

# AGRICULTURAL EXPERIMENT STATION of The Alabama Polytechnic Institute, Auburn, Ala.

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## FURTHER EXPERIMENTS WITH DETOXIFICATION OF COTTONSEED MEAL FOR HOGS

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**I**N a previous study (3), free gossypol was shown to be the primary cause of the poisonous effect of cottonseed meal when fed to hogs in sufficient quantities to constitute the major source of protein in the ration.

Commercial cottonseed meals produced by 16 mills in Alabama were found to contain free gossypol in amounts ranging from 0.055 to 0.252 per cent. When fed at a level of 25 per cent of the ration, the meal containing the least amount of free gossypol proved toxic. Under the conditions of these experiments, the application of moisture and heat to cottonseed meals or meal reduced their free-gossypol content. The reduction was in proportion to the degree of heat, length of time heat was applied, and moisture content of the meal.

The data reported in this publication concerns the application of the principles noted, as well as other modifications in commercial milling practices. Possible variations in the process to reduce cottonseed meal toxicity were studied in the following respects:

- 1) Denaturization or elimination of free gossypol through application of moisture and heat.
- 2) Development of a method for treating cottonseed meal with iron to counteract its toxicity.
- 3) Effect of solvent extraction of cottonseed upon free-gossypol content and toxicity of the resulting meal.

### EXPERIMENTAL PROCEDURE

**Preparation of test materials.**<sup>2</sup> Cottonseed meal was prepared by the batch process, using the maximum amount of moisture that could be employed without reducing the mill out-

put enough to make the procedure uneconomical. In addition, cottonseed meal pellets, which receive treatment with moisture and heat in the pelleting process, were prepared from the batch-cooked meal and examined for free-gossypol content and toxicity.

Although iron solutions have been known to counteract the toxicity of cottonseed meal, the use of iron salts in the dry meal for hogs has not always proved favorable (2). In this investigation, iron-containing pellets were prepared by adding ferrous sulfate to the meal before it entered the pelleting machine, in order to determine if the moisture resulting from the steam spray used in pelleting might be sufficient to satisfy the moisture requirement of the iron-detoxification process.

The cottonseed meal resulting from solvent extraction of cottonseed meals for oil was produced with a method formulated by the cooperating oil company. The meal was made in a pilot plant by the extraction of unheated cottonseed kernel flakes, which were then ground and adjusted to a 41 per cent protein basis by adding hull bran.

**Free gossypol and toxicity tests.** The analytical method used in determining the free-gossypol content of the various mill products was that given by Smith (4).

The toxicity evaluations were arrived at by feeding hogs on a ration made by mixing the following materials: Yellow corn meal 73 per cent, alfalfa leaf meal 5 per cent, minerals 2 per cent, cottonseed meal or pellets

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<sup>2</sup>The Process Development Staff of the Buckeye Cotton Oil Company cooperated in the milling phases of the investigation.

(41 per cent protein) 20 per cent. Minerals were also supplied *ad libitum*.

The several tests were begun with pigs averaging approximately 34 pounds in weight. The tests were continued until the animals receiving the less toxic ration averaged above 200 pounds. Each group of hogs was penned in a dry lot of approximately one-eighth acre in size and given all of the feed the animals would eat in two feedings daily.

### RESULTS

In the course of the investigation, three series of products were made, analyzed, and fed in successive periods. The results are given in Table 1.

**Series 1.** The free-gossypol content of the batch-cooked meal, which received maximum moisture treatment in the cooking process, was lower than that of the regular process meal. Likewise, the pellets contained slightly less free gossypol than the meals from which they were derived. However, at least one hog died or became sick with symptoms of cottonseed meal poisoning in every lot except that receiving the pellets fortified with iron.

The mill operators stated that the batch-cooked meal was prepared with 12.7 per cent moisture in the second kettle, and that the time required to cook out additional moisture slowed production to the point of being uneconomical. It appears, therefore, that the manufacture of non-toxic meals for hogs by hydraulic installations will require changes in the machinery to effect more rapid removal of excess moisture.

**Series 2.** During the first week of the second trial, hogs in the experiment developed a disease similar to erysipelas. Other pigs in the breeding herd from which the experimental animals were selected exhibited similar symptoms, indicating that the trouble was not due to the test feeds. One or more animals in each of the lots became ill, although some of the groups were affected more than others. As a result, the rate and economy of gains were not normal. However, the hogs were continued on experiment for observation of any toxic effects that might develop. One animal receiving the batch-cooked meal died. Post-mortem examination showed both ascites and hydrothorax, which

TABLE 1. FREE GOSSYPOL CONTENT AND TOXICITY OF COTTONSEED MEAL AND PELLETS MILLED IN VARIOUS WAYS

PRODUCT	Free gossypol content <sup>1</sup>	Pigs in lot	Toxic effects	Daily gain per pig	Feed required 100 pounds of grain
	Per cent	Number		Pounds	Pounds
<b>Series One</b>					
Continuous cooked meal, regular process.....	0.074	10	Deaths	—	—
Pellets from the above containing 2% FeSO <sub>4</sub> .....	0.058 <sup>2</sup>	10	None	1.18	450.6
Batch-cooked meal, maximum moisture.....	0.066	10	Sickness	—	—
Pellets from the above.....	0.049	10	Deaths	—	—
<b>Series Two</b>					
Batch-cooked meal, regular process, pelleted.....	0.072	7	Deaths	—	—
Undercooked meal, pelleted with 2% FeSO <sub>4</sub> .....	0.112 <sup>2</sup>	7	None	0.84	426.5
Batch-cooked meal, pelleted with 2% FeSO <sub>4</sub> .....	0.072 <sup>2</sup>	7	None	0.92	393.1
Solvent extracted meal.....	0.036	7	None	0.94	403.1
<b>Series Three</b>					
Undercooked meal, pelleted with 1% FeSO <sub>4</sub> .....	0.129 <sup>2</sup>	8	None	0.91	448.0
Undercooked meal, pelleted with 2% FeSO <sub>4</sub> .....	0.129 <sup>2</sup>	8	None	0.81	470.9
Batch-cooked meal, pelleted with 2% FeSO <sub>4</sub> .....	0.062 <sup>2</sup>	8	None	0.82	469.0
Solvent extracted meal pelleted <sup>3</sup> .....	0.010	8	None	1.31	408.6
Solvent extracted cottonseed meal and soybean meal, 50% each, pelleted <sup>3</sup> .....	0.005	7	None	1.37	397.9

<sup>1</sup>Dry weight basis.

<sup>2</sup>Analysis made prior to treatment with FeSO<sub>4</sub>.

<sup>3</sup>All of the pelleted materials except these two were ground before feeding.

are conditions typical of cottonseed meal poisoning and not characteristic of erysipelas. The iron-treated materials appeared to be unpalatable, but none of the hogs receiving these products or the extracted meal developed disorders that could be attributed to the toxic effect of cottonseed meal. The free-gossypol content of the extracted meal was considerably lower than any commercial meal that had been analyzed previously.

**Series 3.** Despite precautions, the hogs used for testing the third series of products showed symptoms similar to those observed in the previous trial. The symptoms appeared during the first 10 days of the experiment, but as before they were also manifest in the breeding herd. The disease was milder than in the second test, and the subsequent growth of the animals was reasonably satisfactory. However, the rate and economy of gain are probably questionable as indexes of comparison.

None of the products tested in the third trial gave any evidence of toxicity. The pellets containing iron proved to be unpalatable when fed whole for several days. Thereafter, the pellets were ground and mixed with the other ingredients of the ration. However, reaction to the ground material appears to have contributed to lowered total feed consumption, with consequent reduction in economy and rate of gain.

The extracted meal contained less free gossypol than that fed in the second experiment. These pellets were fed whole. The hogs relished the pellets to the extent of consuming the pellets before eating the remainder of the ration. The daily gain per pig, 1.31 pounds, and the feed required per one-hundred weight of gain, 407.0 pounds, were quite satisfactory for a ration composed largely of corn and supplemented with plant protein, in the main, from a single source. The soybean-cottonseed meal mixture pelleted and fed one of the lots in the third series contained too little cottonseed meal to be toxic, even if hydraulic meal were used. It would be expected to be superior to cottonseed meal in promoting growth, but, due to the disease troubles, the results probably are not reliable for comparison with the solvent meal.

## DISCUSSION

The data presented in this report confirm the principle that the free-gossypol content of cottonseed meal produced by the hydraulic process may be reduced through the use of more moisture and heat than is commonly employed by oil mills. However, it appears that production of a meal that is non-toxic to hogs by this procedure will require changes in the milling machinery to remove the excess moisture rapidly enough for the process to be economically feasible.

The rendering of hydraulic meals non-toxic to hogs by incorporating iron into pellets made from the meal appears to have possibilities. Such pellets proved non-toxic, even though prepared from undercooked meats containing relatively large amounts of free gossypol. While these products were unpalatable, additional work may show that poisonless pellets can be manufactured with amounts of iron more acceptable to animal taste.

The solvent-extracted meal studied in these trials appears to be entirely satisfactory for feeding to hogs at a level of 20 per cent of the total feed. Such a proportion is sufficient to supply the protein needed in a ration composed largely of corn. This product contains considerably less free gossypol than meals being sold at present. The manufacturers state that the pilot plant is now producing meal that consistently contains approximately 0.01 per cent free gossypol, and that commercial plants will be able to duplicate this performance.

Although the two trials with hogs fed solvent-extracted meal gave favorable results, additional tests under a variety of conditions are desirable. It should be noted also that rigid control of the free-gossypol content of the meal is necessary if it is to be manufactured and sold as a non-toxic product. Moreover, cottonseed meals, which may be produced by other solvent-extraction methods, will require examination of their toxic properties before they can be recommended for feeding to hogs in large amounts, since different adaptations of the solvent process may alter the nature of the resulting meals.

## SUMMARY

Production of special cottonseed meals and cottonseed meal products in mill operations and feeding of these materials in experiments with hogs showed the following:

1) A cottonseed meal containing one-third to one-fifth of the minimum amount of free gossypol found in hydraulic meals proved non-toxic to hogs in two experiments, when fed as 20 per cent of the ration. This meal, produced by solvent extraction on a pilot plant scale, contained 0.01 per cent free gossypol.

2) A non-toxic meal for hogs could not be produced by the ordinary hydraulic process due to the failure of the standard equipment to drive off the excess moisture required for detoxification rapidly enough to make the procedure commercially feasible. Changes in mill machinery may correct this difficulty.

3) Cottonseed meal pellets were found to

contain less free gossypol than the meal from which they were made, but the difference was not large enough to be of importance in the feeding of hogs.

4) Iron (ferrous sulfate) incorporated into cottonseed meal pellets served to reduce their toxicity, but the amounts of the iron salt used appeared to be unpalatable to hogs.

## LITERATURE

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