

## NOTE

# Lipid and Color Evaluations of Solvent-Extracted Maize Gluten Meal<sup>1</sup>

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### ABSTRACT

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Wet-milled maize gluten meal was lyophilized, and the pigments and lipids were removed using a series of test solvents (acetone, acetonitrile, ethyl acetate, hexane, methanol, and petroleum ether) in a Soxhlet apparatus. Color evaluation, measured by a Hunter color difference meter, and lipid determination using an ethyl ether extraction procedure were

performed on the resultant solvent-extracted maize gluten meal. An acetone extraction procedure was developed that removed most of the lipids and pigments and produced a residue similar in color to defatted soy flour.

Maize gluten meal (MGM), the proteinaceous residue obtained during the wet milling of maize after removal of the bran and starch and germ separations, is bright yellow in color due to the presence of a substantial amount of carotenoid pigments, carotene and xanthophyll. MGM also has an extremely unpleasant odor resulting from the addition of bisulfites during processing and the oxidation of the residual unsaturated maize lipids (15–18%, w/w) during storage (Sternberg et al 1980). Removal of oil, pigments, and undesirable flavor is necessary in order to increase the shelf life and potential uses of MGM in human foods such as bakery and extruded products. Mild extraction with ethyl acetate produces a bland, light-colored maize protein concentrate (MPC) with protein and fat contents of approximately 60 and 0.6%, respectively (Sternberg et al 1980). The objective of this study was to develop an extraction procedure to remove color pigments and lipids from MGM with consideration given to cost.

### MATERIALS AND METHODS

#### Materials

Wet-milled MGM, containing approximately 70% moisture, was obtained from Pennick-Ford (Cedar Rapids, IA). Defatted soy flour (DSF) was obtained from Archer-Daniels Midland Co. (Decatur, IL). Samples were stored at  $-20^{\circ}\text{C}$  before use. Solvents obtained from Fisher Scientific Products (Fair Lawn, NJ) through Scientific Stores at the University of Nebraska (Lincoln, NE) included histological grade acetone, ethyl acetate, and certified A.C.S. acetonitrile, hexane, methanol, and petroleum ether.

#### Methods

Wet-milled MGM was lyophilized prior to solvent extraction to decrease the initial moisture content. All extractions were done using a Soxhlet apparatus. Paper thimbles were constructed from Whatman No. 1 qualitative filter paper and loosely filled with approximately 20 g (db) of lyophilized MGM. Samples were extracted with 175 ml of the test solvent for a specified time. For each individual solvent, the condensation rate was adjusted to approximately 7 ml/min to compensate for boiling point variability. Extraction times with respective solvents are presented in Table I. Acetone (ACE), acetonitrile (ACN), ethyl acetate (EA), and methanol (MET) were selected as possible solvents on the basis of their ability to extract more polar lipids. In addition, ACE and petroleum ether (PET) were selected because of their relatively low cost (Table I). Initially, a 16-hr EA-extracted MGM was selected as a color standard based on the method developed by Sternberg et al (1980), and all solvents were evaluated for their effectiveness at this

same time period. DSF served as an additional color standard. After selection of the appropriate solvent, the extraction time was systematically decreased until the desired end product, an extracted MGM comparable in color to DSF, could no longer be obtained. Extractions were performed in duplicate. The extracted MGM samples were removed from their thimbles, placed in a hood, and allowed to air-dry on trays lined with aluminum foil for 24 hr. After drying, each extracted MGM sample was finely ground using a Janke and Kundel Ika-Werk mill (type A10S1, Staufen i, Breisgau, Germany) and subsequently stored in plastic bags in a desiccator.

#### Color and Lipid Evaluation

The effectiveness of the extraction procedures tested was evaluated on the basis of the color and the residual diethyl ether-extractable lipid content of the finished product. Approximately 20 g of each extracted MGM sample was transferred to a standard microbiological glass petri dish (100 mm diameter) and evaluated

**TABLE I**  
Color Indicators of Defatted Soy Flour, Maize Gluten Meal (MGM), Lyophilized MGM, and Maize Protein Concentrate Samples<sup>a</sup>

Sample	Price/ L <sup>b</sup> (\$)	Boiling Point <sup>c</sup> (°C)	Ex- traction Time (hr)	Hunter Lab Color Index <sup>d</sup>			Visual Color
				L	a	b	
Defatted soy flour			0	81.21	2.95	12.46	Cream
Lyophilized MGM			0	75.31	4.28	26.59	Pale yellow
Acetone	1.75	56.2	0.5	80.42	-1.67	25.82	Yellow
			1	83.81	-2.87	17.01	Yellow
			2	84.51	-2.74	14.43	Cream
			4	84.44	-0.79	11.83	Cream
			8	83.12	-3.91	13.07	Cream
Acetonitrile	10.00	81.6	16	82.85	0.36	12.37	Cream
			16	78.49	1.54	14.36	Pale yellow
Ethyl acetate	9.00	77.0	16	80.90	-2.01	14.89	Pale yellow
Hexane	6.07	69.0	16	81.82	-1.64	22.88	Dark yellow
Methanol	1.80	65.0	16	72.12	-0.70	11.58	Light brown
Petroleum ether	6.33	38.0	16	80.65	0.11	24.59	Dark yellow

<sup>a</sup> Means of six analyses.

<sup>b</sup> Prices obtained from Scientific Stores, University of Nebraska-Lincoln.

<sup>c</sup> Weast 1984.

<sup>d</sup> L (100 white, 0 black), a (+ red, - green), b (+ yellow, - blue).

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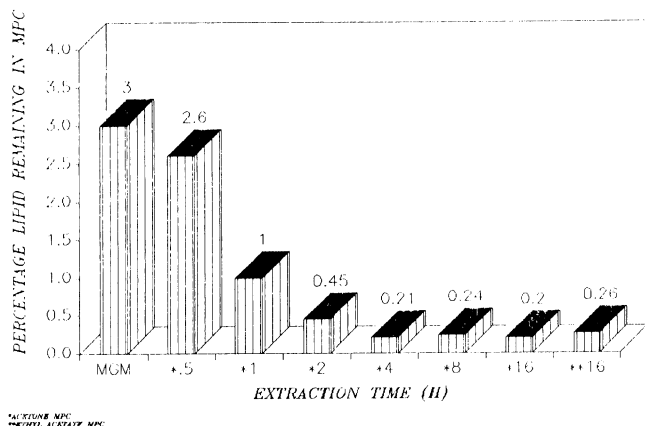


Fig. 1. Ethyl ether lipid analysis of maize gluten meal and maize protein concentrate samples.

for color using the *Lab* scale on a Hunter color difference meter, model D25M-9 (Hunter Associates Laboratories, Inc., Reston, VA). The X, Y, and Z values for the standard color tile were 59.1, 61.3, and 42.7, respectively. These values were automatically converted to the *Lab* scale by the instrument. Differences in color intensity of the test samples indicate varying degrees of light reflection and are represented by *L* values. Reflected red (+) and green (-) light are represented by *a* values, whereas reflected yellow (+) and blue (-) light are represented by *b* values. DSF was analyzed as a color control, and lyophilized MGM was evaluated for color in a similar manner. Determinations were performed in triplicate.

Lipid content (db) was determined on all ACE-extracted samples, the initial lyophilized MGM, and the EA-extracted standard sample using an ethyl ether lipid procedure (14.018; AOAC 1980). Determinations were performed in duplicate. Approximately 10 g of wet-milled MGM was dried at 121°C for 3 hr and analyzed for crude fat content to determine the presence and extent of bound lipids (method 30-10; AACC 1983). Determinations were performed on six replicate samples.

## RESULTS AND DISCUSSION

### Color Evaluation

All solvents substantially reduced the total amount of pigmentation in the lyophilized MGM. The average *L*, *a*, and *b* values for the test samples are presented in Table I. After 16 hr of extraction, the *L* values for the ACE- and HEX-extracted MGM samples were comparable to the *L* value obtained for DSF. HEX-extracted MGM was easily distinguished from these samples because of the dominance of reflected yellow light in this sample. Analysis of *a* values resulted in positive scores for the ACE-, ACN-, and PET-extracted MGM. DSF reflected approximately twice the amount of red light as ACN-extracted MGM and six times more red light than ACE-extracted MGM (Table I). The *b* values were almost identical for DSF and the ACE-extracted MGM. With the exception of a low *b* value for MET-extracted MGM, the other 16-hr-extracted samples had higher *b* values in comparison to DSF and ACE-extracted MGM (Table I). These data agree with Reiners et al (1973), who obtained a light tan methanol-extracted MGM. The MET-extracted MGM appeared to have more brown pigmentation than the ACE-extracted MGM or the DSF. The ACE-extracted MGM was visually lighter in color than the MET-extracted MGM and visually indistinguishable from the color standard, DSF.

Based upon these color evaluations, ACE was selected as the most desirable decolorizing agent. The *L*, *a*, and *b* values for DSF and ACE-extracted MGM, obtained from various extraction times, are presented in Table I. The MGM solvent-extracted sample found to be equal to the visual color of DSF was achieved

after a 16-hr ACE-extraction. With the exception of the 4-hr ACE-extracted MGM sample, yellow pigment removal increased with extraction time. Although not discriminated by the Hunter color difference meter, the 4-hr ACE-extracted MGM sample visually appeared more yellow than the ACE-extracted MGM samples processed for 8 and 16 hr. This may be attributed to the larger *L* value (darkness) observed in the ACE-extracted (4 hr) MGM sample. Differences in *a* and *b* scores between 2, 4, 8, and 16-hr ACE-extracted MGM could be attributed to packing variations in filling the thimbles, which could possibly result in differences in the exposure of MGM particle surfaces to the solvent. For commercial use, agitation of the particles would be recommended in order to maintain continuity between the solvent and the sample. All ACE-extracted MGM samples, except the 0.5- and 1-hr samples, were visually indistinguishable from each other and DSF.

### Lipid Evaluation

Both the ethyl ether and acid hydrolysis procedures resulted in a lipid value of 3% (range 2.7–3.2%), which indicated the absence of any bound lipids in MGM. These results were comparable with those of Shroder and Heiman (1970), who reported a lipid content of 2.5% in wet-milled MGM.

Lipid levels of the ACE-extracted MGM for 2–16 hr were within the acceptable 0.6% level (Fig. 1) (Sternberg et al 1980). The initial 3% lipid content in lyophilized MGM decreased to an acceptable value of 0.45% after 2 hr of acetone extraction, which indicated that the lipid material was quickly removed. Increasing extraction time from 2 to 4 hr resulted in approximately another 50% decrease in lipid content (0.25%). Increasing the extraction time beyond 4 hr did not result in any further decreases in final lipid content.

This procedure was evaluated for effectiveness on large quantities of MGM by extracting 800 g of lyophilized MGM for 24 hr with 2 L of acetone in a Soxhlet apparatus. A lipid value of 0.5% and *L*, *a*, and *b* scores of 80.90, -2.46, and 18.49, respectively, indicate that this procedure can be used in the large scale production of acetone extracted MGM.

## CONCLUSION

The results of this study indicate that a simple, rapid, and inexpensive acetone extraction procedure can be used to develop a low-fat MGM product. This may be beneficial in reducing oxidative rancidity and increasing its functionality in food processing systems such as extrusion cooking. The removal of color pigments and lipids may enhance consumer acceptability of MGM for use in human foods.

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