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The relation between some physical parameters and the soybean protein solubility

Rodica Căpriţă*, A. Căpriţă

Banat's University of Agricultural Sciences and Veterinary Medicine Timişoara,

Abstract

An important and frequently observed effect of food processing is the reduction of protein nutritive quality. The simplest criterion used for the characterization of proteins is their solubility in various media. As in all legumes, the bulk of soybean proteins are globulins, characterized by their solubility in salt solutions. A series of experiments was conducted to evaluate the influence of particle size and pH on the protein solubility of soybean meal in 0.0357 M KOH solution. The obtained results revealed a negative correlation (r = -0.9218) between the protein solubility and the particle size. The soybean proteins exhibit minimum solubility at pH 4.2 to 4.5 (isoelectric region). At pH 12 when the solvent is water, soy proteins are 87% soluble.

Keywords: soybean, protein solubility, isoelectric point

1. Introduction

The soybean is the only vegetable food that contains complete protein, meaning all of the eight amino acids needed for human health are present. Soy is applied in a variety of products including bread, cakes and snacks. In spite of its widespread use in foods, only a small percentage of global soy protein production goes into such products. Today soybeans are grown primarily for the production of vegetable oil for human consumption but, as a by-product, soybean meal (SBM) is becoming increasingly important. On a global scale, soy is dominating the market for protein meals due to its high protein content and good availability.

By far, the most important process encountered with soya products is heat treatment. Defatted soya flour and grits, full-fat soya flour and grits, soyamilk, soyamilk curd and soya protein concentrate, among others, include a heat treatment step in their production.

An important and frequently observed effect of food processing is the reduction of protein nutritive quality. The denaturation of the protein and reduction in amino acid availability by cross-linking, racemization, degradation and formation of complexes with sugar may result in loss of digestibility [1,2,3]. Therefore, when attempting to estimate protein quality, one of the first factors that must be evaluated is its digestibility [4,5].

The anti-nutritional factors in soybean are often associated with the low acceptance of soybean products as they also inhibit protein digestibility. These mainly consist of the heat labile (trypsin inhibitors, lectins, goitrogens, phytates) and heat stable (oligosaccharides) factors. In order for the nutritional value of soybean meal to be maximised, these anti-nutritional factors need to be inactivated or minimised [6,7,8].

For optimum functional properties of soybean, a solubility index above 90% is required.

* Corresponding author: *e-mail address*: rodi.caprita@gmail.com

Good protein solubility generally correlates with optimum gelation, emulsifying and foaming ability of the protein [9]. The solubility of a molecule in water depends on how much of the unfavorable aspects of creating a cavity in water, are compensated by favorable interactions with the surrounding water molecules [10]. Proteins enormously vary in their solubility. Some small globular proteins are very soluble while many proteins involved in building structural elements in organisms are essentially insoluble. In general, the more polar its surface, the more soluble a protein is likely to be, since interactions with solvent molecules principally involve amino acids residues at the protein surface. The solubility of a protein depends on its free energy in solution relative to its free energy when interacting with other molecules and generally increases as the pH moves away from the isoelectric point. At such pH values there is a net relatively high overall charge on the protein resulting in repulsion between protein molecules, keeping them in solution. Solubility of proteins decreases at ionic concentrations of less than 0.1M and increase above this concentration. This is caused by the decreased electrostatic repulsion and enhanced hydrophobic interaction of protein molecules as a result of electrostatic shielding of charge groups in proteins by ions. Solubility increases sharply below and above their iso-electric point (pH 4.2-4.6) [6].

Solubility can be influenced by solvent and other factors [11], such as salts, ionic strength, temperature, degree of agitation, and extraction time.

Experiments were conducted to evaluate the influence of particle size and pH on the protein solubility of soybean meal.

2. Materials and Method

The simplest criterion used for the characterization of proteins is their solubility in various media. As in all legumes, the bulk of soybean proteins are globulins, characterized by their solubility in salt solutions. The solubility of soybean proteins in water is strongly affected by the pH, as shown in Fig.3. Close to 80% of the protein in raw seeds or unheated meal can be extracted at neutral or alkaline pH. As the acidity is increased, solubility drops rapidly and a minimum is observed at pH 4.2 to 4.6. This is the isoelectric region of soybean proteins taken as a whole.

SBM samples were ground and several particle sizes were obtained using a series of standard sieves. The sieves used were 65μ (230 mesh), 125μ (120 mesh), 200μ (75 mesh), 315μ (47.62 mesh), and 630μ (23.81 mesh).

Commercial SBM (crude protein, 43.7% SBM sample, and 48.63% dry substance, respectively) was ground to pass each sieve.

The protein solubility was determined according to the procedure of Araba and Dale [12]. The KOH protein solubility test is based on the solubility of soybean proteins in a dilute solution of potassium hydroxide. The samples were tested by the following procedure: 1.5 grams were mixed with 75 mL 0.0357 M KOH solution in a stopped Erlenmeyer flank and shaken for 20 minutes in a laboratory shaker. The contents of the flask were centrifuged for 5 minutes at 6,000 r.p.m. The supernatant was analyzed for the protein concentration. The solubility of the protein, expressed as a percentage was calculated by dividing the protein content of the KOH-extracted solution by the protein content of the original soybean sample.

Percent total soluble nitrogen of soy protein was determined at various pH's.

3. Results and Discussion

A method which can evaluate the over processing of SBM is the KOH protein solubility test, based on the solubility of soybean proteins in a dilute solution of potassium hydroxide.

A series of experiments was conducted to evaluate the influence of particle size on the protein solubility of soybean meal in 0.0357 M KOH solution.

The results obtained with various particle size, reflecting differences in the protein solubility of soybean meal, are shown in Table 1. Protein solubility is expressed as the ratio of the soluble protein fraction in the KOH solution to the total crude protein content.

Table 1. Effect of soybean meal particle size on protein solubility in 0.0357 M KOH

Particle size		**Soluble protein g %**	**KOH protein solubility %**
μ	**mesh**		
65	230.7	38.93	89.1
125	120	38.67	88.5
200	75	38.19	87.4
315	47.6	37.2	85.12
630	23.8	36.8	84.21

Protein solubility in 0.0357 M KOH decreased as particle size increased (Figure 1). While the soluble fraction increased with reduced particle size, the crude protein value decreased. This suggests that grinding may cause fractionation of the nutrient components of SBM, and indicates the importance of determining both the crude protein and KOH-soluble protein for particles of the same size.

Particles smaller than those which pass through a 75 mesh (0.20 mm) failed to produce a significant increase in protein solubility (Figure 1). This observation agrees with those reported [13,14].

The obtained results revealed a negative correlation (r = -0.9218) between the protein solubility and the particle size (Figure 2).

The solubility of soy proteins is dependent on pH [6,15,16]. A slurry of native soy flour in water has a pH from 6.5-6.8 and at this pH range, 85% of the proteins are soluble.

Figure 3 shows the solubility for soybean meal proteins in the pH range 1-12. Up to pH 3 soy protein is very extractable; soy proteins are least soluble at their isoelectic point (4.2-4.6); above pH 6, soy proteins become extractable. At pH 12 when the solvent is water, soy proteins are 87% soluble.

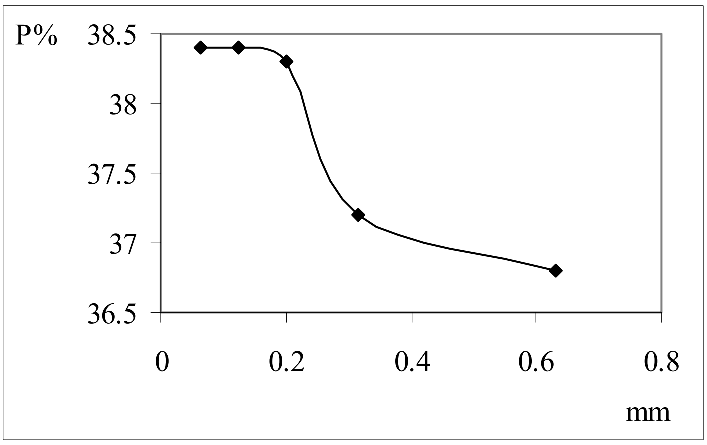

Figure 1. Effect of particle size of soybean meal on protein solubility in 0.0357 M KOH solution

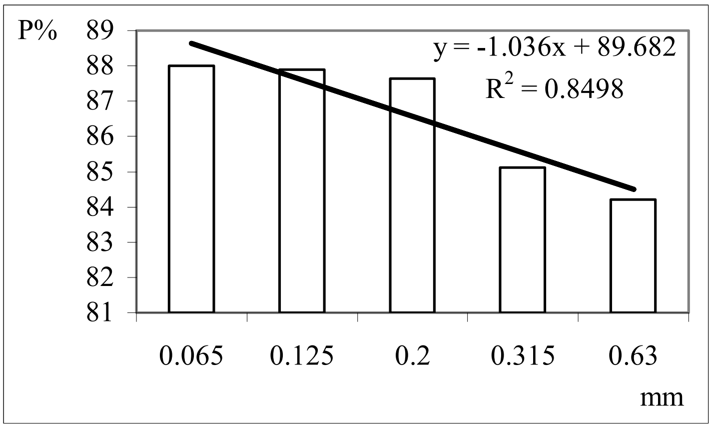

Figure 2. The proportion of soluble protein from the total protein, at different particle size

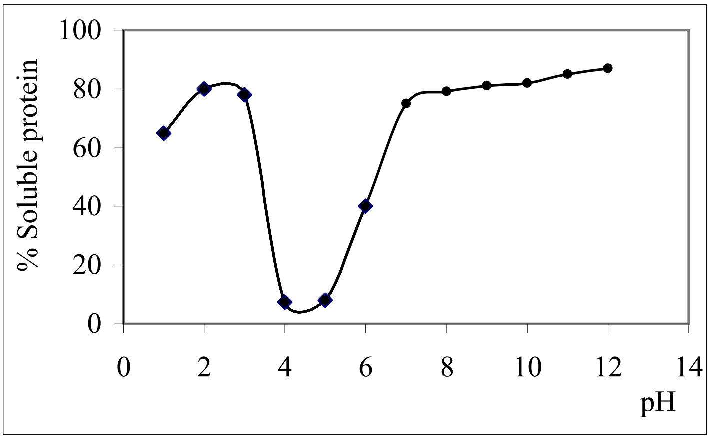

Figure 3. Variation of soluble protein percentage with the pH

4. Conclusion

The experimental data reveal a negative correlation (r = -0.9218) between the KOH protein solubility and the particle size.

The majority of soybean proteins exhibit minimum solubility at pH 4.2 to 4.5 (isoelectric region). Therefore, it is possible to extract the sugars, without solubilizing the majority of the proteins, using, as solvent, water to which an acid has been added so as to keep the pH at the isoelectric region

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