1-2008

Emerging soy protein processing technologies

Tong Wang
Iowa State University, tongwang@iastate.edu

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Abstract
In a study of refunctionalizing EE protein meals, Wang and colleagues (2004) applied HTC with steam (~150Â°C) and high shear to two slurries of heat-denatured protein having protein dispersibility indices (PDI) of 35 and 60, along with solvent-extracted white flakes and full-fat whole soy meal as controls. OTHER EMERGING TECHNOLOGIES Some of the new developments in soy protein processing include (i) producing a protein with health benefits by incorporating phytochemicals such as plant sterols and isoflavones for reducing blood total and low-density lipoprotein cholesterols, (ii) hydrolyzing soy proteins to produce peptides with cholesterol-reducing, free-radical scavenging, and antioxidant effects, and (iii) producing peptides that are active against intestinal infections, that are antimicrobial, and that are inhibitory to rat platelet aggregation.

Disciplines
Food Chemistry | Food Processing | Food Science | Human and Clinical Nutrition

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This article is published as Wang, T. 2008. Emerging soy protein processing technologies. *Inform* 19(1);13-16. Posted with permission.

Emerging soy protein processing technologies

Refunctionalization, fractionation, and gas-supported screw pressing of soy proteins are being investigated at Iowa State University

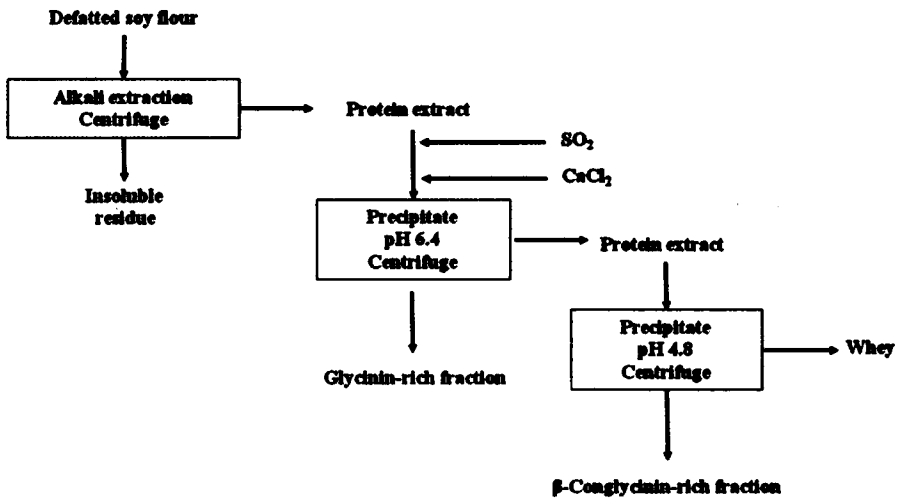

FIG. 1. Simplified soy protein fractionation procedure (Deak et al., 2007).

Tong (Toni) Wang

Applications using soy protein ingredients depend on their functional properties, such as solubility or dispersibility, and their emulsification and foaming properties. There are various types of soy protein products, including full-fat flour, defatted flour, toasted flour, soy protein concentrate (SPC), soy protein isolate (SPI), and nutrient-enriched proteins. This brief review covers three areas of soy protein research conducted at Iowa State University—Center for Crops Utilization Research in Ames.

REFUNCTIONALIZATION OF HEAT-DENATURED PROTEIN AND SPC AND SPI PREPARATION

Extruding-expelling (EE) is a mechanical, nonsolvent process used to separate oil from protein in oilseeds. EE is suitable for identity-preserved soybean processing because of its small-scale operation and flexibility. The soy protein meal thus produced has limited applicability in foods owing to its heat denaturation. If the functional properties of EE proteins can be improved, their food applications and the value of such processing will be enhanced. We have used hydrothermal cooking (HTC) to refunctionalize the heat-denatured protein, and we also prepared SPC and SPI from the HTC-treated EE meal. In addition, we examined the potential of HTC with alkali to enhance functionality and the preparation of SPI from EE meal.

In a study of refunctionalizing EE protein meals, Wang and colleagues (2004) applied HTC with steam (~150°C) and high shear to two slurries of heat-denatured protein having protein dispersibility indices (PDI) of 35 and 60, along with solvent-extracted white flakes and full-fat whole soy meal as controls. Two HTC methods were explored: one had seven different residence times, controlled by varying the holding tube length; the other flashed the treated slurry directly into the atmosphere. Effects of residence time on functional properties of the samples were investigated. Solid dispersibility, protein dispersibility, and emulsification capacity of both EE meals were significantly improved by both types of HTC treatments, and the flash-out HTC gave better results than the withholding-tube HTC. For example, the solids dispersibility, protein dispersibility, and emulsification capacity of EE meal with PDI of 35 were improved 2.0, 4.4, and 2.1 times, respectively, by flash-out HTC treatment. Thus, HTC treatment can restore the functional properties of the heat-denatured soy proteins.

Another study considered whether concentrated protein products can be prepared from EE meals. Wang and co-workers produced SPC and SPI from two EE soybean meals (PDI of 35 and 60) and from hexane-defatted white flakes as the control. Processing characteristics, such as yield and protein content, and the key protein functional properties of the products were investigated. Both acid- and alcohol-washed SPC from the two EE meals had higher yields but lower protein contents than SPC prepared from white flakes. Generally, acid-washed SPC had much better

FIG. 2. First-generation gas-supported screw press (SafeSoy Technologies, Ellsworth, Iowa, USA).

functional properties than alcohol-washed SPC. Protein content in SPI prepared from EE meals was about 80%, which was lower than that from white flakes. Nevertheless, SPI from EE meals had functional properties similar to or better than those from white flakes. SPI made from EE meals also had a higher glycinin to β-conglycinin ratio than that from white flakes.

Alkali (NaOH) addition dramatically enhanced the refunctionalization of EE protein having a PDI of 35. The more alkali that was added, the more refunctionalization that occurred, and the best refunctionalization was achieved at 0.6 mmol alkali/g EE meal. The solid and protein yields of SPI from alkali–HTC-treated EE meals were significantly higher than those from HTC without alkali addition, with the yield of SPI increased from 40 to 82% after HTC treatment at 0.6 mmol alkali/g EE meal compared with no alkali addition. The emulsification capacities of SPI after alkali-HTC were similar to those from HTC without alkali. Therefore, heat-denatured protein can be maximally refunctionalized by HTC with alkali, and concentrated protein ingredients with good functionality can be produced from such treated materials.

IMPROVING PROTEIN FRACTIONATION TECHNOLOGY

Soybean storage protein is composed of two main fractions, the 7S globulins or the β-conglycinin with molecular size of 160 kDa and the 11S globulins or the glycinin with molecular size of 350 kDa. Fractionation of the two proteins is desirable because they are believed to have different functional and nutritional properties.

For example, β-conglycinin can improve the blood lipid profile, and therefore it may promote cardiovascular health. In his Ph.D. research at Iowa State University, Nicholas Deak optimized and simplified the soy protein fractionation procedure and developed a protocol for large-scale fractionation.

Generally, glycinin and β-conglycinin can be fractionated by using alkali extraction, SO_2 treatment, salting-in with NaCl, salting-out by dilution, and pH adjustment to produce a glycinin-rich fraction, a β-conglycinin-rich fraction, and an intermediate fraction that is a mixture of the two proteins. In their study of the effect of reducing agent concentration on soy protein fractionation and functionality, Deak and co-workers (2006) found that the concentration of SO_2 significantly affected fraction yields, purities, and compositions of soy protein fractions. Based on protein yields, purities, and functional properties, the optimal amount of reducing agent was 5 mM. Without SO_2 addition, the glycinin-rich fraction had 29% of the total protein and 63% glycinin, and the β-conglycinin-rich fraction had 10% of the total protein and 94% β-conglycinin. With the addition of 5 mM SO_2, the glycinin-rich fraction contained 23% of the total protein and 82% glycinin, and the β-conglycinin-rich fraction had 17% of the total protein and 84% β-conglycinin. SO_2 addition reduced the emulsification properties of the glycinin-rich fraction and improved those of the β-conglycinin-rich fraction; consequently, the β-conglycinin-rich fraction had better emulsification properties than the glycinin-rich fraction.

In a study of the effects of NaCl concentration on salting-in and dilution during

TABLE 1. Fractionation of soy proteins by simplified and conventional methods

	Simplified procedure	Conventional procedure
Glycinin fraction		
Solid yield, %	15.5	11.6
Protein yield, %	24.4	22.3
Isoflavone, % of total	20.5	9.6
β-Conglycinin fraction		
Solid yield, %	23.1	11.5
Protein yield, %	37.1	18.5
Isoflavone, % of total	37.5	3.3

salting-out on protein fractionation, the optimal NaCl concentration was 250 mM, which gave good protein yield (19%) and purity (85%). To improve the salting-out process for the β-conglycinin-rich fraction, dilutions of 0-, 0.5-, 1.0-, and 2.0-fold were examined. The 1.0-fold dilution gave the best protein yield and purity.

Calcium ion interacts with and changes the properties of soy protein. In substituting $CaCl_2$ for NaCl in a protein fractionation, Deak and co-workers (2007) found that calcium at 5–10 mM and pH 6.4 was effective in precipitating the residual glycinin, after the removal of the glycinin-rich fraction, into the intermediate fraction, therefore improving the purity of the β-conglycinin-rich fraction. The use of 5 mM SO_2 in combination with 5 mM $CaCl_2$ in a two-step fractionation procedure produced the highest purity of the glycinin-rich (85%) and β-conglycinin-rich (81%) fractions. The flowchart of the new and simplified procedure is presented in Figure 1.

Characterization of the soy proteins fractionated by the simplified procedure showed that the fractions not only had higher yields of solid, protein, and isoflavones, and similar protein purity, but also had improved functional properties compared with fractions obtained by the conventional procedures, as shown in Table 1. The conventional procedure produced protein fractions with slightly higher solubility, but those from the simplified procedure had better emulsification and foaming properties.

GAS-SUPPORTED SCREW PRESS (GSSP) AND PROTEIN QUALITY

The GSSP system is essentially a screw press modified to have gaseous or liquid CO_2 injected into the press chamber (Fig. 2). The unique characteristic of this process is that CO_2 helps maintain a cooler temperature throughout the press, which results in better quality oil and protein meal because there is less heat-induced degradation. GSSP also results in more efficient removal of oil from the oilseed. Crown Iron Works in Minneapolis, Minnesota, USA, had acquired and further developed this technology, which is trade-marked as HIPLEX®. This process is considered natural, and it is ideal when hexane use is prohibitive and when small scale and processing of diverse crops are needed. According to Crown Iron Works, the processing capacity is typically under 500 tons (450 metric tons) per day.

A preliminary study conducted jointly by Iowa State University and the SafeSoy Technologies plant at Ellsworth, Iowa (the first such plant constructed, which commenced operations in April 2007), showed that GSSP protein meal had 4.5% residual oil, compared with the 1.2, 6.3, and 7.2% oil of the solvent-extracted, screw-pressed, and the EE protein meals (L.A. Johnson, N.A. Deak, J.A. Gerde, and M. Hill, unpublished results). The KOH solubility and PDI of the GSSP meal were 99.8% and 70.2, compared with 89.1% and 83.3 for solvent-extracted meal, and 61.6% and 10.6 of the screw-pressed meal. These values indicate that the GSSP protein is almost the same as the solvent-extracted

information

- Crown Iron Works, www.crowniron.com/technologies/spx_hple.cfm.
- Deak, N.A., P.A. Murphy, and L.A. Johnson, Effects of Reducing Agent Concentration on Soy Protein Fractionation and Functionality, *J. Food Sci. 71*:C200–C208 (2006).
- Deak, N.A., P.A. Murphy, and L.A. Johnson, Characterization of Fractionated Soy Proteins Produced by a New Simplified Procedure, *J. Am. Oil Chem. Soc. 84*: 137–149 (2007).
- Wang, H., T. Wang, and L.A. Johnson, Refunctionalization of Extruded-Expelled Soybean Meals, *J. Am. Oil Chem. Soc. 81*:789–794 (2004).

flour. The functionality study showed that the protein solubility and emulsification capacity, activity, and stability index of GSSP protein meal were all similar to that of solvent-extracted flour. However, its foaming properties were less desirable. This GSSP meal can be made into SPI with similar protein yield (about 60%) and protein content (>90%) as that from the solvent-extracted flour.

OTHER EMERGING TECHNOLOGIES

Some of the new developments in soy protein processing include (i) producing a protein with health benefits by incorporating phytochemicals such as plant sterols and isoflavones for reducing blood total and low-density lipoprotein cholesterols, (ii) hydrolyzing soy proteins to produce peptides with cholesterol-reducing, free-radical scavenging, and antioxidant effects, and (iii) producing peptides that are active against intestinal infections, that are antimicrobial, and that are inhibitory to rat platelet aggregation.

Other technologies involve producing protein with more versatile applications, such as a homogenization technique for better soy protein stability in acidic suspension, ultra high-pressure homogenization of SPI to improve functionality, and aqueous processing of oilseeds.

Tong Wang is an associate professor in the Department of Food Science and Human Nutrition, Iowa State University, Ames, Iowa 50011, USA. E-mail: tongwang@iastate.edu.