

# Degossypolized Cottonseed Meal as a Source of Plant Protein in Rabbit Feeds

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The sensitivity of nonruminants to toxic cottonseed meal rations has been recognized and investigated for several decades. Concerning the rabbit, Voris et al. ('40) noted intestinal stasis, cecal impaction, bloating, and death in animals fed cottonseed oil cake pellets plus an equal weight of alfalfa hay. More recent studies by Holley et al. ('55) demonstrated hemorrhage of the small intestines, lungs and brain, enlarged gall bladders, edema, anuria, and impaction of the large intestine in rabbits receiving cottonseed meals at levels of 20 and 25% of the ration. Cottonseed meal containing 0.04% of free gossypol proved to be toxic when fed as 20% of the diet, and mortality occurred in some animals where the calculated individual intake was not more than 100 mg of free gossypol. The results of these workers indicated that gossypol is absorbed slowly by rabbits and acts as a cumulative poison, the habit of coprophagy apparently increasing the sensitivity of the rabbit to this toxic substance. Many commercial milling companies are including degossypolized cottonseed meal in rabbit pellets at an undisclosed level. Apparently, it is serving as a satisfactory source of protein and, during most seasons of the year, is one of the least expensive sources of plant protein available.

The purpose of this experiment was to study the tolerance of the rabbit for degossypolized cottonseed meal and to evaluate its use as a replacement for other plant protein sources in rabbit rations.

## MATERIALS AND METHODS

*Design.* A split-plot randomized block design was followed. Thirty mature New Zealand White females (does) were bred to 6 unrelated bucks, forming 6 half-sib blocks. The 5 does within each block

were randomly assigned to one of the 5 rations which were fed throughout 4 successive litters. Where sisters were available they were assigned to different blocks and received different rations.

*Feeding.* Five rations were used, one control and 4 experimental (table 1). The basic stock ration in use at the U. S. Rabbit Experiment Station served both as the control and as the basis of the other 4 rations. Does received the various rations throughout pregnancy and lactation until the young were weaned. Rations were available to the young from the time they left the nest box at approximately three weeks of age, until weaning. All rations were fed free choice.

*General.* All animals were housed in all-metal, self-cleaning hutches equipped with automatic waterers. Does were rebred 52 to 53 days following parturition and palpated for pregnancy 12 days following breeding. They were weighed when placed on test and when each of their litters was weaned. Young were weighed, weaned and removed from experiment at 56 days of age. As far as possible, litters were equalized at 8 young each within three days following parturition. The original number in a litter was then referred to as the "number retained." Illness of does and young, and any treatments administered, were recorded. All animals that died on test were weighed and autopsied to determine cause of death. Feed consumption was determined from parturition to weaning.

Received for publication July 20, 1961.

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TABLE 1  
Composition and chemical analyses<sup>1</sup> of rabbit rations

|   | Rations        |       |       |       |       |
|---|----------------|-------|-------|-------|-------|
|   | 1<br>(Control) | 2     | 3     | 4     | 5     |
|   | %              | %     | %     | %     | %     |
| Suncured alfalfa meal                       | 40.0           | 40.0  | 40.0  | 40.0  | 40.0  |
| Soybean meal (expeller)                     | 18.0           | 15.0  | 13.0  | 11.0  | 9.0   |
| Linseed meal (expeller)                     | 4.0            | 4.0   | 4.0   | 4.0   | 4.0   |
| Barley                                      | 18.5           | 18.5  | 18.5  | 18.5  | 18.5  |
| Oats  | 4.0            | 4.0   | 4.0   | 4.0   | 4.0   |
| Wheat mixed feed (millrun)                  | 15.0           | 15.0  | 15.0  | 15.0  | 15.0  |
| Salt  | 0.5            | 0.5   | 0.5   | 0.5   | 0.5   |
| Degossypolized cottonseed meal <sup>2</sup> | 0.0            | 3.0   | 5.0   | 7.0   | 9.0   |
| Crude protein                               | 21.74          | 19.76 | 20.62 | 20.18 | 20.63 |
| Ether extract                               | 3.14           | 3.14  | 3.09  | 2.99  | 2.88  |
| Crude fiber                                 | 14.62          | 14.98 | 14.40 | 15.16 | 14.76 |
| N. F. E.                                    | 45.16          | 46.80 | 47.14 | 47.13 | 46.59 |
| Ash   | 7.74           | 7.50  | 6.96  | 7.04  | 7.13  |

<sup>1</sup> Determined on an air-dry basis.

<sup>2</sup> Free gossypol, 0.016%; total gossypol, 0.79%. Supplied by San Joaquin Cotton Oil Company, Los Angeles.

*Analysis of data.* Results were evaluated on the basis of average kindling weaning weight per litter, total litter weaning weight, mortality, and feed conversion as determined by amount of feed required to produce a pound of weight at weaning.

Total litter weaning weight and average kindling weaning weight were analyzed with number weaned and rabbit feeding days used as multiple covariates.

Examination of the means of male and female weaning weights showed no sex difference. The mean weaning weights and standard errors were  $3.88 \pm 0.03$  pounds and  $3.87 \pm 0.04$  pounds for the males and females, respectively. Since two litters had no average weaning weights, due to litter mortality prior to weaning, missing data were computed after Federer ('55), and the analysis of variance computed.

Feed conversion data were analyzed by analysis of covariance with feeding days as the covariate (Federer, '55), after estimating one missing plot.

Mortality data were subjected to analyses of variance of both percentage of mortality and the arcsin transformation of percentage of mortality (Federer, '55).

The analysis of variance determined the significance of block and ration differences over whole plots; and litter, block  $\times$  litter and ration  $\times$  litter differences over sub plots.

#### RESULTS AND DISCUSSION

In table 2 are shown the ration means for average kindling weaning weight per litter, total litter weaning weight, feed conversion and percentage of mortality. The analysis of variance of total litter weaning weight ration means indicated no significant differences among rations. However, the linear and quadratic responses of total litter weaning weight to additional cottonseed meal were found to be significant at the 0.05 level. No other significant ration responses were found in the analyses of average kindling weight per litter, feed conversion, percentage of mortality or the arcsin transformation of percentage of mortality.

The significant quadratic regression of unadjusted total weaning weight on percentage of cottonseed meal was caused by better growth with the 3 and 5% rations (table 2). The significant linear regression of unadjusted total weaning weight on percentage of cottonseed meal reflects an increasingly harmful effect when more than the optimal level of cottonseed meal is included in the ration. When the ration means were adjusted to a constant number weaned and a constant number of rabbit feeding days per litter a less negative linear response was noted. This would be expected since the correlation between the total litter weaning weight and number weaned was + 0.95, the correlation between total litter weaning

TABLE 2  
Ration means and standard errors

| Ration         | Average kindling weight per litter |                       | Total litter weaning weight |                       | Feed conversion | Mortality | No. weaned | Rabbit feeding days |
|----------------|------------------------------------|-----------------------|-----------------------------|-----------------------|-----------------|-----------|------------|---------------------|
|                | Unadjusted                         | Adjusted <sup>1</sup> | Unadjusted                  | Adjusted <sup>1</sup> |                 |           |            |                     |
|                | pounds                             | pounds                | pounds                      | pounds                |                 | %         |            |                     |
| 1              | 3.97                               | 4.01 ± 0.08           | 20.06                       | 20.78 ± 0.37          | 3.96            | 26.9      | 5.1        | 204                 |
| 2              | 3.81                               | 3.82 ± 0.08           | 22.54                       | 20.29 ± 0.40          | 3.70            | 19.4      | 5.8        | 220                 |
| 3              | 3.93                               | 3.93 ± 0.07           | 21.24                       | 20.58 ± 0.37          | 3.98            | 25.5      | 5.4        | 209                 |
| 4              | 3.79                               | 3.74 ± 0.08           | 19.68                       | 18.85 ± 0.38          | 3.81            | 24.8      | 5.4        | 202                 |
| 5              | 3.86                               | 3.86 ± 0.09           | 16.61                       | 19.63 ± 0.43          | 4.36            | 37.1      | 4.4        | 184                 |
| Standard error | 0.09                               |                       | 1.26                        |                       | 0.21            | 4.6       | 0.3        | 13                  |

<sup>1</sup> Adjusted for covariance of number rabbits weaned and rabbit feeding days. In this type of analysis standard errors will differ among rations.

weight and rabbit feeding days was + 0.78, and the correlation between number weaned and rabbit feeding days was + 0.87. Therefore, when these data are adjusted for either number weaned or rabbit feeding days they are automatically adjusted to a large extent for the other.

The correlation between average kindling weaning weight per litter and number weaned was - 0.24 and the correlation between rabbit feeding days and average kindling weaning weight per litter was - 0.48. The larger the litter size the less milk each kindling would receive, on the average. Hence, individual growth would be retarded. Likewise with more total rabbit feeding days per litter there would still be less per individual in the larger litters. Since the correlations were smaller between the independent variables and average kindling weaning weight per litter than between these same variables and total weaning weight, the covariance analysis made less adjustment in the average kindling weaning weight per litter than for total litter weaning weight. This again may be traced back indirectly to percentage of mortality, the correlation between percentage of mortality and average kindling weaning weight being + 0.10, whereas the correlation between percentage of mortality and total litter weight was - 0.50. Therefore it seems that the harmful effect, if any, of increased cottonseed meal on growth was counterbalanced to a large extent (for individual kindling weaning weight) by the beneficial effect of making available more milk to the survivors of the litter.

Although the percentage of mortality was not found to differ significantly among rations, the data in table 2 suggest that the 9% of cottonseed meal may increase the percentage of mortality and thus depress total litter weight.

Studies by Cabell and Earle ('56), Stevenson and Earle ('57), and Hale and Lyman ('57) suggest that relatively high protein levels tend to prevent the toxic effects of free gossypol. Since the crude protein levels in the rations used in these investigations approximated 20 to 22% (table 1), it is possible that gossypol tolerance and amino acid balance might be more critical using rations containing 15 to 18% of protein, such as those commonly used in commercial rabbit production. Further studies involving controlled protein levels are needed to answer this question.

#### SUMMARY

Degossypolized cottonseed meal was fed to 30 mature female rabbits throughout 4 successive litters, using a split plot, randomized block design. When used as a replacement for soybean oil meal, at levels of 3, 5, 7 and 9% of the rations, no significant ration responses were found in the analyses of average kindling weaning weight per litter, percentage of mortality, or feed conversion. The linear and quadratic responses of total litter weaning weight to additional cottonseed meal were significant at the 0.05 level. Indications of a depressing effect on total litter weaning weight were found at the 7 and 9% levels. Results indicate that, at levels of

3 and 5% , degossypolized cottonseed meal is a satisfactory source of plant protein in rabbit rations.

#### LITERATURE CITED

- Cabell, C. A., and I. P. Earle 1956 Relation of amount and quality of protein in the diet to free gossypol tolerance by the rat. *J. Am. Oil Chemists' Soc.*, 33: 416.
- Federer, W. T. 1955 *Experimental Design, Theory and Application*, ed. 1. The Macmillan Company, New York, pp. 47, 287, 495.
- Hale, F., and C. M. Lyman 1957 Effect of protein level in the ration on gossypol tolerance in growing-fattening pigs. *J. Animal Sci.*, 16(2): 364.
- Holley, K. T., W. W. Harms, and R. W. Storherr 1955 Cottonseed meal in swine and rabbit rations. Georgia Exp. Sta. Mimeograph Series N.S. 12. Athens, Georgia.
- Stevenson, J. W., and I. P. Earle 1957 Protein — a modifying factor in gossypol toxicity. *Feed Age*, 7: 42.
- Voris, L., L. F. Marcy, E. J. Thacker and W. W. Wainio 1940 Digestible nutrients of feeding stuffs for the domestic rabbit. *J. Agr. Res.*, 61: 673.