Effect of Processing Conditions on the Composition of Soy Milk[1]

W. F. WILKENS and L. R. HACKLER, New York State Agricultural Experiment Station, Department of Food Science and Technology, Cornell University, Geneva, New York 14456

ABSTRACT

Soy milk was prepared from whole and dehulled soybeans, both soaked and unsoaked, by a water extraction process at temperatures from 25° to 100°C. Soak treatments were of 1, 3, and 5 hr. duration at 25° to 60°C. The major effect of soaking on composition was to reduce carbohydrate and increase lipid content with increasing soak temperature. Protein was relatively unaffected. The longer soaks at higher temperatures reduced solids yield, especially with whole beans. Extraction of unsoaked beans reached a maximum solids yield when 60°C. water was used as the extractant.

The flavor of low-cost soy or soy-based beverages has hindered acceptance of the product and has been a factor in the efforts of many commercial companies to develop a product on a commercially profitable scale that will help alleviate protein malnutrition in many developing countries. The methods for production of a bland, wholesome soy beverage base that has good market acceptance may not necessarily coincide with minimal production and marketing costs for a given unit of protein.

Soy milk prepared from soaked beans by a water extraction process has been the conventional method practiced in the Orient for centuries. This type of soy milk is usually too rancid in flavor for acceptance as a product in most countries. Wilkens et al. (1) discussed a water extraction process which produced a fairly bland beverage provided the temperature of the grinding water for the extraction step was sufficiently high to inhibit lipoxidase activity. A filtration step was employed with this process which separated the extract into a milk-like phase and an insoluble residue. The protein contained in the residue is of high nutritional quality[2] and may be dried for utilization after adequate heat treatment as a cereal-like product.

The soy milk produced by a high temperature water extraction lacks the chalky mouth feel that is characteristic of many full-fat soy products or defatted soy bases when reconstituted as beverages. Heat treatment of the filtered beverage to inactivate anti-trypsin factors (Hackler et al., 2) does not seem to affect the suspension of solids.

Both soaked and dry beans may be used in a wet extraction process. The advantages of soaking are two-fold: 1) The power input for grinding is greatly reduced, and 2) a portion of the solids are leached.

Hackler et al. (2) reported that the soak water solids would not support growth of rats. Moreover, the taste of soy soak waters is distinctly unpleasant according to observations made in our laboratory.

A range of possible preprocessing soaking conditions was examined to determine the influence of such parameters on the composition and yield of soy milk extracted with high-temperature water to prevent development of rancid flavor.

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[1]Presented at the 53rd Annual Meeting, Washington, D.C., April 1968. Contribution from the New York State Agricultural Experiment Station, Department of Food Science and Technology, Cornell University, Geneva, N. Y. 14456; approved for publication by the Director as Journal Paper No. 1648.
Supported in part by funds from the Agency for International Development under Contract AID/csd-1815.

[2]L. R. Hackler. Unpublished data (1968).

MATERIALS AND METHODS

Soybeans (Harasoy variety) of 12 to 13% initial moisture content were used in all processing experiments. Dehulling was accomplished by heating the beans for 1(min. at 105° to 110°C. in a circulatory air oven, cooling, and passing them throug a properly spaced burr mill to loosen the hulls without substantial cracking of th cotyledons. The hulls were separated by aspirating a moving bed of cracked soy beans.

Unsoaked Beans

The dehulled beans (100 g.) were ground for 10 min. in a Waring Blend Model CB-5, with 1,000 ml. of distilled water (pH 6.1) at initial water extracti temperatures of 0° to 100°C. The extract was immediately filtered through Agway milk filter with a Buechner funnel under reduced pressure. This type c filter is commonly employed in the dairy barn or farm milk-house.

Soaked Beans

The beans (100 g.) were soaked in 500 ml. distilled water (pH 6.1) for 1, 3, an 5 hr. at water temperatures of 25° to 65°C. The soak water was drained a measured to determine water uptake. The hydrated beans were ground with calculated volume of 100°C. water to obtain the same ratio of solids to water use in preparation of soy milk from unsoaked beans. Grinding and filtration were conducted as for unsoaked beans.

Sample Analysis

The filtered soy milks were measured for volume and pH, frozen at −40°C., and lyophilized for further analysis. Each processing treatment was replicated thre times. A single compositional,analysis was made on each treatment replicate.

Solids

The lyophilized samples were weighed and ground to pass a 20-mesh screen. Samples were taken for absolute dry weight by drying in a vacuum oven at 100°C. for 4 hr. under 29 to 30 in. Hg vacuum.

Crude Protein

Protein was determined by the method of AOAC 22.011 (3) with a conversion factor of N × 6.25. A lower factor is probably more appropriate (Jones et al., 4), but the exact figure for soy milk protein has not been reported.

Crude Lipid

Dry milk samples were extracted 18 hr. by Soxhlet with chloroform-methanol, 2:1, v./v. The extract was washed to remove sugars after the method of Folch et al. (5). Ether extraction methods of AOAC (3) remove less than 50% of the lipid material from dry soy milk and were, therefore, not employed.

Crude Carbohydrate

Carbohydrate was determined by difference and, therefore, inclu materials other than protein and lipid.

Rate of Water Uptake

Water uptake was determined during soaking for both whole and dehulled

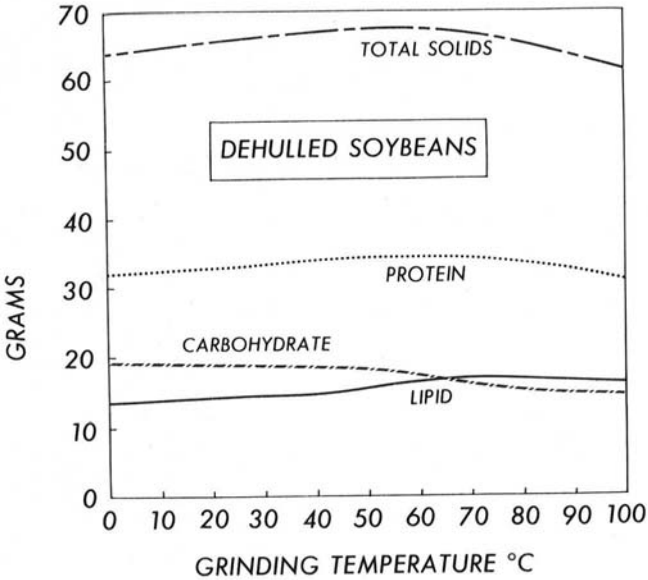

Fig. 1. Effect of water extraction grinding temperature on the composition and yield of soy milk prepared from unsoaked dehulled soybeans.

beans. The beans (100 g.) were soaked in 500 ml. water for various durations at temperatures varying from 30° to 100°C. The beans were drained and weighed to determine H_2O uptake without correction for leached solids. These data are expressed as a Hydration Ratio of weight of soaked beans to weight of dry beans.

RESULTS AND DISCUSSION

The effect of water temperature during grinding on the composition of soy milk extracted from unsoaked dehulled beans is shown in Fig. 1. The most significant effects were a decrease in carbohydrate and an increase in lipid with increasing extraction temperature. Protein recovery started to decrease slightly at 70°C. and higher. Although maximum solids are extracted at 50° to 70°C., with a decrease in solids at higher temperatures, a minimum temperature of 80°C. should be employed at the initiation of grinding to prevent off-flavor development (Wilkens et al., 1). With higher extraction temperatures, 70°C. and above, there was an indication that the insoluble carbohydrate fraction, with hydroscopic and swelling properties (Hafner, 6), may significantly contribute to inhibition of filtration and cause losses in the solids yield of the soy milk. Since the biological utilization of certain carbohydrate fractions of the soybean by man is not firmly established, losses of carbohydrate may be of minor importance, except for functional properties in the milk and also its effect on protein recovery in the filtered milk.

Total filtrable solids decreased with both increasing soak time and soak temperatures for dehulled beans as shown in Fig. 2. The effect of short-duration soaking was predominantly leaching of water-soluble carbohydrate. On the average, carbohydrate accounted for as much as 60% of the solids contained in the soak

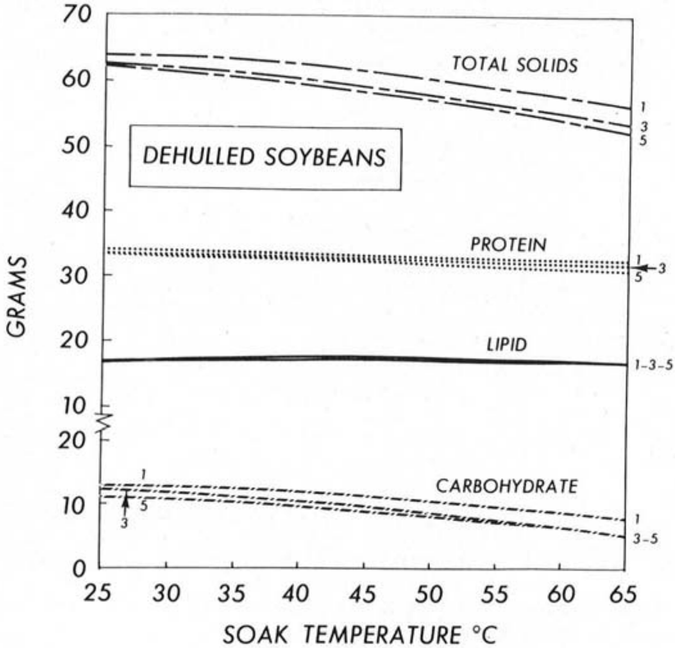

Fig. 2. Effect of soak temperature and time on the composition and yield of soy milk prepared from dehulled beans with a 100°C. water extraction grinding. Soak time: 1, 3, and 5 hr.

water. About 6% of the soak water solids was lipid and the remainder crude protein. About 50% of soak water crude protein was nonprotein nitrogen[3].

The over-all effect of soaking is enrichment of the crude protein and lipid content of the filtered soy milk. Longer soaking periods than those investigated may be considered as unwarranted in the production of soy milk from dehulled soaked beans by the wet extraction process. Soaking at higher temperatures drastically reduced the yield of milk. As shown in Fig. 3, hydration of beans was very rapid during the first hour of soaking over the temperature range of 50° to 65°C. and accounts for about 90% of the water uptake attained by a 5-hr. soak under similar conditions. The rate of water uptake for whole beans, Fig. 4, was initially slower, but after 5 hr. at the higher soak temperatures, the water uptake was nearly equal that of dehulled beans. This comparison may not be absolutely valid, since the hulls account for about 8% of the dry weight of the beans and may have different water absorption properties than the cotyledons. There is no doubt that the hulls hinder both water absorption by the cotyledons and leaching of cotyledon solids.

With whole beans, the effects of soaking at higher temperatures resulted in a more drastic reduction in yield than for dehulled beans as shown in Fig. 5. At

[3] Y. W. Lo. Factors relating to extraction, concentration, and sterilization of soy milk. M.S. Thesis, Cornell University (1967).

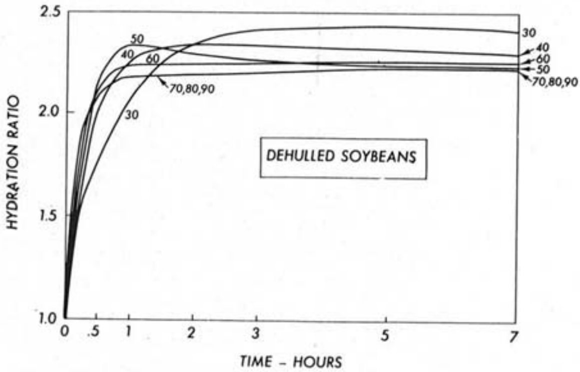

Fig. 3. Effect of soak temperature and time on the water uptake of dehulled soybeans.

temperatures of 80°C. and higher during soaking, the filtration of the milk was almost completely inhibited. The data indicate that the carbohydrate fraction may be involved in the filtrability of the milk. This fraction showed the greatest decrease in solids with increasing soak temperature for both dehulled and whole soybeans. For both whole and dehulled soybeans, the higher time and temperature soak treatments may affect gelation of both the soluble and insoluble protein fractions so that they, too, may contribute to reduction of yield during filtration.

The volume of soy milk recovered by filtration was related closely to total solids recovery as shown in Fig. 6. The pH of the soy milks was rather constant with values between 6.6 and 6.7.

These data indicate the trends that may be expected, but are not absolute guides for processing conditions. Several factors may influence composition and yield, such as variety, initial moisture content, and the type of processing equipment. For instance, a centrifugal separation of insoluble solids from those normally suspended

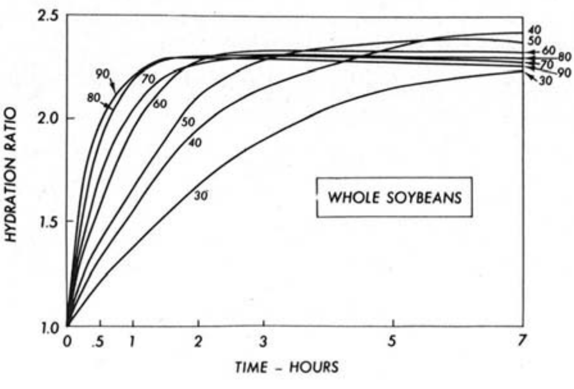

Fig. 4. Effect of soak temperature and time on the water uptake of whole soybeans.

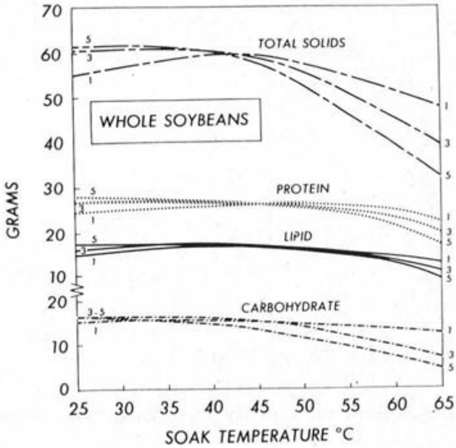

Fig. 5. Effect of soak temperature and time on the composition and yield of soy milk prepared from whole soybeans with a 100°C. water extraction grinding. Soak time: 1, 3, and 5 hr.

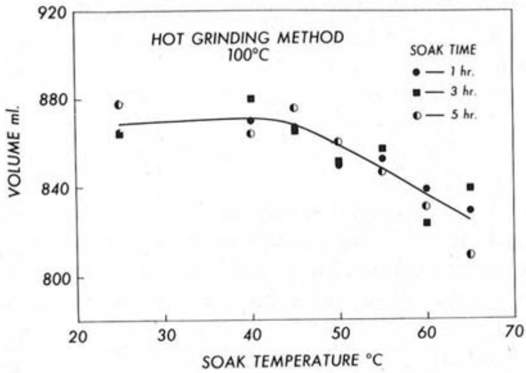

Fig. 6. Relation of soak temperature and time to the volume of filtered soy milk recovered from dehulled beans with a 100°C. water extraction grinding.

in the milk phase may give higher yields than a filtration at the higher soak times and temperatures.

Acknowledgment

The authors gratefully acknowledge the assistance of Mrs. Grace Parsons in sample preparation and lipid analysis.

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[Received June 25, 1968. Accepted October 8, 1968]