PROCESSING COTTONSEED AND GIN WASTE TOGETHER TO PRODUCE A LIVESTOCK FEED

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Abstract

Whole cottonseed and cotton gin waste (CGW) were mixed together and then heated and compressed to produce a material suitable as a livestock feed. The product was in the form of chips that would be easy to handle with feed handling equipment. The nutritional value of the product was good, free gossypol content was greatly reduced during the process, and Methomyl and Dropp residues were reduced while those of other chemicals were not. The process required only two machines: a ribbon mixer and an expander cooker. Seed to CGW mix ratios of 1:1 up to 9:1 worked well with this process, but attempts with less seed than CGW resulted in an unacceptable product.

Introduction

CGW Disposal

Cotton gin waste (CGW) presents a sizable problem for the ginning industry. Gins in the U.S. produce approximately 2.8 million tons of CGW per year. Since gins can no longer incinerate CGW legally, they are faced with alternative disposal methods requiring much more labor, transportation, management, and capital. Environmentally sound disposal methods, such as composting and spreading on farm soil, yield very little value from the CGW. Additionally, storage of CGW during decomposition presents environmental problems of its own: fires, noxious odors, flies, possible water contamination, etc. Over the years, a number of alternatives have been proposed for disposal and/or utilization of CGW. Some of these alternatives have involved using it as a livestock feed. Unprocessed CGW is occasionally used as a roughage-type feed for cattle, but this practice is generally discouraged because of the lack of knowledge concerning chemical residues in CGW. In very few instances, CGW has been pelletized and sold as a cattle feed. This is true in at least one case in the Lubbock, Texas, area where few crop production chemicals are used, so there is less concern over residues. However, disposal of CGW remains a problem, and the possibilities for use as a livestock feed are largely untapped.

Cottonseed Market Enhancement

Cottonseed (annual nationwide production about 8.5 million tons) is generally a much more valuable product than CGW. Its oil and meal are extracted for food, feed, and industrial purposes. Raw cottonseed has been shown to be quite valuable as a cattle feed. However, cottonseed contains the toxin, gossypol, which limits the amount that can be fed to livestock. Also, unprocessed cottonseed is very difficult to handle mechanically because of its fluffy, non-flowing, texture. Recent experiments have resulted in a coating that allows cottonseed to be handled like a smooth seed, but this makes it more expensive as a livestock feed. Increases in cottonseed marketability are needed for full utilization of the cottonseed supply.

Rationale

Mayfield (1994) stated that crop-production-chemical residues in CGW had decreased from the 1970s to the present, and that current residues have relatively short lives compared to those of chemicals used in the past. He also said that the potential for blending CGW with cottonseed is excellent, partly because the heat and pressure of extrusion could further reduce pesticide residues. However, only one instance of extruding a mixture of cottonseed and CGW was discovered in preparation for this project (Mayfield, 1996). In this experiment, conducted ca. 1992, a mixture of 50% cottonseed and 50% CGW had been extruded successfully. The normal extrusion process consists of screening the raw materials to remove fine particles and dirt; grinding and mixing the raw materials; conditioning, cooking, and flaking the mixture; and then extruding pellets.

For this project a simpler process was envisioned wherein cottonseed and CGW could be mixed and processed into high-quality feeds. In so doing, the mixture could be heated and pressurized to generate a compact and easily handled material, and levels of gossypol in seed and crop-production-chemical residues in CGW would be greatly reduced. Processing cottonseed and CGW in this way would have several benefits. The cotton industry would benefit from increased profitability at cotton gins and greater marketability of cottonseed. The livestock industry would benefit from a valuable new feed source. The rural environment would benefit by reducing the amount of CGW requiring storage and disposal, and by destruction of chemical residues in the CGW. The rural economy would

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benefit from converting a by-product of little value into a valuable feed, and in general from the creation of a new product. The entire process could be performed at cotton ginning facilities, where cottonseed and CGW are separated from cotton fiber and are in ready supply.

Objectives

The objective of this research was (1) to develop a process whereby cottonseed and CGW are mixed in proper proportions and extruded to produce a compact and easily handled material, (2) to evaluate the palatability and feed quality of the product, (3) to evaluate the reduction in gossypol levels from the heat and pressure of extrusion, and (4) to evaluate the reduction in crop-production-chemical residues from the heat and pressure of extrusion.

Approach

Two approaches to processing were considered. (1) At gins processing picker-harvested cotton, the seed output outweighs the CGW output by anywhere from 3:1 to 9:1. If the seed and CGW were mixed at their output proportions, then both materials would be fully used to produce one high-value product. No low-value product would remain. This was thought of as "hiding" the low-value CGW in the high-value seed. (2) The other idea was to add a small amount of seed to the CGW to increase its value to a more marketable level.

Methods and Materials

Two Studies

Two studies were conducted to satisfy the objectives of the project. The initial study included an evaluation of processing seed and CGW at their gin-output proportions. The secondary study included an evaluation of processing CGW with a small amount of seed added. The procedures for material collection were the same in both studies. Also, the processing configuration was the same in both studies, but the mix ratios used were different. Further, the nutritional and gossypol analyses were conducted in the same manner in both studies.

Material Collection

Several hundred pounds of CGW (not including gin motes and lint-cleaner waste) and raw cottonseed were collected during ginning of a Midsouth, spindle-picked, seed cotton at the full-scale gin, U.S. Cotton Ginning Laboratory, USDA/ARS, Stoneville, Mississippi. A large amount of each was collected and transported to the Food Protein Research and Development Center (FPRDC) at Texas A&M University, College Station, Texas.

Material Preparation

Initial Study. In the initial study, no special preparation of the seed or CGW was performed prior to processing.

Secondary Study. In the secondary study, the investigators desired to find out if the process used in the initial study would reduce the amounts of crop-production chemical residues in the seed-CGW mix. To assure measurable levels of the chemicals of interest, the CGW was "spiked" with the chemicals prior to processing. First, the CGW was spread out in a thin layer on a plastic sheet. Several crop-production chemicals were applied over the top of the CGW with a spray rig mounted on a tractor.

Processing Configuration

The following method was used to process the CGW and seed. The two materials were mixed with a ribbon mixer. The mixtures were fed into an Anderson 4.5-inch Expander Cooker in different runs. The Expander Cooker was operated in the DOX configuration (that of a dry expander for mechanical cooking of oilseeds). Unlike standard extrusion, the entire processing sequence consisted of the mixer and the Expander Cooker.

Mix Ratios

Initial Study. In the initial study, CGW and seed were mixed in the following proportions: 90% seed and 10% CGW, 80% seed and 20% CGW, and 50% seed and 50% CGW, and 100% cottonseed.

Secondary Study. In an attempt to lower the amount of seed in the mix, an initial ratio of 10% seed and 90% CGW was processed in the secondary study. This was followed by a mix ratio of 25% seed and 75% CGW. Then the 50-50 mix was repeated as in the initial study. Subsequently, mixes of 75% seed and 25% CGW, and 90% seed and 10% CGW were processed.

Nutritional analyses

Samples of each raw material and each mix-ratio product were analyzed for nutritional content at the Soil, Water and Forage Testing Laboratory (SWFTL) at Texas A&M University, College Station, Texas.

Palatability Analysis

Initial Study. Samples of each mix-ratio product from the initial study were sent to the University of Georgia Cooperative Extension Service, Tifton, Georgia. There the samples were used in a rudimentary study of palatability with sheep.

Secondary Study. No palatability analysis was conducted with products of the secondary study.

Gossypol Analysis

Samples of raw materials and each mix-ratio product from the initial study were sent to the Animal Nutrition Section, Texas Agricultural Experiment Station, San Angelo, Texas. There the samples were analyzed for free and total gossypol content.

Chemical-Residue Analysis

Initial Study. No chemical-residue analysis was conducted with raw materials or products of the initial study.

Secondary Study. To determine possible reductions in crop-production-chemical residues, samples of the raw materials and products from the secondary study were sent to Mississippi State University's State Chemical Laboratory, Mississippi State, Mississippi.

Results

In the initial study, after some preliminary process adjustments, the system produced an acceptable material at each mix ratio. The results of the nutritional tests in the initial study are given in Table 1, and the data show the products to have relatively good feed value. No palatability problems were evident with any mix ratio. Levels of free gossypol were greatly reduced during the process. The initial study showed that a potentially valuable livestock feed could be made through value-added processing of various cottonseed and cotton gin waste (CGW) mixtures.

In the secondary study, the product resulting from a mix ratio of 10% seed and 90% CGW was a loose and fluffy mixture. The same result occurred with the mix ratio of 25% seed and 75% CGW. The 50-50, 75-25 and 90-10 seed-to-CGW mix ratios were successful. Results of nutritional analyses in the secondary study are given in Table 2, and again the data show the products to have relatively good feed value. Further, residues of methomyl were reduced by about two-thirds, and residues of Dropp were reduced about 90% during processing.

These experiments indicate that a simple, relatively low-cost, extrusion system could be set up in a gin to handle all the production of seed and CGW. This idea is seen to have the advantage of "hiding" the CGW in the higher-value seed without reducing the seed's value as a feed. At the expected output ratio from a gin (ratios from 1:1 to 9:1), the process produced an easily handled product with good feed qualities and palatability to ruminants. Further, some unwanted properties in cottonseed and CGW were shown to be reduced by the processing performed in these experiments.

Future Work

The objectives of further research in this area involve the following: (1) perfecting the process (re temperatures, pressures, water/steam addition rates, etc.) to provide the greatest possible reductions in gossypol and chemical residues, and associated studies to define the metabolites of chemical residues from the process; (2) a feeding trial to determine the effects of the feed on livestock; (3) a comparison of the feed value to that of other common feeds; and (4) a look at other means of reducing the seed-to-CGW ratio.

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Table 1. Results of all analyses, study 1.

	Whole material		Mix (% cottonseed in product)			
Property of interest	CS	CGW	100%	90%	80%	50%
%Crude protein (CP)	18.7	15.2	20.1	25.6	21.4	21.1
%Digestible CP	14.9	11.5	16.3	21.6	17.5	17.3
%Acid deterg. fiber	45.2	51.2	40.8	41	41.7	44.1
%Total digest. nutr.	46.7	34.3	53	52.7	52	48.4
Mcal/lb	0.94	0.69	1.06	1.06	1.04	0.97
%P	1.17	0.38	0.62	0.78	0.71	0.62
%K	2.31	1.63	1.13	1.16	1.22	1.32
%Ca	0.27	1.62	0.22	0.21	0.34	0.62
%Mg	0.63	0.42	0.34	0.4	0.39	0.4
Na, ppm	124	234	4	54	92	124
Zn, ppm	65	48	33	41	42	44
Fe, ppm	59	248	91	114	156	210
Cu, ppm	12	6	6	7	7	7
Mn, ppm	37	42	19	21	23	29
Total gossypol	0.51	0.18	0.42	0.34	0.42	0.42
Free gossypol	0.51	0.18	0.04	0.04	0.04	0.04

Table 2. Results of all analyses, study 2.

	Whole Material		Mix (% cottonseed in mix)		
Property of interest	CS	CGW	90%	75%	50%
%Crude protein (CP)	28	16.6	20.7	19.9	19.8
%Digestible CP	23.9	12.9	16.8	16.1	16
%Acid detergent fiber	55.3	50.8	43.1	41	49.1
%Total digest. nutrients	23.1	35.3	50	52.7	39.1
Mcal/lb	0.46	0.71	1	1.06	0.78
%P	0.53	0.42	0.68	0.62	0.48
%K	0.92	1.47	1.08	1.32	1.22
%Ca	0.13	1.85	0.36	0.61	1.23
%Mg	0.38	0.49	0.47	0.45	0.45
Na, ppm	311	528	404	383	466
Zn, ppm	32	104	52	61	89
Fe, ppm	153	1411	236	358	706
Cu, ppm	5	15	8	7	8
Mn, ppm	12	62	18	23	39
DEF, ppm	0.19	160	40	82	108
Methyl Parathion, ppm	0	67	12	24	27
Profenofos, ppm	0	3.3	0.32	0.76	2.1
Methomyl, ppm	0	65	3.9	12	9.7
Dropp, ppm	0	18	0.14	0.62	0.73