Chick Feeding Tests on Treated Tung Meals

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Abstract

In attempts to detoxify tung meal, batches were treated with gaseous ammonia at 100 psi at room temp and at 110C, also at 110C with phosphoric acid, with sodium carbonate, and with urea, and by benzene extraction. The analyses of the meals for total, ammonia and nonprotein nitrogen, and for pH are given. The treated meals were fed to chicks by replacing half the protein in a standard chick ration by protein from the tung meals. All treatments except benzene extraction greatly reduced toxicity of the meal, but no ration containing tung meal was equal to the standard chick ration in its effect on rate of growth. The best meal was that treated with ammonia. The average gain in weight of chicks in 21 days (15th to 36th day) on the ration containing this meal was 247 g compared to 325 g for the chicks on the standard ration. None of the rations containing treated meals killed any chicks except the benzene-extracted meal. The untreated meal killed 23 out of 40 chicks and the survivors gained only 88 g in 21 days.

Introduction

TUNG NUTS ARE GROWN for the production of tung oil within about 75 miles of the Gulf coast of the states of Louisiana, Mississippi, Alabama, Georgia and Florida. Tung meal (or cake) is obtained as a by-product from the processing of the fruit for oil. Like the meal from other oil-producing seeds, tung meal has a high protein content (with an amino acid composition similar to that of cottonseed meal), and should make a good animal food except for its high toxicity. Several workers have studied the toxicity of tung meal (1–7,11,12,15). A patent (14) has been issued on a method claiming the detoxification of tung meal by ammoniation but no experimental work has been reported showing the effectiveness of the ammoniation treatment. A combination of heat treatment and extraction with ethanol eliminated most of the toxicity (4,9–11) but the process is too expensive for application on a commercial scale. Most workers have considered that tung meal contains at least two toxic substances (4,6,7,9–11), one insoluble in organic solvents such as ether and alcohol and comparatively heat labile and the other soluble in such solvents (but not extractable from the meal by petroleum ether) and comparatively heat stable. Watson (15) reported that saponification and oxidation destroyed the toxicity of the soluble toxins. Holmes and Rayner (6) found that saponification as well as ammoniation and acetylation destroyed their toxicity. These facts suggest that hydrolysis might destroy the toxicity of the soluble toxins.

Several treatments that offered promise of detoxifying the tung meal (treatments with ammonia, sodium carbonate, phosphoric acid, urea) and the effect on chicks of incorporating the treated meals in their rations are reported in this paper.

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Experimental Procedures

The tung meal used for the treatments was a commercial tung meal which had been in storage for 6 months in vapor-proof multi-wall paper bags. For the first 2 months it was stored at room temperature, then transferred to a cool room kept at 15C. After treatment the meals were stored another 4 months at room temperature before the chick-feeding tests were made. For comparison with the stored meal, a sample of untreated fresh meal which had been stored for three months before the feeding trials was also included in the feeding tests.

The treatments applied to the meal are shown in Table I. The treatments in which ammonia and urea were used were carried out in a specially built ammoniator which had a capacity of 50 lb of meal and was built to withstand a pressure of 500 psi. The ammoniator could be heated by electric strip heaters around the outside and contained a stirrer which could be run continuously. When treating the meal with gaseous ammonia a tank of ammonia was connected to the ammoniator and enough ammonia allowed to flow into the ammoniator to displace air. The discharge valve to the ammoniator was then closed and when the pressure had risen to 100 psi, the valve to the ammonia tank was closed. As reaction proceeded pressure in the ammoniator decreased. By opening and closing the valve to the ammonia tank, pressure in the ammoniator was kept at approximately 100 psi for 1 hr. The temperature in the ammoniator rose several degrees showing that reaction was taking place.

Another batch of meal was subjected to the same treatment except the temperature in the ammoniator was kept at 110C.

For the treatments involving urea and concentrated aqueous ammonia, the materials were thoroughly mixed

TABLE I
Treatments Applied to Tung Meal and Results of Feeding Tests on Chicks[a]

Meal No.	Treatment applied to tung meal	No. of deaths	Ave. gain in wt g
1.	Standard chick ration	0	325.4
2.	Ammoniated with gaseous ammonia at 100 psi and room temp	1	246.9
3.	Ammoniated with gaseous ammonia at 100 psi and 110C	2	241.3
4.	5% Phosphoric acid and 15% water added, heated at 110C	0	213.9
5.	4 lb concd aqueous ammonia per 100 lbs meal, heated at 110C	2	204.9
6.	Same as No. 4, then neutralized with 5% calcium hydroxide	2	203.3
7.	10% Sodium carbonate and 40% water added and heated at 110C	3	187.1
8.	Same as No. 5 except 16% water was added	1	177.8
9.	10% Urea and 10% water added and heated at 110C	2	162.9
10.	Benzene extraction	15	90.4
11.	Untreated tung meal about 9 mo old (Batches of this meal were given the above treatments)	23	88.2
12.	Untreated tung meal taken from mill just before chick feeding tests were started	28	53.4

[a] All treatments on the meals were carried out for 1 hr. Forty chicks were fed each ration for 21 days, one-half the protein of the standard ration being replaced by the protein of the tung meals. In the last column the vertical bars connect values that are not significantly different at a 5% level. See text.

TABLE II
Analyses of Tung Meals

Meal. No.	Moist %	Nitrogen on dry basis			pH
		Total %	Ammonia %	Non-protein %	
2	11.0	4.99	0.33	1.03	7.8
3	9.3	5.69	0.46	1.39	8.3
4	5.5	3.74	.....	.....	3.3[a]
5	8.2	4.66	0.29	0.78	7.3
6	7.1	3.38	.....	.....	11.9
7	22.1	3.14	.....	.....	9.5
8	17.6	4.88	0.44	0.93	8.7
9	15.3	8.12	0.24	4.46[b]	8.2
10	9.7	4.36	.....	.....	6.2
11	11.0	3.92	0.00	0.39	5.8
12	.....	3.79 (wet basis)	.....	.....	5.8

[a] The titratable acidity of this sample was 4.58 ml 0.1 N NaOH.
[b] Urea added should account for 3.67% of the nonprotein nitrogen.

with the meal and heated in the closed ammoniator for 1 hr at 110C.

The phosphoric acid and sodium carbonate treatments were carried out by thoroughly mixing the materials, then heating in an oven at 110C for 1 hr. The phosphoric acid-treated meal was enclosed in polyethylene bags to prevent contact of the acid with the metal trays.

All meals were analyzed for total nitrogen, moisture, and pH value and certain of them for ammonia and nonprotein nitrogen. (See Table II).

The tung meals were tested on chicks by mixing with a standard chick ration and keeping the feed before the chicks at all times. The standard ration consisted of the following proportions of materials: 25.6 soybean meal (50% protein), 51.1 yellow corn meal, 7.0 No. 2 tallow, 3.0 fish meal, 2.0 dried whey, 1.0 oyster shell flour, 2.0 dicalcium phosphate, 0.5 salt and 1.0 vitamin mixture. The tung meal rations were made by replacing one-half the protein in the standard ration by protein from the tung meals and varying the proportion of corn meal to keep the percentage protein in all rations the same.

The chicks were 2 weeks old when the feeding tests were started and had been on the standard ration for a week. The feeding tests were continued for 3 weeks. Forty chicks, divided into two batches of 20 each, were fed each ration containing the experimental meals.

The treatments applied to the meal, the number of deaths among the 40 chicks fed each ration, and the average gains in weights of the survivors at the end of three weeks are shown in Table I.

Discussion and Conclusions

The interpretation of the data on chicks receiving the different rations is complicated by the fact that both an attribute (death) and a measurement (gain in weight) should be considered.

Based on past experience with chicks about 1 out of 40 is expected to die from natural causes. By means of the chi-square test (13), it can be shown that significantly more deaths than 1 out of 40 occurred from the three meals at the bottom of Table I, but there is not a significant difference between the numbers of deaths resulting from these three meals.

Since for the rest of the treatments the number of deaths did not differ significantly from the expected 1 out of 40, an analysis of variance was run on the gains in weights at the end of 21 days (with unequal numbers of chicks per treatment because of the several deaths).

By this means the remaining meals were rated by Duncan's Multiple Range Test (8) as shown in Table I, where the average gains are arranged in descending order and those not significantly different at the 5% level are connected by vertical bars.

While no treatment of the tung meal produced a meal equal to the standard ration, every treatment (except benzene extraction) greatly reduced the toxicity of the meal. The best tung meal resulted from ammoniation with ammonia gas at 100 psi pressure, whether the ammoniation was done at 110C or at room temperature. The next best tung meals resulted from heating the meal at 110C with 5% phosphoric acid or with 4 lb of concentrated ammonium hydroxide per 50 lb of meal. Neutralization of the phosphoric acid with calcium hydroxide had no significant effect as compared with the meal containing un-neutralized acid. Heating the meal with 10% urea or 10% sodium carbonate gave even poorer results.

Other work has indicated that the toxicity of tung meal decreases on storage (4). Meal No. 11, portions of which were subjected to treatments No. 2–10, had been stored in vapor-proof bags for 9 months, about half that time at room temperature and the other half at 15C. Meal No. 12 was taken at the mill 3 months before the chick-feeding tests started and was subjected to no treatment. There was little or no difference in the toxicity of these meals, but it may have been because the meals were stored in vapor-proof bags which reduced oxidation.

It is also of interest that extraction with benzene (meal No. 10) had little effect on the toxicity of the tung meal. Much of our work on the soluble toxins has been done on the toxins obtained by extraction of the press cake with benzene, and this particular meal had been extracted in the pilot plant with benzene to obtain material for studying the soluble toxins. The soluble toxins seem to account for only a minor part of the toxicity of the meal.

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