FUNCTIONAL PROPERTIES OF "COTTON PROTEIN."

II. EMULSIFYING PROPERTIES OF COTTON PROTEIN ISOLATES OBTAINED BY EXTRACTION WITH ACID

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UDC 541.18.051

It has been shown that a cotton seed protein isolate obtained by extraction with acid possesses a high emulsifying activity. The level of activity depends substantially on the pH of the medium and the method of precipitating the proteins. The stability of an emulsion obtained on the basis of the cottonseed isolate studied depends on its solubility.

Among technical oil-plant crops the cotton plant occupies one of the leading positions. In the USSR, cotton seeds are attracting great attention as a potential nontraditional source of food protein. Since, on the one hand, in the Soviet Union varieties of the cotton plant are cultivated which contain gossypol and, on the other hand, the existing technology for obtaining oils presupposes the production of meal with a high gossypol content, the problem of gossypol-free protein isolates is a very acute one. Investigations of recent years have shown that the most suitable method for its resolution is the extraction of the protein from cottonseed meal with an acid solution [1]. The isolate obtained in this way has properties which greatly distinguish it from protein isolates obtained either by extraction with alkali or by salt solutions at neutral pH values.

A distinguishing feature of the protein isolate obtained by extraction with acid is the high degree of denaturation of the protein molecules under these conditions, which determines the characteristics of the functional properties of the isolate obtained. In a study of the emulsifying properties of a cottonseed isolate it was particularly those factors having practical importance that were taken into account: 1) the conditions of drying (spray-drying and freeze-drying); 2) the phytate content; and 3) the influence of the pH of the protein solution on its emulsifying properties.

Below we give the values of the emulsifying activity (EA) for the samples of cottonseed protein isolate studied (kg/g):

Food protein	pH 3.0	pH 7.0	pH 11.0
Spray-drying	0.4	4.4	5.5
Freeze-drying	0.13	4.8	5.0
Precipitated with a 2% solution of HCl and freeze-dried	0.64	1.8	6.4

As we see, with a rise in the pH there was a sharp rise in the EA, the EA even increasing at pH values above the isoelectric point of the isolate under investigation, although for native proteins the highest EA value is characteristic in the region of the isoelectric point [2]. The values of the EA for protein preparations were lowest in the acid region. It must be mentioned that at alkaline pH values neither the method of drying not the method of precipitation had fundamental influence on the EA. Conversely, at acid pH values a direct dependence of the emulsifying activity on the method of drying and the conditions of precipitating the proteins was observed. The greatest practical interest is presented by the emulsifying properties at neutral pH values (the creation of a whole-milk substitute, additives for sausages,

Institute of the Chemistry of Plant Substances, Academy of Sciences of the Uzbek SSR, Tashkent.. Translated from Khimiya Prirodnykh Soedinenii, No. 3, pp. 357-359, May-June, 1986. Original article submitted October 21, 1985.

0009-3130/86/2203-0331$12.50

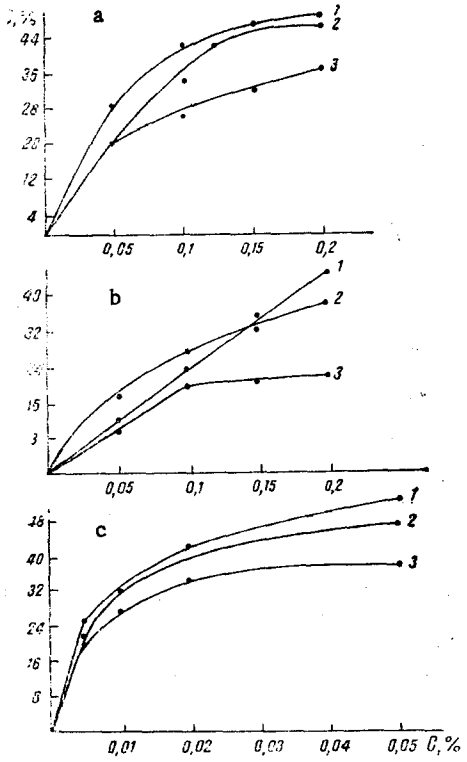

Fig. 1. Curves of the S/C relationship for food proteins (C is the concentration of protein, %; S is the area of the corresponding emulsion on emulsion stability diagrams, % [3]): a) pH 3.0; b) pH 7.0; c) pH 11.0; 1) freeze-drying; 2) spray-drying; 3) protein precipitated with 2% HCl.

etc.). The method of drying the isolate has no appreciable influence on the EA of proteins at pH 7.0. At the same time, a sharp fall in the EA is characteristic for proteins treated either with a 2% solution of HCl or with acid at elevated temperatures. This is apparently connected with a change in the solubility of the protein isolates on such treatment.

The solubility of protein emulsifying agents largely determines the stability of the direct emulsions. The results of a study of the emulsion stability of various samples of cottonseed protein isolate are shown in Fig. 1.

Thus, a change in the pH of the medium has the greatest influence on the emulsifying properties of a cottonseed protein isolate. The method of drying and the conditions of precipitation also change the capacity of proteins for stabilizing direct emulsions, but to a smaller degree.

EXPERIMENTAL

Preparation of a Protein Isolate from Industrial Cottonseed Meal. The protein isolate was obtained as described in [1].

The emulsifying properties of the protein solutions were studied by a method proposed by A. N. Gurov et al. [3].

Spray-drying was performed in an Anhydro No. 1 dryer (Denmark) with a temperature of the heat carrier at the inlet of about 200°C and at the outlet of about 80°C. A 5-7% slurry ground in a laboratory homogenizer was fed to the dryer.

SUMMARY

It has been shown that a cottonseed isolate obtained by extraction with acid has a high emulsion activity at neutral and alkaline pH values. The stability of direct emulsions based on the isolate studied depends on its solubility.

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FUNCTIONAL PROPERTIES OF "COTTON PROTEIN."

III. INFLUENCE OF GOSSYPOL AND PHYTATES ON THE SOLUBILITY OF GOSSYPULIN

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UDC 547.962.5

The solubility of gossypulin and its derivatives under various conditions has been studied by turbidimetric titration. It was found that the low solubility of the protein under investigation in the neutral range of pH values at a low ionic strength may be due to the presence of phytin and gossypol. The minimum in the solubility of the gossypol-free protein shifted into the more alkaline region (pH 6.0-6.7) as compared with the initial gossypulin (with 0.6% of gossypol). The treatment of gossypulin with dilute solutions of phytin at pH 5.0 led to a shift in the pH of precipitation (pH 3.75), but in the presence of an excess of phytic acid the aggregation capacity of the protein increased and the pH of precipitation changed (pH 4.5-5.0). When Ca^{2+} ions were added, there was a shift of the solubility minimum into the alkaline pH range. In the presence of pectin, the pH of precipitation of all the samples studied shifted into a more acid pH range.

Plant raw material is a potential source of food protein. It can be used for human nutrition provided that it is isolated in the form of preparations with definite functional properties. One of such properties is solubility. The solubility profile as a function of the pH is frequently the first experimentally measured functional property and it can be monitored at each stage of the process of obtaining the protein. A knowledge of the solubility under various conditions (temperature, pH, ionic strength, etc.) enables the optimum conditions for the extraction of the protein to be determined. A number of other functional properties depend on the solubility of the protein, such as its emulsifying and gel- and foam-forming capacities.

We have previously studied the solubility of the native globulin fraction from the seeds of the cotton plant. It was shown that the isoelectric point of the protein is about 6.0. Denaturation of the protein broadens the solubility minimum [1]. We have continued a study of the solubility of gossypulin — quantitatively the main component of the globulin fraction — and have shown how the substances accompanying the protein affect its solubility.

According to Osborne's classification, gossypulin can be assigned to the class of globulins, since it dissolves only in solutions of salts. With a rise in the concentration of NaCl from 1 to 10% at pH 7.3, the solubility of gossypulin increases uniformly from 0.65 to 13.3 mg/ml. A further increase in the concentration of salt (15%) leads to a fall in solubility, i.e., a "salting-out" effect is observed (Fig. 1).

The poor solubility of the protein under investigation in the neutral region at a low ionic strength can be explained by the presence of gossypol and phytin. In the study of solubility we used a dynamic method based on turbidimetry or the nephelometry of the protein solutions. Figure 2 shows the curves of the nephelometric titration of dilute solutions of gossypulin (0.6% of gossypol). As can be seen from Fig. 2, the curves of the nephelometric titration of a gossypulin solution from an alkaline to an acid pH range and from an acid to an alkaline range do not coincide. Apparently, this protein gives different denaturation prod-

Institute of the Chemistry of Plant Substances, Academy of Sciences of the Uzbek SSR, Tashkent. Translated from Khimiya Prirodnykh Soedinenii, No. 3, pp. 359-364, May-June, 1986. Original article submitted January 6, 1986.

0009-3130/86/2203-0333$12.50