Proceedings 5th World Rabbit Congress, 25-30 July 1992, Corvallis – USA, 1301-1313.

REPRODUCTIVE AND GROWTH PERFORMANCE OF NEW ZEALAND WHITE RABBITS FED DIETS CONTAINING COTTONSEED MEAL

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Abstract

Two studies were conducted to evaluate the effects of feeding diets containing graded levels of cottonseed meal (CSM) on the reproductive and growth performance of does and fryer rabbits. The CSM contained 0.675% and 1.124% free and total gossypol respectively. Study one utilized 64 multiparous does that were randomly assigned to four dietary treatments of 0%, 5%, 10% and 20% CSM. Each treatment was replicated to contain an equal number of 16 does. The does were subdivided into two groups of eight, to which two bucks fed either diets of the same CSM level or the control diet were assigned for breeding. The does fed 20% cottonseed meal had the lowest performance with respect to all the reproductive parameters measured, and also had the highest mortality rate of 93.75%. However, conception rates, birth weight, number of still-born, preweaning mortality and the weights at weaning were not significantly different (P>.05) between treatments. Buck performance was not significantly influenced by dietary effects. The does on the 10% CSM diet outperformed all of the other groups in all variables. The second study involved the fryers that were weaned from the same experimental does and continued on a fryer diet containing the same levels of CSM as the does for a 28 day growth study, and were placed in cages in a group of five or one per cage. The results showed that the fryers on the 20% CSM had the poorest performance irrespective of whether they were group-fed or in individual cages. It was concluded that 20% CSM (0.135% free gossypol in the diet) adversely affected both growth and reproduction, but at least 10% CSM (0.0675% dietary free gossypol) can be used without adverse effects.

Introduction

Cottonseed meal (CSM) is a widely available protein supplement used in animal feeding. It contains gossypol, a toxic phenolic compound, that can have adverse effects on animal health and performance (Cheeke and Shull 1985). Ruminants are less susceptible to gossypol toxicity than nonruminants because of the binding of free gossypol to soluble proteins in the rumen (Reiser and Fu, 1962). Possibly the same type of microbial detoxification could occur in the cecum of rabbit. McNitt (1981) reviewed the utilization of CSM by rabbits. Conflicting reports on the sensitivity of rabbits to gossypol suggest that further evaluation of the use of CSM in rabbit diets is necessary. Therefore the of objectives of this study were: 1). To evaluate the reproductive performance of does fed different levels of CSM over an extended period of time. 2). To determine if fertility of bucks can be affected by the consumption of CSM containing diets. 3). To evaluate the growth performance of weanling rabbits fed different levels of CSM.

Materials and Methods

The dietary treatments consisted of 0%, 5%, 10% and 20% cottonseed meal (CSM). The CSM was used to replace soybean meal on an isonitrogenous basis. All other nutrients were balanced to meet the requirement of reproducing and growing rabbits (NRC 1977, Cheeke 1987). The diets were mixed and pelleted at a commercial feed mill (Pendelton Grain Growers, Hermaston, OR) and were fed ad libitum to the animals throughout the experimental period. Tables 1 and 2 show diet composition and the chemical analysis. The does were individually housed in cages measuring (76 x 76 x 61 cm) equipped with a nest box, a J-shaped screened metal feeder (25.4cm long) and an automated waterer located in front of each. An additional 12 cages of 76 x 76 x 46cm with no nest box provision were used to house the bucks used for breeding and the replacement herds.
Sixty-four multiparous New Zealand White (NZW) does of varying ages and weights were randomly assigned to each of the four dietary treatments (16 does per treatment). Two mature bucks on each of the dietary treatments were used to breed the does. The 16 does were subdivided into two groups of 8 and bred to a buck fed either the CSM based diets or a control diet. The subdivisions are designated as (0%x0%, 0%x20%, 5%x0%, 5%x5%, 10%x0%, 10%x10%, 20%x0%, and 20%x20%), referring to the dietary combination on which either does or bucks were on.

All the standard doe management practices were observed with a breed back period of 7 days. Does that failed to conceive were returned to the same buck for rebreeding ten days after breeding. Those that were palpated to be pregnant were provided with a wooden nest box lined at the bottom with 3.2mm wire mesh containing laboratory grade wood shavings on the 28^{th} day of pregnancy. At kindling, litter size (number of kits born alive and weights) and those born dead were recorded. At day 21, the nest boxes were removed, and body weight measured. The kits were weaned on day 28. Does without a litter were fed a restricted amount of feed.

Does that died or were culled were replaced immediately, using the replacement criteria of Sanchez et. al. (1986), and the dead ones taken to the Veterinary Diagnostic Laboratory for determination of the cause of death. The nulliparous does kept for replacement were raised on the same experimental diet they were to be placed on later, and were bred at approximately 5-6 months of age. Upon weaning at day 28, the litters were placed into either a group of five or one per cage for the growth study. They were fed the same diet as they were on preweaning for an experimental period of 28 days, during which beginning weight, ending weight, feed consumption, and mortality were recorded.

All proximate analysis were determined by using the standard procedures of AOAC (1984). The CSM used in the formulation of the ration was analyzed for gossypol content by Hron et. al. (1990). Data were subjected to one way analysis of variance using the GLM methods of SAS (1991). Upon detection of significance, treatment means were separated by Duncan's multiple range method of means comparison (SAS 1991).

Results and Discussion

The diets and their chemical composition are shown in table 1 and 2 respectively. The nutrients were basically the same in all the dietary treatments except the gossypol content of the CSM, which is shown to 0.675 % and 1.124 % free and total gossypol respectively, which was reflected in the gossypol content of the diets. Table 3 shows the breeding combinations and the effects of CSM on the reproductive performance of the does. There was no difference with respect to percent conception rate among all treatments. All the other parameters were significantly lower from the combinations of 20%x0% and 20%x20% CSM diet, but these were not significantly different (P>.05) from the control diet. The performances of does on 5% and 10% CSM were similar and not different (P>.05) between each other. Difference in performances between does bred to bucks on either the same CSM levels or control diets were not significant (P>.05), indicating that the levels of CSM used did not significantly influence male fertility. Contrary, Randel et. al. 1992, suggested that at effective doses, gossypol causes males to be infertile.

Table 4 shows the litter preweaning performance. All variables were not significantly affected by the dietary treatments, except the average weight at day 21 and average weight at weaning. The highest average weight at day 21 was obtained from the 0%x0% combination (451.60 gm), but was not significantly different from the 20%x20% (376.56 gm) and 5%x0% (381.32). The average number of kits born per litter was not significantly different between treatment, but the average number weaned per litter was highest from those on 5%x5%, but was not significantly different from 0%x20%, 5%x0%, 10%x0% and 10%x10%. The lowest number of kits weaned per litter were from those on 0%x0%, 20%x20% and 20%x0% which significantly different from the rest. The possible reason for this observation may be due to the fact that there were fewer number of kits weaned per litter from these groups, hence they had more milk and subsequently, a better performance. The lowest weight at weaning was from the 20%x0%, and was significantly different from the rest of the treatment combination (P<.05). This might have also been related to gossypol toxicity, since the 20% CSM had high levels of gossypol.

Table 5 shows the effects of CSM on the reproductive performance of the 16 does per treatment irrespective of the buck diet. The number of litters born dead and the average weight at weaning were not (P>.05) significantly influenced by the dietary treatments. Other measured parameters were significantly lower (P<.05) between the does on the 20% CSM, and the rest of the treatments. Although the number of the litter born alive, weight at birth, number at day 21, and the average weight at weaning that were lower on the 20% CSM, they were not significantly different from the control diet. Doe mortality was very high (93.75%) for the group on 20% CSM. Out of the 16 does that were started on the experiment, only one survived to the end of the 12 months study, the rest including several of the replacements died, apparently of gossypol toxicity. This indicates that the diets containing higher levels of CSM (20%) influenced the performance of the does in all of the measured variables. The LD_{50} for rabbits is between 350 to 600 milligrams/kilogram of body weight (Randel et. al. 1992, Abou-Donia 1976). Higher levels of free gossypol are also known to depress intake and impair the ability of does to adequately support their kits, and in poultry, they are known to depress hatchability and egg production (Johnston and Berrio, 1985, Fitzsimmons et.al., 1989). Other studies have suggested that gossypol may have no effect on females (Nomier and Abou-Donia 1985), but Zirkle et. al. (1988), reported that embryos cultured in higher doses of gossypol acetic acid degenerated, suggesting that it may have a direct action on embryos. Randel et. al. 1992, also indicated that gossypol may have direct effects on developing embryos. In males, it has been reported that up to 99.9% antifertility efficacy was achieved in human subjects that received a 20 mg/day gossypol based pill for six months with their sperm showing decreased motility and malformed spermatozoa (Anonymous 1978). Chang et.al., (1980) also indicated that rabbits fed 10mg/kg of body weight gossypol acetic acid for 15 weeks had lower sperm numbers and the gossypol caused immotile, curved and detached head and tail of spermatozoa in rats and hamsters. Randel et. al. (1992) have reported similar observations. Thus it appears higher levels of gossypol were responsible for the poor performance of the does fed diets containing higher levels of CSM. The result of the growth trials either in group or individual cages is presented in table 6. The initial weights of the fryers on each of the dietary treatments were significantly ($P < .05$) different because all of the weaned rabbits were used without an attempt to equalize their body weights, a reflection in the overall net gain of the rabbits in both studies. Group survival was highest from the 5% CSM based diet. Out of the 38 groups of five fryers per cage placed on the 5% CSM, 25 groups survived without any mortality.

Mortality was highest from the rabbits on the 20% CSM diets in both trials (group and individual) being 32% and 34% respectively. This may be associated with the higher free gossypol levels (0.135%) in the 20% CSM which was higher that the FDA recommended dietary level of 0.04% for nonruminants. Several other reports have indicated that high levels of gossypol are known to cause mortalities in various species of animals (Akanbi et. al 1984, Balogun et. al., 1990). Waldroup, and Goodner (1973) indicated that increasing levels of gossypol are shown to correlate with increased mortality.

Mortality of fryer rabbits is not uncommon. One of the major causes implicated in mortality of young rabbits is enteritis, particularly if the diet contains high levels of starch, because such diets are known to allow bacteria such as *Clostridium spiroforme* to proliferate leading to diarrhea or enteritis. (Cheeke 1987; Sinkovics et. al. 1980a). In non-ruminants Haschek et. al. (1989) indicated that, toxicity and mortality problems can occur if the animals ingest dietary gossypol, which is then absorbed from the gastrointestinal tract and transported to the kidney, muscle, and other tissues. Mortality is believed to result when gossypol binds to the free epsilon group of lysine making it unavailable for protein synthesis which then results in problems like iron chelation in the gastrointestinal tract and liver causing anemia and inhibition of oxygen release from hemoglobin and subsequently, death. It is therefore, not surprising that rabbits on higher levels of CSM based diets had such a high percent mortality. However, it is not clear why mortality occurred from the groups on the control diet as high as in the group on the 10% CSM diet, but it may be associated with enteritis which is one of the main causes fryer mortality in rabbit production, (Cheeke et. al 1987).

Figure 1 shows the effects of CSM on average daily feed intake, average weight gain and feed efficiency in the two studies (grouped and individual). In both trials, the fryers on the 20% CSM diet showed a significantly poorer performance ($P < .05$) from the other treatments. Although the daily intake of free gossypol in 10% and 20% CSM based diets was high, it did not significantly influence the average daily feed intake of the individually caged fryers. High levels of gossypol in diets of different species of animals may result into depression of feed intake (Ofojekwu and Ejike 1984).

Summary and Conclusions

The effect of CSM on the reproductive and growth performance of does and fryer rabbits was studied for an extended period of twelve months. The does were individually caged and fed graded levels of CSM diets and bred to bucks that were either on the same levels of CSM or control diet. The fryers were weaned from the experimental does and continued on the same level of CSM for a 28 day growth study. They were placed either in a group of five or one per cage. The results indicated that performance of does fed higher levels of CSM diets significantly decreased with respect to all the variables measured, but there was no apparent influence of CSM on male fertility. Fryer performance in both growth studies also indicated that poor performance was correlated to higher CSM levels. Thus it can be concluded that does and fryer rabbits can fed diets containing up to 10% levels of CSM without adverse effects on doe and fryer performance.

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Table 1. Composition of Experimental diets Cottonseed Meal fed to Fryer and Doe rabbits.

	Control Diet		Cottonseed Meal Diets		
Ingredient	Doe Diet	Fryer Diet	5 % CSM	10 % CSM	20 % CSM
Suncured Alfalfa	54.00	56.50	54.00	54.00	54.00
Wheat Mill Run	21.00	37.00	21.00	21.00	21.00
Soybean Meal	20.00	- -	15.00	10.00	0.00
Cottonseed meal	- -	- -	5.00	10.00	20.00
Molasses	3.00	3.00	3.00	3.00	3.00
Corn	1.25	- -	1.25	1.25	1.25
*TM Salt	0.50	0.50	0.50	0.50	0.50
Dical. Phosph.	0.25	0.25	0.25	0.25	0.25
Bentonite	- -	1.25	- -		
Copper Sulfate	- -	.100	- -		
Meat Meal	- -	.82	- -		
Vitamin Premix*					

* The vitamin premix supplied the following quantities per kilogram of feed: Vitamin A 3,300 IU; vitamin D 1,100 IU; vitamin E 1.1 IU; vitamin K 0.55 mg; vitamin B_{12} 0.0055 mg; riboflavin 3.3 mg; pantothenic acid 5.5 mg; niacin 22 mg; choline chloride 220 mg; folic acid 0.22 mg; and ethoxyquin 64.43 mg.

*Trace mineral premix supplied per kilogram of feed, the following: Calcium 107.5 mg; manganese 60 mg; iron 20 mg; zinc 28 mg; copper 2 mg; iodine 1.2 mg and cobalt 0.205 mg.

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Table 2. Analytical Results of Cottonseed Meal and the experimental Diets.

Parameter	CSM[1]	Fryer Diet	Doe Diet	5 % CSM	10 % CSM	20 % CSM
DEnergy. Kcal/Kg	- -	2300.00	2844.27	2842.86	2810.74	2737.28
Dry Matter %	89.77	89.73	88.63	90.98	87.86	88.79
Crude Prot. %	41.25	16.00	18.59	19.70	18.31	18.37
Neut D. Fiber%	- -	41.24	38.14	35.94	35.60	37.24
Acid D. Fiber%	15.83	22.89	21.04	22.60	22.84	23.38
Fat %	1.50	2.89	2.71	2.65	1.69	2.47
Ash %	6.80	7.72	7.64	7.42	7.86	7.86
[2]Gossypol% Free	0.675	- -	--	0.034	0.068	0.135
Total%	1.124	- -	--	0.057	.01124	0.225

[1] Calculated value.

[2] Analyzed by Hron, R. J. of USDA Mid South Area Southern Regional Research Center, New Orleans Louisiana 70179.

Table 3. Performance of NZW Does fed graded levels of CSM based on treatment combination.

Diet Combinations	Parameters							
Doe x Buck	Number of time bred*	Times Kindled*	%Conception^{NS}	Number born Alive*	Number at day 21**	Number Weaned**	Number born Alive/litter	Number weaned Per litter
0% x 0%	5.50 ± 0.46^{a}	3.63 ± 0.38^{ab}	68.33 ± 7.73	17.62 ± 2.16^{c}	13.63 ± 2.17^{cd}	12.63 ± 2.28^{c}	$6.44 \pm .74^{NS}$	$4.59 \pm .67^{d}$
0% x 20%	6.00 ± 0.27^{a}	4.13 ± 0.55^{ab}	71.73 ± 11.07	32.50 ± 6.22^{abc}	24.75 ± 4.08^{abcd}	24.00 ± 3.89^{abc}	$7.98 \pm .73$	$6.58 \pm .38^{abcd}$
5% x 5%	5.38 ± 0.38^{a}	4.38 ± 0.32^{a}	84.10 ± 7.36	32.63 ± 5.08^{abc}	26.75 ± 3.65^{ab}	25.62 ± 3.36^{ab}	$8.20 \pm .59$	$6.59 \pm .33^{abcd}$
5% x 5%	5.62 ± 0.52^{a}	4.50 ± 0.65^{a}	79.10 ± 8.27	37.88 ± 8.13^{ab}	31.38 ± 6.76^{a}	30.00 ± 6.36^{a}	$8.62 \pm .74$	$7.65 \pm .54^{a}$
10% x 0%	4.71 ± 0.42^{a}	3.86 ± 0.46^{ab}	82.14 ± 7.37	29.86 ± 4.25^{abc}	25.86 ± 3.28^{abc}	25.28 ± 3.16^{ab}	$7.70 \pm .50$	$6.85 \pm .39^{abc}$
10% x 10%	5.63 ± 0.32^{a}	5.13 ± 0.35^{a}	90.92 ± 3.60	43.25 ± 3.51^{a}	34.38 ± 3.96^{a}	33.88 ± 3.89^{a}	$8.92 \pm .39$	$7.44 \pm .29^{ab}$
20% x 0%	3.38 ± 0.59^{b}	2.63 ± 0.63^{b}	75.00 ± 12.19	22.71 ± 2.77^{bc}	16.86 ± 1.87^{bcd}	16.43 ± 1.91^{bc}	6.68 ± 1.60	5.47 ± 1.24^{bcd}
20% x 20%	3.14 ± 0.55^{b}	2.57 ± 0.48^{b}	82.14 ± 7.37	16.71 ± 4.48^{c}	12.43 ± 4.62^{d}	12.29 ± 4.59^{c}	$6.88 \pm .96$	$4.90 \pm .68^{cd}$

^{abcd} Means within a column with a different superscripts is significant * ($P<0.01$) and ** ($P<0.02$).

^{NS} Means within a column without a superscript is not significant ($P>0.05$).

Means and standard errors are base on eight observations.

Table 4. Effects of CSM containing on Preweaning performance of litters.

Diet combinations	Parameter						
Doe x Buck	Average WT at Birth (g)	Average WT at Day 21 (g)*	Average WT at Weaning (g)**	Number Born Dead	%Preweaning Mortality	% Weaned at Day 28[NS]	Number of Does
0% x 0%	51.69 ± 5.38	451.60 ± 32.07[a]	938.83 ± 80.17[ab]	6.50 ± 2.52	32.06 ± 7.54	67.93 ± 7.54	8
0% x 20%	49.18 ± 3.83	370.37 ± 25.30[b]	928.81 ± 35.36[ab]	5.63 ± 2.99	20.41 ± 6.24	79.59 ± 6.23	8
5% x 0%	58.29 ± 2.94	381.32 ± 22.39[ab]	927.38 ± 35.00[ab]	6.00 ± 2.28	18.45 ± 3.90	81.55 ± 3.90	8
5% x 5%	55.90 ± 2.99	338.20 ± 15.82[b]	930.05 ± 59.58[ab]	6.38 ± 2.84	18.81 ± 7.15	81.19 ± 7.15	8
10% x 0%	60.38 ± 1.66	371.31 ± 11.63[b]	991.99 ± 71.17[a]	1.43 ± 0.61	12.09 ± 5.69	87.90 ± 5.69	8
10% x 10%	60.10 ± 2.26	336.62 ± 17.20[b]	922.36 ± 43.12[ab]	4.88 ± 1.39	22.95 ± 4.95	77.05 ± 4.94	8
20% x 0%	56.10 ± 2.79	322.58 ± 29.28[b]	803.43 ± 33.53[c]	6.86 ± 3.84	24.74 ± 6.48	75.26 ± 6.48	8
20% x 20%	53.38 ± 4.71	376.56 ± 38.10[ab]	909.23 ± 52.68[ab]	2.57 ± 0.48	25.99 ± 11.15	74.00 ± 11.15	8

[ab] Means within a column with a different superscript are significant * ($P<0.01$) and ** ($P<0.05$)

[NS] Means without superscripts are not significant ($P>0.05$).

Means and standard errors are based on eight observations.

Table 5. Means reproductive performance of does fed graded levels of CSM based diets irrespective of buck diet.

Parameter	Control Diet	5 % CSM	10 % CSM	20 % CSM
Aver. times bred	5.75 ± 0.26^{a}	5.50 ± 0.32^{a}	5.20 ± 0.28^{a}	$3.27 \pm 0.39^{b*}$
Aver. times kindled	3.88 ± 0.33^{a}	4.43 ± 0.35^{a}	4.53 ± 0.32^{a}	$2.60 \pm 0.39^{b*}$
No. Born /litter	7.21 ± 0.54	8.41 ± 0.46	8.35 ± 0.34	6.78 ± 0.90^{NS}
No. Born Alive	25.06 ± 3.72^{b}	35.25 ± 0.68^{a}	37.00 ± 3.18^{a}	$19.71 \pm 2.66^{b*}$
Ave. Live Wt (g)	50.44 ± 3.20^{b}	57.09 ± 2.05^{ab}	60.23 ± 1.38^{a}	$54.74 \pm 2.65^{ab*}$
No. Born Dead	6.06 ± 1.89	6.19 ± 1.76	3.27 ± 0.89	4.17 ± 1.96^{NS}
No. at Day 21	19.19 ± 2.65^{b}	29.06 ± 3.76^{a}	30.40 ± 2.76^{a}	$14.64 \pm 2.47^{b**}$
Ave. Wt at Day 21 (g)	410.98 ± 22.34^{a}	359.89 ± 14.38^{b}	352.80 ± 11.29^{b}	$349.57 \pm 24.27^{b**}$
Number Weaned	18.31 ± 2.63^{b}	27.81 ± 3.52^{a}	29.87 ± 2.71^{a}	$14.36 \pm 2.46^{b***}$
No. Weaned /litter	5.58 ± 0.45^{b}	7.12 ± 0.33^{a}	7.17 ± 0.24^{a}	5.18 ± 0.69^{bc}
Ave. Weaned Wt (g)	933.82 ± 42.35	928.71 ± 33.38	954.85 ± 39.94	856.33 ± 33.39^{NS}
Percent Weaned	73.76 ± 4.96	81.37 ± 3.94	82.11 ± 3.88	74.63 ± 6.20^{NS}
% Prewean Mort.	26.93 ± 1.93	21.10 ± 1.66	19.28 ± 1.57	27.17 ± 1.60^{NS}
Doe Mortality %	31.25	12.50	25.00	93.75

[ab] Means within the same row with a different superscript are significant * ($P<0.01$), ** ($P<0.02$) and *** ($P<0.05$).

[NS] Means within a row without a superscript are not significant ($P>0.05$).

Means and standard error are based on sixteen observations.

Table 6 Performance of Fryer Rabbits fed diets containing Cottonseed Meal

Parameter	Fryer Diet	5 %CSM	10 % CSM	20 % CSM
[1]Initial Wt. (g)	904.82 ± 25.81[c]	897.54 ± 22.11[d]	951.64±16.96[a]	920.50±30.93[b]
[1]Net Gain (g)	1040.04 ± 36.34[a]	1009.0 ± 21.22[a]	1020.0 ± 16.90[a]	949.0 ± 37.0[b]
Mortality N/N_2	14/56	21/83	7/88	16/50
% Mortality	25.00	25.30	8.00	32.00
	Group	Performance		
Initial Wt. (g)	1010.47 ± 14.67[a]	939.61 ± 13.12[c]	975.68 ± 16.78[b]	912.25 ± 22.59[d]
Net Gain (g)	984.52 ± 17.53[ab]	1025.25 ± 10.24[a]	947.98 ± 12.79[b]	823.83 ± 21.42[c]
Mortality	36/130	14/190	55/190	32/95
Group survival	8/26	25/38	17/38	6/19
% Mortality	27.69	7.37	28.95	33.68
Daily Gossypol Intake Free	- -	0.044	0.073	0.175
Daily Gossypol In. Total	- -	0.074	0.145	0.291

[ab] Means within the same row with the same superscript are not significantly different ($P > .05$).

[1] Means within the same row without a superscripts are not different ($P > 0.05$).

N_2 Number used based on leftover after group study was set.

[3]Calculated Value based on analytical results and feed intake.