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# Two Food Applications of Cottonseed Flours and Meals

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## ABSTRACT

Procedures for preparing texturized cottonseed protein and isolate. In either case the free gossypol is effectively reduced. Further work is in progress especially on cottonseed protein isolate.

## INTRODUCTION

Cottonseed meals and flours are often in excess in the local markets of tropical countries like Colombia (20,000 tons in 1974). Their use in human foods is restricted by well known factors, free gossypol and dark green color. Work has been done in Colombia and in many other places towards the economical elimination of these two drawbacks. Our results correspond to the work done at I.I.T., Colombia, on the production from commercial cottonseed meals of texturized vegetable protein through extrusion and on the production of 90% protein isolate using as extracting agent a hexametaphosphate solution.

## TEXTURIZED VEGETABLE PROTEIN

In 1974 preliminary studies conducted at I.I.T. (1) showed that cottonseed flours could be texturized in a similar way to soybean flour, and that free gossypol contents were simultaneously reduced to safe levels. Further work done during the last few years has verified reduction in free gossypol, to evaluate the nutritional properties of the extrudate and the influence of the quality of the raw materials and processing conditions on the physical and textural properties of the extrudates.

Flours with different fiber, protein, and initial gossypol contents were run through extruders (Wenger X-5 and X-25) as seen in Table I, the extreme ones being flours C, and G (free gossypol and fiber). The extrusion variables studied were: die hole diameter, die type, flour/water mass ratio (2.65:8.30). Water pH (6.3, 7.0, 8.5, 10.0).

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Temperatures at the exit die were between 75 and 115 C in the X-5, and 103 to 135 C in the X-25. Product moisture at the exit die varied from 12.0 to 16.0% in the X-25 extruder. Methods used for chemical, physical and biological analysis were the conventional ones as described by Cabrera et al. (2) and Salazar- de Buckle et al. (3).

## RESULTS

The results obtained showed it was possible to obtain a textured product with sensory characteristics similar to those of soybean texturized products as measured by the texture profile method (4). Scanning electron microscopy showed a structure (Fig. 1) similar to that of soybean T.V.P., rivulets, protein strands and their systematic layering as well as some spherical bodies that we believe may be intact protein bodies. Photomicrographs 1 and 2 correspond to soybean and cottonseed, respectively. Photomicrograph 3 we believe could be illustrating the strand formation through the elongation of one of the spherical bodies and shows another one already elongated that connects two layers of orientated protein fibers. Photomicrographs 4 and 5 show the fiber orientation observed, both in cottonseed and in soybean textured protein. In the cottonseed, a two dimensional layering which resembles that of bovine muscle tissues is observed, while in soybean the fibers or layers show a more complex interweaving. These seem to correlate with higher integrity indexes observed for soybean products.

Table II shows how the free gossypol content was lowered to levels below 0.020%. It also shows that high integrity indexes are correlated with low bulk density and high expansion indexes. The most appropriate water pH values were between 7.0 and 8.5.

Table III shows some data concerning the biological value of cottonseed extrudates compared with soybean TVP and whole hens' egg. The biological value obtained by using the slope ratio techniques (5) show similar results to those of the soybean-extruded product. The free gossypol

TABLE I

Chemical Analysis of Cottonseed Flours (Moisture Free Basis)[a]

| Sample | Fat (%) | Crude fiber (%) | Protein (N x 6.25) (%) | Free gossypol (%) | Available lysine g/100 g protein |
|---|---|---|---|---|---|
| C | 0.73 | 5.27 | 57.6 | 0.077 | 3.8 |
| D | 0.59 | 13.98 | 47.5 | 0.082 | 3.8 |
| G | 0.75 | 12.85 | 46.3 | 0.073 | --- |

[a]Alkali Soluble protein (NaOH, 0.02 N) was 70.5 – 71.0 for all three samples.

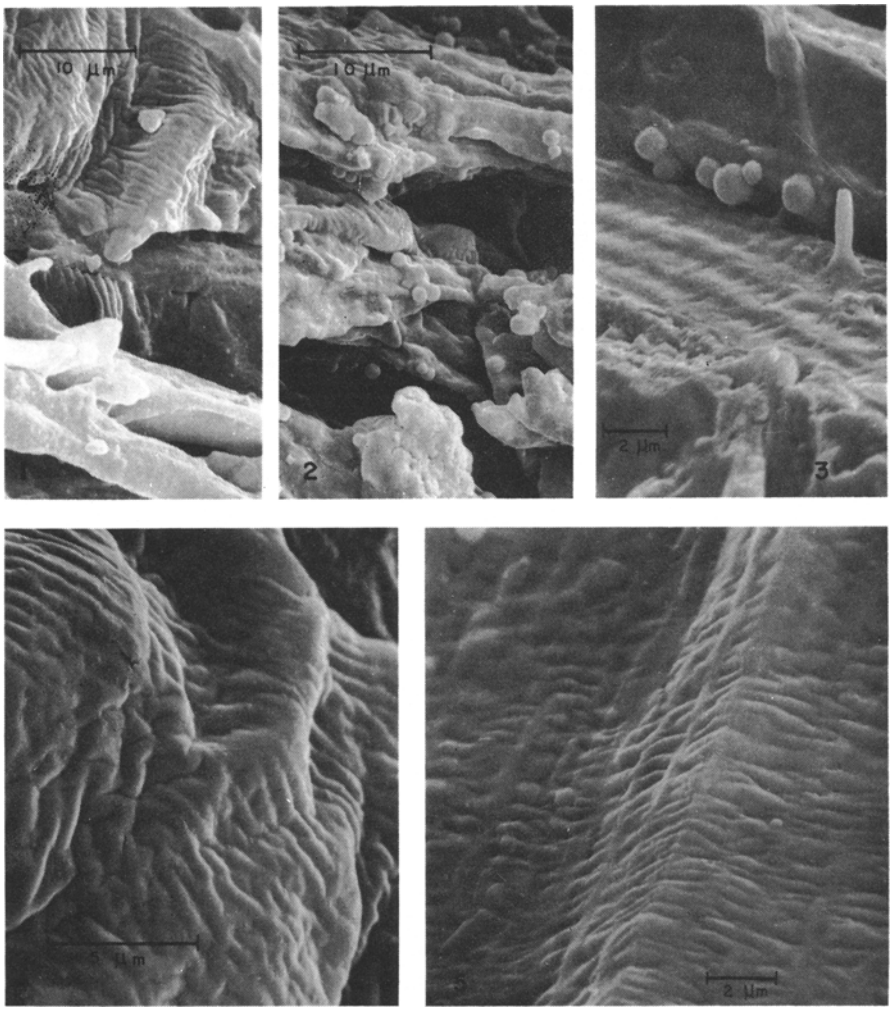


FIG. 1. Photomicrographs: (1) cross fracture of soybean extrudate; (2) cross fracture of cottonseed extrudate; (3) cross fracture of cottonseed extrudate showing transformation degrees to textured forms; (4) and (5) longitudinal fractures of soybean extrudate (4) and cottonseed extrudate (5) showing fibrilar arrangement.

TABLE II

Physical and Chemcial Characteristics of Cottonseed Textured Proteins

| Sample | Free[a] gossypol (%) | Integrity index | WAI[b] (g/100 g) | Bulk density (g/ml) | Expansion index |
|---|---|---|---|---|---|
| C-6 | 0.016 | 27 | 192 | 0.209 | 1.15 |
| C-8 | --- | --- | 40 | 0.460 | 1.11 |
| C-9 | --- | --- | 40 | 0.430 | 1.22 |
| C-10 | 0.012 | 45 | 140 | 0.200 | 1.29 |
| C-11 | 0.011 | 65 | 160 | 0.190 | 1.49 |
| C-12 | 0.009 | 53 | 240 | 0.140 | 1.41 |
| C-13 | 0.012 | 57 | 267 | 0.150 | 1.47 |
| D-17 | 0.015 | 16 | 141 | 0.226 | 1.45 |
| D-18 | 0.013 | 17 | 181 | 0.175 | 1.15 |
| D-19 | 0.015 | 20 | 181 | 0.182 | 1.26 |
| D-22 | 0.025 | 17 | 134 | 0.297 | 1.04 |
| D-24 | 0.022 | 26 | 180 | 0.210 | 1.01 |
| D-26 | --- | --- | 60 | 0.420 | 0.79 |
| C-X25 | 0.018 | 44 | 248 | 0.262 | n.d. |
| G-X25 | 0.014 | 46 | 225 | 0.333 | n.d. |
| $C_1$-X25 | 0.016 | 47 | 160 | 0.200 | n.d. |

[a]Original free gossypol content: Sample C 0.077%; D 0.082%; G 0.073.
[b]Water Absorption Index; n.d.: Not determined.

values are low (well below 0.04% maximum value for human consumption). The available lysine value of the extrudate corresponds to a free gossypol reduction from 0.077 to 0.01% if it is supposed that one mole of free gossypol combines with 2.8 moles of available lysine according to work of Cater et al. (6) Results obtained with extrusion allow us to conclude that (a) it is possible to produce from commercial defatted flours (expeller-solvent extraction) TVP with textural acceptable properties and with free gossypol content lowered to acceptable values without damaging the nutritional quality of the cottonseed product; and (b) commercial application of the process

TABLE III

Biological Value, Available Lysine and Free Gossypol of Some Textured Products[a]

| Product | Biological value | Available lysine (g/100 g protein) | Free gossypol (%) |
|---|---|---|---|
| Hen's egg (whole) | 100 | 6.9 | --- |
| Cottonseed textured protein[b] | 57 | 3.6 | 0.014 |
| Cottonseed textured protein[c] | 55 | 3.6 | 0.016 |
| Soy textured protein | 56 | 6.3 | --- |

[a]Using Cottonseed Flour C (Table I).
[b]Extrusion Temperature: 150 C.
[c]Extrusion Temperature: 175 C.

could be feasible since the textured product enters well in dishes where red meat is traditionally used and since cottonseed flours generally have a price 30-50% below that of soybean flours. This texturized product represents an interesting alternative for tropical countries where cottonseed abounds.

## COTTONSEED PROTEIN ISOLATE

The starting raw material is a cottonseed meal produced by the commercial expeller-solvent extraction process. The process consists of the extraction of the protein with 2% hexametaphosphate solution followed by precipitation of the protein at pH 2.3, pH adjustment, washing and drying (7). As a by-product of the process, a meal with 34.0% protein and 20% fiber is obtained. Yield of the isolate is 16% with respect based on starting cottonseed flour. The isolate has an equivalent of 90% protein (N x 6.25), a white-creamy color and a bland flavor. No greenish colors are developed in the presence of water and heat. Its free gossypol content is about 0.01%.

Available lysine in the isolate is 3.3g/16 gN. Its biological value is being measured at the present time. The present cost estimate of this product is US $2.00/kilo or $2.2/Kg of protein.

The applicability of this process in the five Andean countries is to be evaluated in 1979, through the pilot production of 10 tons of the isolate and acceptability testing among children and mothers of the different countries. These results together with those of a prefeasibility study will indicate the potentials of the application of this process in cottonseed-producing countries.

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