Practical Significance of Gossypol in Feed Formulation[1]

KEITH J. SMITH, National Cottonseed Products Association, Inc., P.O. Box 12023, Memphis, Tennessee 38112

Abstract

It has been recognized that gossypol has a limiting effect on the usage of cottonseed meal in nonruminant rations. Extensive research supported by practical experience has shown that cottonseed meal may be a major oilseed supplemental protein source in nonruminant rations when care is taken to accept and adjust for gossypol limitations. Scientifically derived gossypol limitations will not significantly restrict cottonseed meal usage in practical nonruminant rations.

Gossypol has been the object of concentrated study for many years. Volumes of research data have been published on its chemistry and physiological-toxicological effects. For many years the National Cottonseed Products Association has actively supported research designed to allow increased cottonseed meal usage in nonruminant rations through minimizing the adverse effects of gossypol. Much has been accomplished and, while exact figures are not available, it is estimated that at least one third of the total cottonseed meal produced finds its ultimate use in nonruminant rations.

The purpose of this paper is to discuss the role of gossypol in restricting cottonseed meal usage in feeds formulated for the nonruminant. Research has adequately defined the limits of gossypol permissible in rations supporting efficient performance. Knowing the limitations on maximum gossypol levels in a specific ration and the characteristics of the cottonseed meal to be included, a ration may be scientifically formulated to make maximum use of cottonseed meal. Cottonseed meal usage in most rations for nonruminants is influenced more by fiber, energy and amino acid levels of the meal than by gossypol levels.

The level of cottonseed meal in a particular ration is dependent upon three factors: (a) restrictions or specifications imposed on the ration (these restrictions may be in the form of maximum or minimum amounts of any particular component or ingredient), (b) the economic aspects pertaining to individual ingredients or ingredient combinations, and (c) the chemical composition of the cottonseed meal and of alternate protein sources.

During the past two to three years mixed feed manufacturers have progressively increased their use of computers to take the time-consuming calculations out of ration formulations. The many different formulation programs used by the mixed feed manufacturer are basically similar. To formulate a specific ration, the computer is programmed with a set of restrictions. These restrictions place minimum and/or maximum limits on key nutrients, such as the various amino acids, minerals and vitamins. The program will also specify energy content. For example, a broiler ration program may specify "at least 10% alfalfa meal" or "a maximum level of 300 lb. of milo." These restrictions are specified by the nutritionists to assure a scientifically sound final ration.

The second step in formulating a ration, using a computer program, is to provide the program with the cost of the various ingredients available. The computer, having been programmed with the specific ration restrictions (or specifications), the nutritional characteristics of the available ingredients, and cost data then calculates the most economical method of combining the ingredients available into a ration which will meet the restrictions imposed.

This brief discussion is to illustrate that an ingredient is considered by the computer program as a source of several nutrients (energy, minerals, vitamins and amino acids), and not solely as a source of energy or protein or some other nutrient.

Let us go back to the use of cottonseed meal in scientifically formulated rations; the question comes up as to how these restrictions affect cottonseed meal usage. The first major concern is whether the nutritionist will include cottonseed meal as an alternate ingredient for consideration in the ration formulation program. Often cottonseed meal usage in nonruminant rations is curtailed by prejudice originating with impressions as to the toxic nature of gossypol, which has been so thoroughly investigated over the years. As will be pointed out later, this prejudice must be overcome and replaced by acceptance of maximum levels of gossypol in the final ration that will not affect animal performance.

Eliminating this prejudice against any cottonseed meal usage in nonruminant rations and including cottonseed meal as an alternate ingredient which may make up part of the final ration, the decision on the level of cottonseed meal in the ration is then based entirely on the meal's ability to supply nutrients more economically than other feedstuffs.

Certain nutrients vary between cottonseed meal production processes. These variations are important in determining the level of usage in scientifically formulated rations (Table I). Screw pressed cottonseed meals are relatively high in residual lipids and lowest in free gossypol and protein quality for nonruminants, as indicated by nitrogen solubility and available lysine. Prepress solvent meals are low in residual lipids and free gossypol and moderate to high in protein quality. Direct solvent meals are high in protein quality, moderate in residual oil, and highest in free gossypol. It should again be noted that there are meals which do not fit these general observations. It should also be pointed out that protein quality, as used in this discussion, refers only to the availability of essential amino acids for poultry and swine.

Since cottonseed meal must compete with soybean meal in nonruminant rations, it is interesting to compare the two oilseed meals without regard to process. Cottonseed meal is normally merchandized with less protein and more lipid and fiber than is contained in soybean meal. Cottonseed protein contains less of the amino acids lysine, isoleucine, leucine, and possibly threonine and valine, than soybean meal; it is equal to or exceeds soybean meal in all other critical amino acids. These differences in nutrients are directly involved in determining the competitive price and use levels for these two oilseed proteins in nonruminant rations. When these nutrients are taken into consideration in ration formulation, often the feed manufacturer will find considerable economic advantage in utilizing maximum amounts of cottonseed meal.

During the past couple of months we undertook an

[1] Presented at the Carl M. Lyman Memorial Symposium on Gossypol, AOCS Meeting, New Orleans, April 1970.

TABLE I
Analytical Values for Cottonseed Meals[a]

Meal	Prepress solvent		Screw press		Direct solvent	
	Mean	Range	Mean	Range	Mean	Range
Protein	41.7	(40.6 –43.0)	41.4	(39.9 –42.8)	42.1	(39.2 –45.3)
Lipid	0.8	(0.4 – 2.0)	3.9	(3.4 – 4.6)	2.1	(0.5 – 4.3)
Gossypol free	0.04	(0.02– 0.07)	0.03	(0.02– 0.03)	0.24	(0.02– 0.43)
Gossypol total	1.04	(0.83– 1.28)	0.96	(0.80– 1.09)	0.98	(0.83– 1.29)
EAF lysine	3.02	(2.68– 3.64)	2.36	(1.88– 2.87)	3.48	(3.38– 3.64)
N-Solubility	57.0	(52–67)	42.6	(31–62)	71.4	(62–78)

[a] National Cottonseed Products Association, 1970.

extensive review of the literature to determine what restrictions should be placed on free gossypol levels in the various rations. A number of experiments have been conducted with just one objective in mind, to demonstrate a gossypol effect. In many studies extreme stress is applied to the protein source which magnifies treatment effects. This procedure is not objectionable as long as the results are correctly interpreted. However, too often conclusions developed in artificial situations are applied to practical feeding conditions. From the review it has been possible to make practical recommendations which are scientifically sound and which may be used with confidence in practical feeding operations. The following recommendations were concluded from this review.

Ruminants

In animals with a functioning rumen, dietary gossypol has not been shown to affect performance. The rumen fermentation action and by-products render the gossypol inert. Symptoms of gossypol toxicity, however, have been demonstrated when gossypol has been injected into the bloodstream.

Broilers

Tolerance to gossypol may be affected by age and strain of birds, level of dietary protein, iron salts, alkaline materials and possibly other ration components. These variables account for the wide variation in gossypol tolerances in the literature. Broiler performance is not affected by dietary free gossypol levels up to 150 ppm (0.015%). Levels up to approximately 400 ppm (0.04%) in the ration may be fed successfully if ferrous sulfate is added at a 1:1 iron to free gossypol weight ratio.

In most cereal based broiler rations, lysine content is critical. Attention has to be given to maintaining adequate lysine levels when cottonseed meal is included in the ration. A simple corn-soybean meal broiler ration is marginal in lysine. Since cottonseed meal contains approximately two thirds of the lysine as soybean meal, the importance of this key ingredient is readily apparent. Combinations of cottonseed meal and soybean meal in a nutritionally adequate ration often have been shown to support greater performance than either when fed alone. (Fig. 1.)

Layers

Nutrient levels in cottonseed meal are compatible with requirements of the laying hen. Egg production is unaffected by dietary free gossypol up to 200 ppm (0.02%). Dietary levels of free gossypol up to 50 ppm may be fed without egg yolk discoloration. When higher levels of free gossypol (up to 150 ppm) are fed, protection against yolk discoloration is provided by supplementing with iron at a 4:1 weight ratio to gossypol. Since cottonseed lipids have been shown to enhance gossypol yolk discoloration, it is advisable to minimize residue lipid levels in the ration. (Fig. 2.)

Swine

Performance of growing-finishing swine is not affected by feeding rations containing up to 100 ppm (0.01%) free gossypol. A 1:1 weight ratio of iron to free gossypol may be used to inactivate free gossypol in excess of 100 ppm. Maximum level of supplemental iron recommended is 400 ppm. (Fig. 3.)

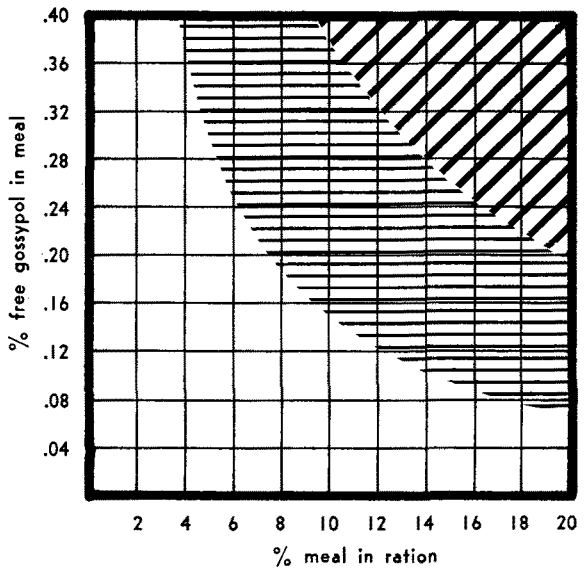

FIG. 1. Recommended cottonseed meal usage, broiler rations. □, Levels for efficient production in balanced rations; ≡, permissible for optimal performance with iron salt supplementation; ///, excessive free gossypol levels.

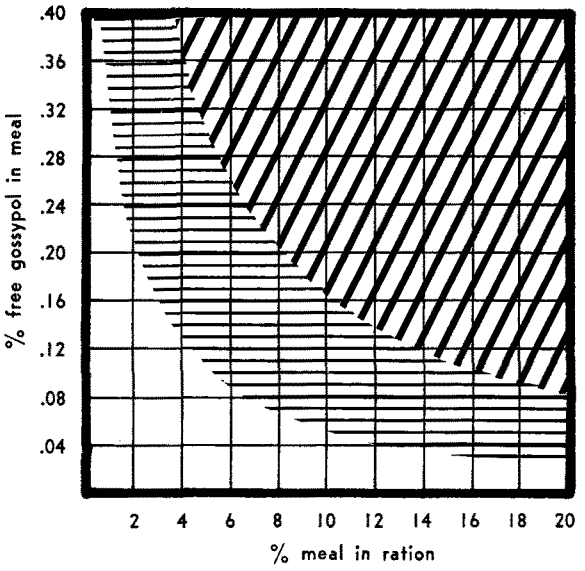

FIG. 2. Recommended cottonseed meal usage layer rations, yolk discoloration. □, Levels for efficient production in balanced rations; ≡, permissible for optimal performance with iron salt supplementation; ///, excessive free gossypol levels.

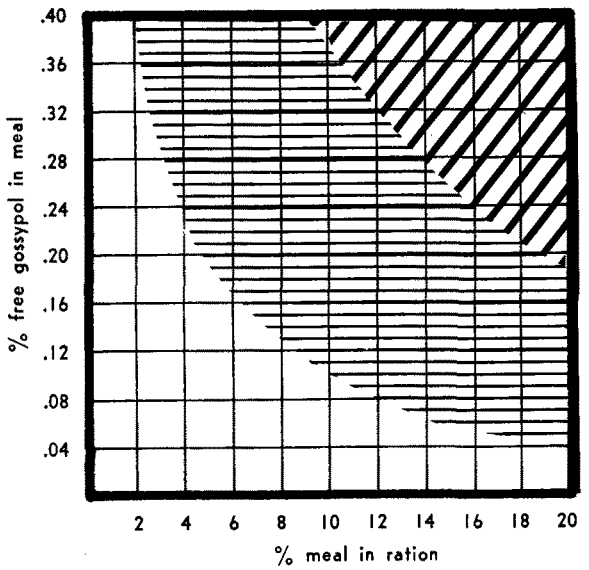

FIG. 3. Recommended cottonseed meal usage swine rations. □, Levels for efficient production in balanced rations; ≡, permissible for optimal performance with iron salt supplementation; ///, excessive free gossypol levels.

The level of an ingredient in a least cost ration is either specified in the program or is calculated to be the most economical source of total nutrients required. In other words, the value of an ingredient is based solely on its nutrient content, its ability to contribute energy, amino acids, vitamins and/or minerals to the total ration.

The maximum level at which it will be used in a ration will be based on two factors: price per unit and ration restrictions such as free gossypol contents, fiber, etc. Therefore, it is concluded that free gossypol may influence use both by creating prejudice against cottonseed meal and by restricting use to levels supplying only allowable free gossypol for optimum performance.

Usually it is safe to conclude that the low free gossypol level in screw press and prepress solvent meals is not a significant factor in determining use in practical swine and poultry rations. The upper cottonseed meal level is usually determined by the lysine-fiber-energy variables, assuming that the meal is economically competitive.

The higher free gossypol levels in direct solvent meals may limit quantities in selected rations or may necessitate the need to include iron salts to inactivate the free gossypol present. However, even with the gossypol restrictions imposed on high gossypol meals, sizable quantities of cottonseed meal may be used safely in nonruminant rations.

While it is true that processing variables, which influence fiber, energy, and amino acid levels in a meal, may make possible immediate and sizable gains in cottonseed meal usage in selected rations, the psychological problems associated with gossypol are still present. The removal of these psychological barriers, or unfounded prejudices, could greatly expand use of cottonseed meal in selected rations. Glandless cottonseed could greatly assist in obtaining wider acceptance of cottonseed meal for nonruminants. It may be that the full potential of cottonseed meal may not be realized until the psychological aspects are removed by the production of glandless meals or by methods of processing which remove gossypol.

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