Aqueous Processing of Full-Fat Sunflower Seeds: Yields of Oil and Protein

ABSTRACT

Undehulled sunflower seeds were comminuted and extracted with water containing 0.2% Na_2SO_3 at pH 10, which extracted from the fiber 86% of the oil and 85% of the protein. Isolate was prepared by addition of acid, with best yield achieved from pH 5 precipitation.

INTRODUCTION

Research efforts have been underway at Texas A&M University to investigate the aqueous processing of full-fat oilseeds, as recently summarized by Cater, et al. (1). This article describes an extension of those efforts to sunflower seed.

One important point should be made regarding the results discussed in this article, and that is that the sunflower seed was processed without prior removal of hulls. The rationale for retaining hulls was that completely dehulled seeds of the oilseed variety are not commercially available, and it seemed preferable to look at processes that might be directly applicable to a presently available commodity.

METHODS

The seed used was registered Peredovic seed, grown in Texas in 1972. The seed was cleaned by aspiration and screening. Analysis (standard methods) showed that the cleaned seed had the following analysis: 6.1±1% moisture, 38.4±1% oil, 3.77±0.1% nitrogen, 13.3±1% crude fiber, and 3.59±0.1% ash. Oil extracted from the seed had 1.5±0.7% free fatty acids and an iodine value of 107±2.

Seed was comminuted by flaking, then passing through a disc attrition mill which was set to grind as fine as possible without overheating the product. After this procedure, ca. 70% of the material was -20 mesh (0.84 mm sieve opening).

During aqueous extraction of comminuted seed, 0.2% sodium sulfite was employed to inhibit color change (2). Fresh solution of sodium sulfite was mixed with comminuted seed (10:1 ratio of solution to seed). The mixture was adjusted to the desired pH value with NaOH or HCl solutions, with stirring and readjustment continuing for 45 min.

Batch centrifugation of the mixture was accomplished by centrifuging in a typical laboratory centrifuge at 9000 x g for 10 min. The basket centrifuge (operated at 1700 x g) consists of a perforated bowl, with a nylon net positioned to retain solids but allow the aqueous extract (containing emulsified oil) to pass through the retained solids and out of the bowl. The solids retained in the bowl were rinsed once with fresh solution. The liquid recovered from the basket centrifuge was passed through a clarifying centrifuge

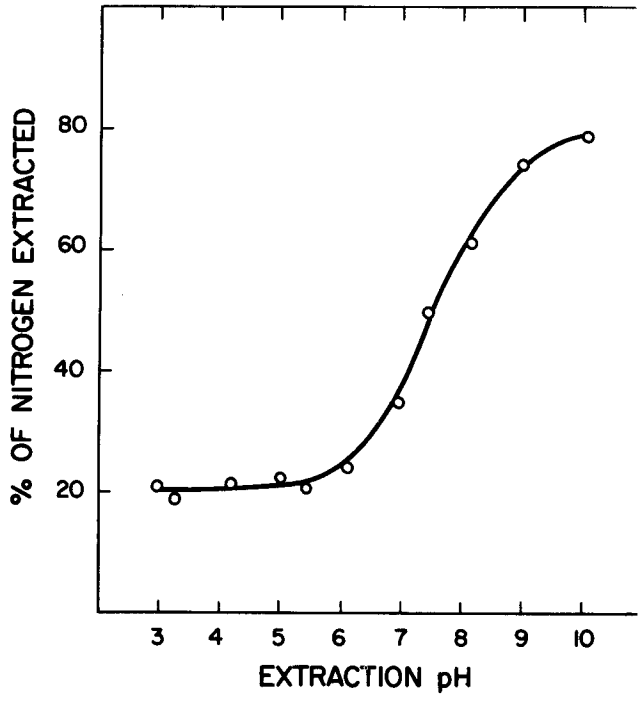

FIG. 1. Extraction of protein (as nitrogen) from full-fat sunflower seed as a function of pH. Each value is the average of at least two measurements at 25 C.

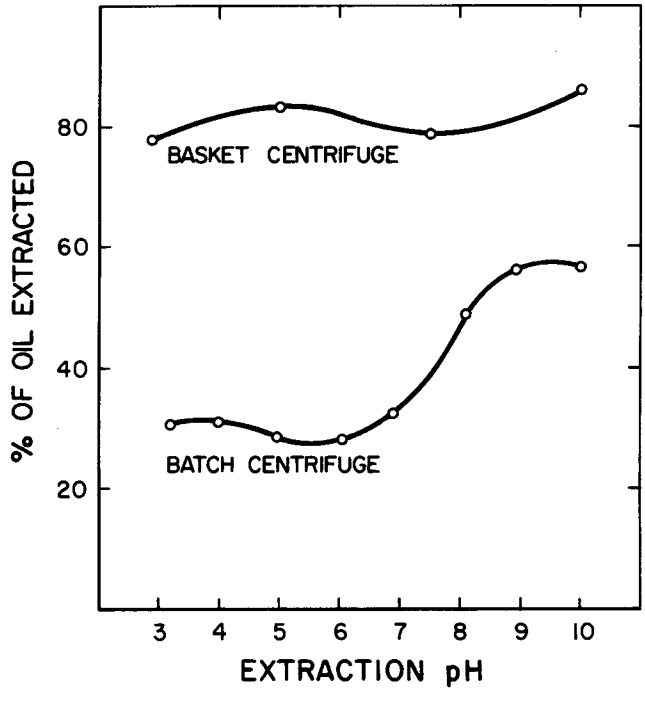

FIG. 2. Extraction of oil from full-fat sunflower seed as function of pH. Each value is the average of at least two measurements at 25 C.

(Sharpless), which removed solids but not oil. The solids removed by the Sharpless centrifuge were combined with the solids retained in the basket centrifuge to make a product called residue. The clarified liquid (containing emulsified oil) was called extract.

Solutions were clarified before measurement of extracted protein. For measurement of amount of protein precipitated during isolate preparation, seed was extracted at pH 10. The liquid extract then was adjusted to low pH and all precipitated protein separated by high speed centrifugation (27,000 x g for 10 min). All analyses for protein were based upon Kjeldahl nitrogen determination.

All reported results are the average of at least two measurements. Results are reported with 95% confidence intervals following ± signs.

RESULTS AND DISCUSSION

A crucial step in aqueous processing of full-fat sunflower seed is the solid-liquid separation that follows the aqueous extraction of comminuted seed. The liquid product of this separation (extract) is an oil-in-water emulsion containing dissolved protein, carbohydrates, and salts. The solid product (residue) contains crude fiber, insoluble protein, and other insolubles.

After preliminary testing, it was decided that the most promising technique for aqueous processing of sunflower seed is to have the protein dissolved in the extract at high pH. This decision was largely based upon the observation that undissolved protein when mixed with hull particles formed a dark and unattractive product. A disadvantage of the selected procedure is that the protein is darkened by exposure to basic pH.

Figure 1 shows the pH dependence of the solubility of sunflower seed protein. Each data point is the average of two or more results. The data in Figure 1 suggest that optimum extraction would be achieved at pH 10, where 80±5% of the protein is dissolved.

Because the oilseed variety of sunflower seed is grown for production of oil, the efficiency of oil recovery is a major concern. Figure 2 shows dependence of oil recovery on pH of extraction for two types of solid-liquid separation: batch centrifugation in a laboratory centrifuge and basket centrifugation. The data indicate that basket centrifugation gives far superior separation of oil and residue, with only ca. 14% of the oil remaining in the residue at pH 10, while ca. 44% remains after the identical separation by batch centrifugation, although no significant difference between the two separation techniques was observed for protein extraction (data not shown).

A more detailed analysis of product distribution was made only for the basket centrifugation technique. Comminuted seed was extracted with 0.2% Na_2SO_3 at pH 10. Residue and extract were separated with basket centrifuge and clarifying centrifuge, with the clarifying centrifuge collecting 17% of the residue. The dried residue weighed 47±4% of starting seed and contained 15±3% of total protein and 14±2% of total oil. The extract contained only 0.3±0.04% of the crude fiber. The clarifying centrifuge collected 7% of total crude fiber, which suggests that the clarification step was necessary.

After extraction and solid-liquid separation, the next important processing step is three phase centrifugation to separate oil and aqueous phase. This separation was performed with a disc-type three phase centrifuge with no difficulties. Two liquid products were recovered from the centrifuge: the higher density phase being the aqueous phase with dissolved protein and the lower density phase being a viscous oil-in-water emulsion. Preliminary experiments indicated that the emulsion can be broken by an inversion technique that consists of adding oil to reduce moisture and agitating to invert the emulsion, which is a technique used by this author in coconut processing (3).

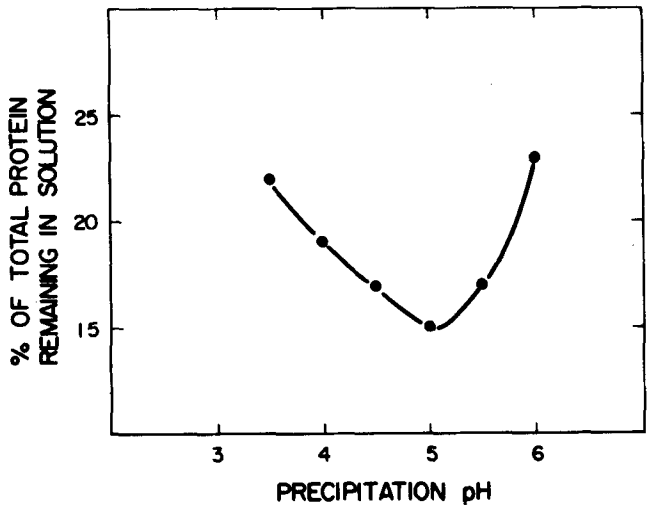

FIG. 3. Precipitation of sunflower protein as a function of pH. Prior to precipitation 83% of the total protein was dissolved by extraction at pH 10. Each result is the average of two measurements at 25 C.

Preparation of protein isolate from the aqueous phase was accomplished by a single step acid precipitation of protein. The data in Figure 3 indicate that pH of maximum precipitation occurs at ca. pH 5.0, where the amount of protein recovered as isolates is 68±5% of all the protein found in the sunflower seed, or 82% of that dissolved at pH 10. The minimum solubility range is rather broad, with only 2% of yield being lost if the optimum precipitation pH is missed by 0.5 pH units.

Extraction of sunflower seed at elevated pH or temperature raised some concern over formation of free fatty acids. Therefore, free fatty acids of the oil were measured for samples of sunflower seed that were incubated with water for 1 hr, with 0.2% Na_2SO_3 added. No change in free fatty acid was observable over the range 5-65 C and pH 4.5-10.0.

The protein isolate produced, as described in this article, was observed to be brownish colored, despite use of sodium sulfite. The presence of hulls in the starting materials is not believed to be an important factor in color of final product, based upon unpublished observations. The protein isolate produced from sunflower protein would probably only find use in food applications in which a brown colored protein would not be objectionable. Organoleptic and nutritional evaluations of the protein product were not included in our work.

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REFERENCES

1. Cater, C.M., K.C. Rhee, and R.D. Hagenmaier, JAOCS 51:137 (1974).
2. Gheyasuddin, S., C.M. Cater, and K.F. Mattil, Food Technol. 24:36 (1970).
3. Hagenmaier, R., C.M. Cater, and K.F. Mattil, JAOCS 49:178 (1972).

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