Session K — Advances in New Vegetable Proteins

Food Uses for Cottonseed Protein

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ABSTRACT

Cottonseed, available in many countries located in both temperate and tropical climates, is rarely used as a source of edible protein even though its use as food was suggested as early as 1876. Development of edible protein products from cottonseed has been impeded by the presence of gossypol-containing pigment glands in the kernels, and the economic value of the oil. Cottonseed flour produced by mechanical pressing has been marketed in limited quantities as two edible protein products. One, known as "Proflo," is used primarily to impart functional characteristics to baked and confectionery products. The other is used as an ingredient in "Incaparina" to combat malnutrition in Latin America. Because of the manner in which these cottonseed protein products are processed, their full nutritional and functional potentials and versatility have not been realized. Recent advances in breeding glandless cottonseed, processing glanded cottonseed (e.g., the liquid cyclone process), and related technology have increased the potential of cottonseed protein for food uses. Flours, concentrates, and isolates differ qualitatively and quantitatively in protein and amino acid composition. Consequently, they have different functional and nutritional characteristics and end uses. Flours and concentrates as well as their texturized counterparts are acceptable as functional and nutritional additives to meat products, baked goods, and cereals. Three isolates including storage protein, nonstorage protein, and a mixture of both have been prepared from flours and concentrates. The storage protein isolate imparts functional characteristics, such as texture, acid solubility and foam stability. The nonstorage protein isolate has good nutritional characteristics primarily because of its high lysine content.

Cottonseed is rarely utilized as an edible protein. Among oilseeds, cottonseed production of 22 to 24 million metric tons annually is second only to soybeans (1). Approximately 20% of this is protein, which is equivalent to about 6% of the world's supply of edible protein (2). Not all of this protein could be recovered for edible purposes, but the large potential availability of food-grade cottonseed protein is an important consideration in helping to feed the world of the future.

Cottonseed was first suggested as a source of human food in 1876 for diets requiring a low starch content. Apparently the flour was produced from finely ground press cake. There is no evidence of widespread acceptance (3). For over 30 years, and until about 2 years ago, one U.S. company marketed two cottonseed flour products, namely "Proflo" and "cinacoa." These products were used in certain baked goods and confections to impart functional characteristics such as dough machinability, controlled spread, reduced fat absorption, improved browning and reduced loss of oil from the chocolate candy coating (4). Additionally, Incaparina (or INCAP vegetable mixture 9), a blend of cottonseed flour, corn flour, sorghum flour, and torula yeast plus calcium carbonate and vitamin A, is marketed in Latin America (5,6). It is used to prepare a low cost, highly nutritious product to combat malnutrition.

These products, however, are prepared from cottonseed meals produced by screw pressing and do not exemplify the inherent nutritional and functional characteristics available in specially processed, defatted cottonseed protein products.

Development of edible protein products from cottonseed has been impeded by the presence of pigment glands containing gossypol, and the importance placed on the economic value of the oil. Gossypol is a highly reactive, yellow, polyphenolic compound that is toxic to most monogastric animals in its metabolically active or "free" form (7). It also imparts a yellow color to cottonseed products. Economic importance of the oil dictates that mill processing conditions be selected to maximize oil recovery from the seed, usually at the expense of meal quality.

Two distinctly different approaches have emerged to eliminate or minimize adverse effects of free gossypol in cottonseed protein. First is the development of glandless varieties of cottonseed that are essentially free of pigment glands. To date, only limited plantings have been made. The other approach is development of processes that remove the pigment glands without deleterious effect to the meal.

TABLE I

Proximate Composition[a] of Selected Cottonseed Protein Products

Component	Flour (glandless) %	Concentrate (LCP-deglanded) %	Isolates (glandless) Classical %	Storage %	Nonstorage %
Nitrogen	9.3	10.9	15.6	16.5	13.8
Lipids	0.9	0.6	1.1	0.8	2.8
Crude fiber	2.5	2.5	0.5	0.1	0.2
Ash	8.1	8.2	3.4	1.4	5.9
Total sugars	6.2	7.7	0.5	0.2	3.5
Reducing sugars	0.2	0.1	Nil	0.1	0.1
Phosphorus	1.8	1.8	0.7	0.5	3.3

[a]Moisture-free basis.

TABLE II

Typical Essential Amino Acid Composition of Selected Cottonseed Protein Products (g/100 g Protein)

Amino acid composition	Flour (glandless)	Concentrate (LCP-deglanded)	Isolates (glandless) Classical	Storage	Nonstorage
Isoleucine	3.0	2.9	3.4	3.6	3.4
Leucine	5.8	5.4	5.7	6.4	6.3
Lysine	4.3	4.2	3.4	3.6	6.3
Methionine	1.2	1.3	1.4	1.2	1.6
Half-cystine	1.2	1.2	---	1.3	3.3
Phenylalanine	5.5	5.2	5.7	6.8	4.0
Tyrosine	3.1	2.8	2.8	3.3	3.6
Threonine	3.2	3.0	2.9	3.2	3.7
Tryptophan	1.4	1.3	---	1.3	1.4
Valine	4.3	4.1	4.7	4.9	4.5

The liquid cyclone process (LCP) simultaneously removes intact pigment glands and extracts the oil to produce a defatted protein concentrate (2). The air classification pigment glands to produce a protein concentrate fraction.

Edible flours can be produced from glandless seed, and concentrates from both glandless and glanded seed. Either the flours or concentrates can be used to prepare classical, storage (SP), and nonstorage (NSP) protein isolates. The classical isolate contains both groups of proteins.

Table I shows the proximate composition of typical selected cottonseed protein isolates. As noted in the first two columns, compositions of the glandless flour and the LCP concentrate are similar except for the nitrogen contents. The three isolates, however, differ appreciably in most of the components that apparently contribute to their different characteristics.

Table II shows the amino acid composition of selected cottonseed protein products. Again a similarity is noted between the glandless flour and LCP concentrates; the amino acid composition is essentially the same. Although most of the amino acid compositions of the three isolates are comparable, there are some important exceptions. The lysine and half-cystine contents of the nonstorage protein isolate are appreciably higher and the phenylalanine is lower than those of the other two isolates. The nonstorage isolates also contain slightly higher amounts of some of the other amino acids. The protein content of LCP concentrate prepared from glanded seed is over 65% and the PER compares favorably with that of casein. The water absorption of 2.5 g/g of material is half that of soy concentrate, and for this reason the cottonseed concentrate may be a valuable ingredient for products such as high protein frankfurters. The oil absorption and oil emulsification characteristics are comparable to those of soy concentrate.

Chemical composition and characteristics of cottonseed protein products, as well as their essentially bland flavor and light cream color, are all conducive to the use of cottonseed protein products to formulate foods with enhanced nutritive value and functional properties.

Cottonseed concentrate has been approved in the United States as a food additive by the Food and Drug Administration. This product has probably been evaluated more extensively in food applications than all other cottonseed protein products.

LCP concentrate has been evaluated in several meat products, namely, beef patties, meat balls and gravies, chili preparations, beef broths, fresh sausages, and frankfurter-type products (9). Concentrate used at levels up to 8% in beef patties reduced frying losses and imparted very desirable flavor and texture. Similarly, when the concentrate was added to fresh sausages, retention of fat and moisture was enhanced, along with good texture and flavor. In meat balls and gravies and in chili preparations, inclusion of the LCP concentrate retarded the separation of fat and moisture. In beef broths, addition of the LCP product to the other broth ingredients improved color and reduced the shiny appearance characteristic of broths made with starch. Color and flavor of the samples containing the concentrate were excellent.

Cottonseed protein concentrate did not perform as well at the 3% level in frankfurter-type products. This was partially attributed to the low water absorption of cottonseed protein. However, because of this characteristic, cottonseed protein may be a valuable ingredient at the 10% level or above for a high protein, frankfurter-type product.

An extensive study (10) to determine the effectiveness of LCP concentrate in diets of growing children showed that the use of one-third of the protein from cottonseed in a moderate diet resulted in normal growth and development.

LCP concentrate has also been used to prepare extruded, texturized proteins (9,11). The extruded, undenatured LCP concentrate has excellent expansion characteristics. Extruded mixtures of wheat flour and cottonseed concentrate are very appealing cereal-type products. Similarly, rice and corn have been extruded with cottonseed concentrate to produce expanded types of snack products (12). However, by partially denaturing cottonseed concentrate and modifying the extruder, textured products can be made that have approximately the same densities and utility as extruded, textured soy proteins (11). Similarly, glandless cottonseed flour has been texturized with the same degree of success as the LCP concentrate.

Cottonseed protein products have been evaluated in baked goods (13-18) such as cookies, doughnuts, cakes, and breads (19,10). Successful cookie products have been prepared in which 12% to 20% or more of the wheat flour was replaced with cottonseed flour or concentrate. Up to 13% wheat flour has been replaced with cottonseed concentrate in doughnuts.The concentrate imparted a rich, yellow color to the doughnut and produced a moist product with no off-flavor. A slight darkening of crumb color was common when the flour or concentrate was used in bread at the 3% level. Storage protein isolate was successfully used at the 10% level in a bread in which a sponge and dough formation was used without materially affecting the structure of the loaf (15). Good color, flavor, grain, and texture were noted when cottonseed concentrate was used in devil's food cake. The cake had a more desirable, moist mouth feel than did the control cakes. In some baked goods where color is important, such as in pancakes, waffles, and white layer cake, added cottonseed protein imparted an undesirable color to the products. It has been reported that cottonseed protein concentrate incorporated into a nondairy caramel formulation imparted good flavor and excellent handling properties (20).

The storage proteins have excellent functional characteristics. They are acid soluble, have exceptional foam capacity and stability, and have good texturing capacity in simulated meat products. This protein isolate, dried at pH 3.5, is white and almost completely soluble at that pH. It has been utilized at levels up to 6% to fortify acidic beverages with protein (3). It is also an excellent whipping agent, comparable to egg white solids and sodium caseinate (3) at more acid pHs.

Glandless cottonseed kernels have been used to produce another snack food product (21,22). By roasting the kernels, a high protein, nut-like product called "Tamunut" was developed as a snack item and for possible use in products such as noncooked candies, and as toppings on bakery goods and ice cream specialties. A cottonseed butter has been produced by grinding the roasted kernels in equipment used for making peanut butter.

Nonroasted and partially roasted kernels, evaluated in baked cookies, bread, and cooked candies such as peanut brittle were found to be acceptable.

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