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COTTONSEED MEAL AS A PROTEIN SUPPLEMENT IN WEANLING FOAL DIETS

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Thirty-two weanlings were employed to compare growth performance of foals fed diets containing soybean or cottonseed meal and to monitor potential liver damage due to ingestion of free gossypol. Foals were weaned one week prior to their four month birthday and fed a standard weanling ration. Foals were blocked by sex, sire, and birthdate and on the morning of their four month birthday were randomly assigned to one of four diets providing eight animals per group. The four diets utilized in the study are shown in table 1. Diet I served as the control and contained soybean meal as the principal protein supplement. Diets II through IV contained solvent extracted cottonseed meal (0.2% free gossypol) as the principal protein supplement. Diets II and III were identical with the exception that supplemental lysine (L-lysine HCl) was added to III to provide lysine levels equal to the control diet. Diet IV contained a 1:1 mixture of soybean and cottonseed meals. Weanlings were fed the concentrate diets in a 70:30 ratio of concentrate to Coastal bermudagrass hay twice daily in individual feeding stalls. Foals were allowed to eat to appetite for three hours. Concentrate and hay proportions were changed to 65:35 at 6 months of age (56 days). Weight, height and heartgirth measurements were taken on days 0, 28, 56, 84, and 112 of the feeding trial to assess growth. To monitor any effects gossypol might have had on liver, venous blood samples were taken on days 28, 56, 84, and 112. Samples were assayed for sorbitol dehydrogenase (SDH) (Sigma Tech Bulletin 50-UV), an hepatic enzyme present in serum only during episodes of altered plasma membrane permeability, as might be experienced from ingestion of a toxin. In addition, serum profiles (SMA 12/60, Technicon Instruments Company, Tarrytown, N.Y.) were conducted to assess any alterations in the overall serum profile. Liver biopsies were taken on day 112 for histological examination.

Results of the feeding trial are shown in table 2. Weanlings on treatments I, III, and IV made significantly ($P<.05$) greater weight and heartgirth gains and were more efficient at converting feed to gain than weanlings on treatment II. Also, foals in groups I, III, and IV consumed significantly more feed than those in group II. No differences in height gain were detected between treatments ($P<.05$).

All blood constituents monitored are shown in table 3. All values were within normal ranges of this laboratory with exception of SDH for foals in treatment II. The SDH levels in this group tended to be higher than others suggesting a change in hepatocyte membrane permeability allowing release of the enzyme. However, histological examination of liver samples revealed no lesions indicative of liver damage in any foal on any diet treatment.

TABLE 1. COMPOSITION OF CONCENTRATE DIETS (%) (AS FED BASIS)

	Diet			
Ingredient	I - SBM	II - CSM	III – CSM + LYS	IV – CSM + SBM
Crimped Oats	33.8	33.0	32.9	32.6
Cracked Corn	33.9	33.0	32.9	32.7
Soybean Meal	22.5	-	-	12.5
Cottonseed Meal	-	24.5	24.5	12.5
Molasses	7.0	7.0	7.0	7.0
Dical P	1.1	-	-	0.7
Gnd. Lime	1.2	2.0	2.0	1.5
TM Salt	0.5	0.5	0.5	0.5
Vitamin A*	+	+	+	+
Lysine (78.4%)	-	-	0.2	-
Calculated Analyses:				
Digestible Energy (Mcal/kg)	3.09	3.04	3.04	3.06
Crude Protein %	18.0	18.0	18.0	18.0
Calciumn %	0.85	0.85	0.85	0.85
Phosphorus %	0.65	0.65	0.65	0.65
Lysine %	0.86	0.64	0.86	0.78

[a,b,c] Means within the same row bearing different superscripts are significantly different (P<.05).

TABLE 2. GROWTH PERFORMANCE OF WEANLINGS THROUGH 112 DAYS [1,2]

	Treatment			
	SBM	CSM	CSM + LYS	CSM + SBM
Average Initial Weight	186.4	189.6	177.4	183.3
Average Daily Gain	0.63 [a]	0.46 [b]	0.68 [a]	0.63 [a]
Average Daily Feed	4.83 [a]	4.35 [b]	4.98 [a]	4.83 [a]
Feed/Gain	7.74 [a]	10.39 [b]	7.41 [a]	7.85 [a]
Average Initial Height	122.2	122.7	119.9	118.6
Average Height Gain	9.0	9.8	10.7	10.8
Average Initial Girth	129.3	131.1	127.0	128.3
Average Girth Gain	16.6 [a]	11.9 [b]	16.8 [a]	15.2 [a]

[1] Weights are in kilograms

[2] Height and girth measurements are in centimeters

[a,b] Means within the same row bearing different superscripts are significantly different (P<.OS).

TABLE 3. CONCENTRATIONS OF SERUM CONSTITUENTS AT 112 DAYS

	Treatment			
	SBM	CSM	CSM + LYS	CSM + SBM
SDH IU/l	2.2 [c]	6.8 [a]	4.7 [ab]	3.6 [bc]
Albumin g/dl	3.5 [a]	3.1 [b]	3.4 [a]	3.3 [a]
Calcium mg/dl	11.5	11.7	11.7	11.6
Phosphorus mg/dl	5.3	5.4	5.8	5.7
Clucose mg/dl	111	118	114	109
Blood Urea Nitrogen mg/dl	19	19	20	23
Creatine mg/dl	1.6	1.6	1.6	1.6
Total Bilirubin mg/dl	0.8	0.9	0.6	0.6
Alkaline Phosphatase IU/l	366 [c]	454 [a]	383 [bc]	435 [ab]
Creatine Phosphokinase IU/l	290	300	390	370
LDH IU/l	370 [b]	480 [a]	450 [ab]	420 [ab]
SGPT IU/l	13 [a]	8 [b]	14 [a]	4 [b]
SGOT IU/l	340 [ab]	385 [ab]	405 [a]	330 [b]
Total Serum Protein g/dl	6.6	6.1	6.3	6.3

[a, b, c] Means within the same row bearing different superscripts are significantly different (P<.05).

COTTONSEED MEAL AND GROWTH OF YOUNG HORSES

THE EFFECT OF COTTONSEED MEAL UPON GROWTH OF YOUNG HORSES [1]

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Summary

Twelve grade weanling fillies were blocked by weight and randomly assigned to experimental diets containing O, 10 or 20% low gossypol cottonseed meal. The isolysine and isocaloric diets were balanced to meet NRC growth requirements for weanlinq horses. The following growth measurements were taken every 28 days during the l80-day trial: body weight, body length, withers height, hip height, knee height, hock height, heart girth circumference and cannon bone circumference. Average daily gains for the 0, 10 and 20% cottonseed meal groups were .72, .77 and .66 kg respectively, while feed efficiencies were 10.8, 9.9 and 12.7 kg feed/kg gain. Neither of these two parameters was significantly affected by treatment. Blocking exhibited an effect on body weight (P<.Ol), heart girth circumference (P<.Ol), cannon bone circumference (P<.Ol) and body length (P<.05). There was a significant diet x time interaction for withers height as well as for cannon bone circumference. There were no apparent ill effects from the .04 free gossypol contained in the cottonseed meal. One subject contracted an illness not related to the experiment and was subsequently dropped from the trial. Data for this horse were generated according to the missing data formu1a for a completely randomized block.

Results and Discussion

Composition and analysis of the three experimental diets, as determined by AOAC (1970) procedures, are given in table 1. Analysis of variance is shown in table 2, and treatment means for all parameters measured are presented in tables 3 and 4. The varied levels of cottonseed meal had no significant effect on any of the measurements. However, there was a nonsignificant trend toward superiority for the control group in body length, hip height, hock heiqht and withers height. The control group was designated as that which consumed the diet containing no cottonseed meal and 20% soybean meal. The high cottonseed meal diet contained 20% cottonseed meal and the low cottonseed meal diet contained 10% cottonseed meal and 10% soybean meal. Since the weights of the animals varied from 204 to 283 kg on the initial day of the trial, four weight blocks were

created to eliminate this nuisance variable. Therefore, a significant effect due to blocking was expected for body weight and other closely related parameters, and such was found for body weight (P<.Ol), body length (P<.O5), heart girth circumference (P<.Ol) and cannon bone circumference (P<.Ol). Reed and Dunn (1977) measured growth rates of Arabian horses and observed a correlation (P<.O5) in males between length of body and body height. As evidenced by the standard errors, body weight was the most variable parameter measured. The same authors also noted that the greatest body weight gains occurred during the first 12 months of life. There was no significant difference in average daily gains or feed efficiencies among the three groups. The control group gained an average of .72 kg/day, while the low cottonseed meal group averaged .77 kg and the high cottonseed meal group .66 kg for the entire feeding period. Feed consumed per kilogram of weight gained averaged 10.8 kg for the control group, 9.9 kg for the low cottonseed meal group and 12.7 kg for the high cottonseed meal group. There was little variability within groups in cannon bone circumference, but there was a diet x time interaction (P<.05) for both cannon bone circumference and withers height. Further analysis indicated a superiority of the control diet over the high cottonseed meal diet, but the difference was not consistent over the 6-month period.

There were no apparent ill effects of the gossypol consumed by either of the cottonseed meal groups. Subjects did not exhibit common external symptoms of gossypol toxicity such as anorexia, lassitude or labored breathing. Safety was expected based upon the work of G. D. Potter (unpublished data), who successfully fed weanling foals .2% free gossypol in the cottonseed meal, whereas the present study used cottonseed meal with levels of .04% free gossypol. All groups exhibited vast improvements in appearance. Coat condition changed from rough and lackluster to a smooth, glossy sheen.

The results of this 6-month growth trial indicated that low gossypol cottonseed meal with added lysine is an acceptable source of supplemental protein for young horses. We suggest that the horse industry could safely update feeding recommendations to include more low gossypol cottonseed meal in diets that have been balanced to meet growth requirements.

Literature Cited

AOAC. 1970. Official Methods of Analysis (11th Ed.). Association of Official Analytical Chemists. Washington, DC.

Reed, K. R. and N. K. Dunn. 1977. Growth and development of the Arabian horse. Proc. 5th Equine Nutr. Physiol. Symp., p. 76.

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TABLE 1. COMPOSITION AND ANALYSIS OF EXPERIMENTAL DIETS

	Level of Cottonseed Meal		
Ingredients [a]	0%	10%	20%
Oat hay, kg (IFN 1-03-277)	227.3	227.3	227.3
Cottonseed meal, kg (IFN 5-07-872)	.0	45.5	90.9
Soybean meal, kg (IFN 5-04-604)	90.0	45.5	.0
Oats, kg (IFN 4-07-999)	52.3	52.3	52.3
Corn, kg (IFN 4-02-985)	54.5	54.5	54.5
Fat, kg	4.5	4.5	4.5
Molasses, kg (IFN 4-04-695)	22.7	22.7	22.7
Lysine HCl, kg	.0	.5	1.0
Ground limestone, kg	5.5	4.2	3.2
Vitamin A, IU	900,000	900,000	900,000
Trace mineral salt, kg	2.3	2.3	2.3
Total kg per mix	459.1	459.3	457.7
Dietary analysis, % [b]			
Ash	6.23	6.74	6.29
Crude protein	14.83	15.07	13.53
Lysine [c]	1.12	1.12	1.12
Ether extract	3.36	3.22	3.65
Crude fiber	15.44	17.01	15.72
Nitrogen-free extract	50.44	48.87	50.61

[a] Expressed as amount per mix

[b] Expressed on a dry matter basis

[c] Calculated value

TABLE 2. ANALYSIS OF VARIANCE FOR GROWTH MEASUREMENTS

		Measurements [a]							
Source	df	Body Weight	Body Weight	Withers Height	Hip Height	Knee Height	Hock Height	Heart Girth	Cannon Bone Circum.
Main Plot	11								
Block x weight	3	41,245.631**	439.048*	392.814	503.156	66.083	172.248	749.079**	26.945**
Diet	2	2270.749	245.552	293.409	181.148	89.737	150.965	3.731	2.750
Error (diet)	6	1903.217	52.062	132.468	164.727	39.184	43.175	47.682	1.814
Subplot	76								
Months	6	22,891.253**	355.553**	177.987**	150.729**	28.304**	30.105**	1344.711**	3.503**
(Diet) (Months)	12	149,041	5.008	4.281*	3.524	.883	1.116	14.323	.297*
Error (months) [b]	47	312.940	6.483	1.9215	2.756	1.040	1.159	9.560	.143

[a] Mean squares

[b] Seven degrees of freedom subtracted for missing data estimates

* P < .05

** P < .01

TABLE 3. TREATMENT MEANS FOR VARIOUS BODY MEASUREMENTS

		Month						
Measurement	%CSM	Feb	Mar	Apr	May	June	July	Aug
Body weight, kg	0	241.8±17.8 [a]	247.8±19.7	287.3±20.7	306.8±22.8	324.6±23.3	350.0±26.1	363.6±24.7
	10	233.8±13.5	268.9±17.7	290.6±21.0	304.5±24.3	330.9±27.1	357.8±30.3	375.7±32.7
	20	236.3±10.3	262.0±15.1	276.9±20.7	288.3±24.1	308.7±29.5	328.5±33.9	347.5±36.7
Body length, cm	0	130.4±2.6	131.6±2.8	135.8±2.9	140.0±1.9	141.0±1.9	144.2±1.6	147.1±0.7
	10	127.2±3.1	129.0±2.3	133.7±3.2	139.9±3.9	138.9±3.3	140.9±3.2	141.5±1.5
	20	126.1±1.7	127.9±2.4	130.8±2.5	133.6±3.4	135.2±4.1	137.4±4.0	138.9±4.0
Cannon bone circum, cm	0	16.9±0.4	17.0±0.6	17.3±0.5	17.4±0.5	17.7±0.4	17.8±0.3	18.0±0.3
	10	15.7±0.5	16.1±0.6	17.2±0.5	17.5±0.6	17.5±0.6	17.9±0.6	18.1±0.5
	20	16.1±0.5	16.6±0.7	16.9±0.8	17.0±0.8	17.0±0.9	17.0±0.9	17.2±0.9
Hearth girth circum, cm	0	144.8±4.2	150.4±3.6	157.3±4.1	163.4±3.3	166.4±2.9	170.2±4.0	172.0±5.3
	10	145.1±2.7	150.8±3.1	158.3±4.0	160.5±3.1	165.9±3.2	176.3±5.1	172.2±3.6
	20	145.9±0.9	151.0±2.1	155.9±3.0	163.2±2.6	167.4±3.6	169.6±2.9	175.5±2.0

[a] Treatment mean ± standard error

TABLE 4. TREATMENT MEANS FOR VARIOUS HEIGHT MEASUREMENTS

		Month						
Measurement	%CSM	Feb	Mar	Apr	May	June	July	Aug
Weithers height, kg	0	133.4±2.4 [a]	134.0±2.5	138.1±1.8	140.2±2.1	141.9±2.1	142.0±1.9	144.1±2.0
	10	125.8±1.8	128.9±2.0	132.0±2.3	134.7±2.1	136.4±1.9	136.9±2.1	138.8±2.2
	20	129.4±2.8	130.8±3.0	132.9±3.8	134.2±3.8	135.9±4.2	135.9±4.8	136.6±4.8
Hip height, cm	0	135.3±2.5	138.4±2.6	140.6±2.5	142.5±2.1	144.2±2.3	144.9±1.6	146.1±2.0
	10	132.1±1.6	134.3±2.5	136.5±2.4	139.0±2.1	140.3±2.4	142.2±2.5	143.7±2.4
	20	133.5±3.7	133.5±4.0	135.6±3.9	137.0±4.1	138.2±4.6	138.6±5.4	139.9±5.3
Knee height, cm	0	46.2±1.1	46.4±1.2	47.9±1.4	48.6±0.7	49.7±0.8	49.0±0.8	49.3±0.9
	10	44.1±1.0	43.8±0.6	45.3±0.8	46.7±1.0	47.1±1.0	48.1±1.1	48.8±1.2
	20	42.7±1.8	43.0±1.4	44.0±2.0	45.2±1.9	45.4±2.0	45.7±2.3	46.0±2.3
Hock height, cm	0	58.1±0.9	58.3±1.4	59.0±0.9	61.0±0.5	61.1±0.8	60.0±0.6	61.0±0.8
	10	57.2±1.8	57.4±1.8	57.8±1.3	59.4±0.9	61.0±1.3	59.6±1.2	60.3±1.3
	20	52.0±2.6	53.6±2.9	54.8±2.5	56.9±2.5	57.0±2.5	56.4±3.0	57.2±2.4

[a] Treatment mean ± standard error