Cottonseed Utilization and Human Nutrition

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ABSTRACT

The introduction of glandless cotton, which is free of the 'gossypol' pigments, makes possible a reduction of processing cost and refining loss of edible cottonseed oil and also enables cottonseeds and/or cottonseed protein to be consumed by swine, poultry and humans. Cottonseed utilization in human foods offers a tremendous new market for glandless cottonseed products. In the last decades, much effort has been expended on research aimed at increasing the use of cottonseed protein in foods. Glandless cottonseed flour contains 51/2 times as much protein as wheat flour, therefore, it can be used to protein-fortify foods. Research has shown that cottonseed protein is very effective in supplementing the diets of malnourished children. Glandless cottonseed products have many other potential food uses such as in simulated meat products, fortified cereal products, bread, cookies, snacks, gravies, sauces, puddings, ice cream, whipped toppings and other bakery and confectionery goods. Glandless cottonseed can be used both to protein fortify traditional foods and to develop new, unique foods, i.e. nut-like products.

Introduction

In the early 1950's, geneticists in California discovered a new cotton that contained no pigment glands in the seed. These glands appear as dark specks in the seed and contain gossypol and other pigments that give a dark reddish colour to crude cottonseed oil and a yellowish-brown colour to cottonseed meal and flour. The introduction of glandless cotton made possible a reduction in processing cost and losses in the production of edible cottonseed oil and protein and rendered them edible to swine, poultry and humans. For example, cottonseed flour has played an important role in fighting malnutrition in Central and South America as a major ingredient in Incaparina Foods. It provided the nutritional equivalent of powdered whole milk at one-tenth the cost, improving the diets of the low income families.

Cottonseed is the world's second largest major cotton producing areas including the U.S.A, China, India, former soviet countries and many equatorial developing nations. Greece is the E.E's first largest pool of cotton production which is primarily used as a vital natural fiber for clothing and secondly as by-product cottonseed meal for livestock feed (app. 38% fiber and 62% cottonseeds).

About 27 million metric tons of fuzzy cottonseed is produced annually in the world, the equivalent of 5 million metric tons of protein that could feed 200 million persons (65 gr/day basis).

Production of Cotton seed Products

Cottonseed is processed into cotton fiber while approximately 9% of the weight of the original pinned seed becomes cotton linters (short cellulose fibers) which are used in paper manufacture, batting and other industrial applications. Another 25% of the seed is hulls used as animal feed and other specialized purposes. In addition, 16% of the seed is crude cottonseed oil which after refining is predominately used for salad and cooking oil, margarine and other lipids for human consumption. But, the bulk of the seed at 45% yields cottonseed meal which is a high protein concentrate primarily used in animal feeds. The remaining 5% is waste.

Cotton oil is extracted from the kernels by means or a screw press, or by the use of solvent such as hexane, etc. In another pre-press solvent process, the kernels go through a light screw press treatment prior to a final extraction with solvent.

Thus, cottonseed oil, meal an other products such as nuts have each been the subject of extensive investigation for more that a century. When seed goes to processing, the first step is cleaning to remote trash and other foreign materials. The seed are then delinted. Approximately 90 kg of linters are removed per ton of seed. Once the linters are removed, the seed is then dehulted. About 260 kg of hulls are removed per ton of seed crushed and used in many feeds for primarily ruminant animals. The remained seed kernel after dehulling in the cooked, flaked and sent through the extraction process to remove the oil. Approximately, 175 kg of oil are removed per ton of seed processed and is used for cooking and frying (comparisons with other oils is shown in the literature 'fatty acid profiles' (see cottonseed processing steps, Fig. 1).

The residue remaining after oil extraction is then ground into meal. The physical properties (color, texture and fineness) of cottonseed meal vary with the processing method. Hence, the physical appearance of cottonseed meal is at best only moderately indicative of its nutritional value and often can be misleading.

Composition of Processed Meals

Proceedings of the World Cotton Research Conference-2. Athens, Greece, September 6-12, 1998. pp.1148-1151.

As determined by various studies, screw-pressed meals are relatively high in residual lipids, while pre-pressed solvent meals are low and direct solvent meals are intermediate.

Gossypol is a yellow pigment present in cottonseed that is toxic to non-ruminant animals. Gossypol is present in the kernel or meal either in a free or bound state.

However, numerous groups of scientists have recognized the world nutrition potential of cottonseed and have attempted to detoxify gossypol in meal by heat treatment, or to remove it by use of solvents. Unfortunately, most procedures have not been commercially successful.

Thus, a gossypol-free phenotype was the direction of scientists in 1960's. Although cotton varieties that were genetically free of gossypol were developed these glandless varieties, as they called, had not yet made a significant economic impact in the world. They are called 'glandless' because the small discrete sacs where the polyphenolic gossypol pigment is found are called 'glands and the genetics modification removed these.

In the ensuing years since the discovery of glandless cotton, scientists in cotton-breeding have been attempted to create cotton glandless varieties with characteristics close to commercial varieties. Since cotton is grown primarily for the fiber, glandlessness must be a 'plus' factor if does not reduce significantly the quality of fiber. This goal is close to the reality with several varieties which have been released and more are on the way to come.

Leaders in glandless cottonseed utilization research have been Texas A&M University, Texas Woman's University and the USDA SRRC of USA with the France based CIDAD-CA (formerly IRCT). Processing, utilization and nutritional studies have, also, been conducted in Egypt (University of Alexandria). An interesting development of glandless cottonseed in Pakistan, Peru, and Paraguay has also been reported.

Glandless Cottonseed Processing and Utilization

Glandless cottonseed has the same gross composition as glanded seed, except for the absence of gossypol and handles similar process equipment, except that the objective is to produce completely lint and hull free products, under sanitary conditions. Cottonseeds are cleaned to remove dockage and conditioned with steam or water mist to about 8% moisture. After dehulling the kernels and hulls are separated on a shaker table using aspiration. Kernels can be used in foods as nut replacements or processed into flour. The defatted flour can then be further processed into food protein concentrates (70% protein) or into several types of protein isolates (90% protein).

Food Applications

Greater utilization of cottonseed in human foods offers new market for glandless cottonseed products which can be used in candies, cookies, bread, and other bakery and/or confectionery products. In contrary, the flour produced from the Kernels can be used to increase the protein content and enhance the handling properties of traditional foods. Glandless cottonseed products have many other potential food used (simulating meat products, fortified cereal products, bread, cookies, noodles, pastas, snacks, gravies, sauces, puddings, ice cream, and others.

In human nutrition, researchers have been shown that cottonseed protein is very effective in supplementing the diets of malnourished children. Glandless flour contains 5.5 times as much protein as wheat flour. Therefore, low levels of flour can be used both to protein-fortify traditional foods and to develop new, unique ones. The future uses of cottonseed protein are unlimited and only limited by our imagination and ingenuity.

Conclusions

The gross composition of glandless cottonseed kernels, flour and flour derivatives (proteins) are well documented in the literature (see Table 1). A comparison of the amino acid profile of glandless cottonseed with the FAO reference has shown high values in many nutrients (see Table 2). Methionine and isoleucine are the limiting amino acids in processed cottonseed protein. Conventionally prepared cottonseed meal typically 99shows PER values similar to commercial soybean meal in the 1.8 to 2.0 PER range. Other researchers have shown that the PER of protein in glandless cottonseed flour, prepared with mild heat treatment, can be nearly similar to casein at 2.5.

The oil of glandless cottonseed is light colour and as much as 50% reduction in energy requirements for refining in comparison to traditional cottonseed oil. Work of other researchers indicates that for the first time recovery and marketing of cottonseed phospholipids and lecithin as food and industrial emulsifiers may be possible.

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Table 1. Composition (%) of glandless cottonseed.

Analysis	Raw Kernels	Flour	Protein	
			Concentrate	Isolate
Protein (NX6.25)	38,9	62,6	73,5	92
Fat	39,7	0,8	1,5	0,3
Fiber	1,7	2,8	2,9	0,2
Ash	-	7,8	11,8	5,4
Sugars	6,8	14,6	0	5,9

Table 2. Adjusted mean nutrient composition of glanded cottonseed meal.

Nutrient Component	Screw Press Process	Nutrient Component	Screw Press Process
Dry Matter	91,4 %	Cobalt	0,7 mg/lb
Crude Fiber	13,5 %	Biotin	0,24 mg/lb
Ash	6,2 %	Choline	1276 mg/lb
Crude Protein	41,0 %	Niacin	17,2 mg/lb
Gossypol - Free	0,04 %	Thiamine	4,4 mg/lb
Gossypol - Total	1,02 %	Lysine	1,6 %
N - Solubility	36,8 %	Agrinine	4.3 %
Calcium	0,16 %	Aspartic Acid	3.8 %
Magnesium	0,42 %	Alanine	1,6 %
Iron	0.01 %	Valine	1,8 %
Potassium	1,20 %	Methonine	0,5 %
Phosphorus	0,93 %	Leucine	2,2 %
Zinc	26,1 mg/lb	Phenylalanine	2,2 %

Figure 1. Cottonseed processing steps.