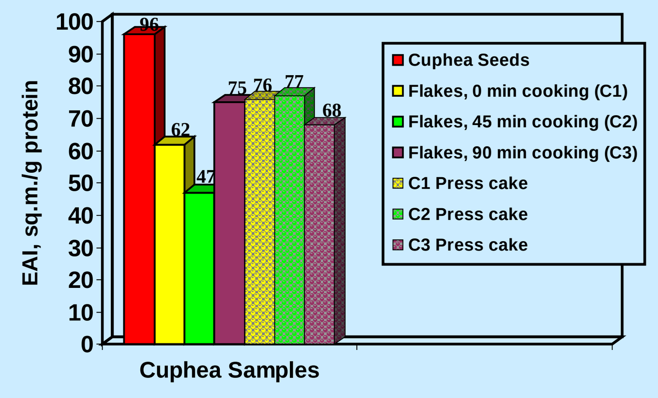
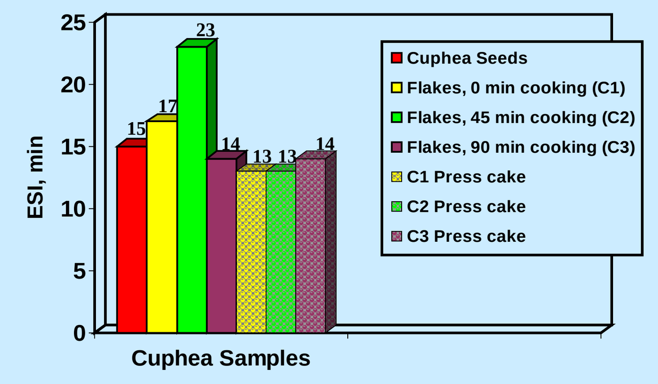


Fig. 5. Emulsion Stabilities at pH 10 of Ground *Cuphea* Seeds, Cooked Flakes and Press Cakes



CONCLUSIONS

- *Cuphea* seed proteins may find some use in industrial applications because of their very high solubility at alkaline pH.
- Exposure to heat during seed cooking and screw-pressing had significant detrimental effects on the solubility of *Cuphea* seed proteins, which would limit the usefulness of press cakes.
- Prolonged cooking improved foam capacity of *Cuphea* seed proteins but reduced emulsifying capacity.

References

1. Isbell, T.A., and R.W. Behle, Progress in the development of *Cuphea* as a crop for Midwest growers, *inform 14(8)*:513-515 (2003).
2. Knapp, S.J., Breakthroughs towards the domestication of *Cuphea,* in *New Crops,* J. Janick and J.E. Simon (eds.), 1993, pp. 372-379.
3. American Oil Chemists' Society, *Official Methods and Recommended Practices of the American Oil Chemists' Society,* 5th Edn., AOCS Press, Champaign, 1998.
4. Balmaceda, E.A., M.K. Kim, R. Franzen, B. Mardones, and J.C. Lugay, Protein Functionality Methodology-Standard Tests, in *Food Protein Chemistry,* J.M. Regenstein and C.E. Regenstein (eds.), Academic Press, New York, 1984, pp. 278-291.
5. Myers, D.J., M.P. Hojilla-Evangelista, and L.A. Johnson, Functional properties of protein extracted from flaked, defatted, whole corn by ethanol/alkali during sequential extraction processing, *J. Am. Oil Chem. Soc. 71*:1201-1204 (1994).
6. Wu, W.U., N.S. Hettiarachchy, and M. Qi, Hydrophobicity, solubility, and emulsifying properties of soy protein peptides prepared by papain modification and ultrafiltration, *Ibid. 75*:845-850 (1998).