AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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1. SUBJECT CLASSIFICATION

A. PRIMARY: Agriculture — AL30-0000-0000

B. SECONDARY: Animal nutrition

2. TITLE AND SUBTITLE

Effects of bird resistant sorghum grain and various commercial tannins on chick performance

3. AUTHOR(S)

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4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1974	16p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS

Purdue

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER

PN-RAA-440

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Chickens
Methionine
Sorghum
Tannic acid
Toxic tolerances

13. PROJECT NUMBER

14. CONTRACT NUMBER

CSD-1175 Res.

15. TYPE OF DOCUMENT

Effects of Bird Resistant Sorghum Grain and Various Commercial Tannins on Chick Performance

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Shortened Title: Tannin Effects on Chick Performance

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Introductio

Studies by Rostagno et al. (1973) and Armstrong et al. (1973) have shown that weight gain and feed conversion were reduced by feeding high-tannin sorghum grains to chicks at sub-optimal levels of protein (14-16%). Damron et al. (1968) substituted one-half of the corn in a 21.7% protein corn-soybean meal diet with either of three bird resistant or two non-resistant sorghum grains and observed no depression in feed consumption or chick weight gain due to the bird resistant varieties. Armstrong et al. (1973) showed that 0.15% supplemental DL-methionine improved the performance of chicks fed bird resistant sorghum grains up to that of non-resistant sorghum grain diets at a sub-optimal level of protein.

Several workers have shown that dietary tannic acid has a detrimental effect on chick performance (Chang and Fuller, 1964; Vohra et al., 1966; Rostagno et al., 1973; Armstrong et al., 1973) and rat performance (Handler and Baker, 1944; Glick and Joslyn, 1970a and b). Studies by Chang and Fuller (1964) and Fuller et al. (1967) have shown that additions of methionine, choline and other methyl group donors helped overcome the growth depression caused by dietary tannic acid, the extent of the improvement being related to the level of dietary tannic acid. Rayudu et al. (1970) studied the effects of adding reagent grade tannic acid, gallic acid, pyrocatechol and pyrogallol to chick diets. Pyrocatechol and pyrogallol, metabolites of tannic acid, were growth depressing at 0.1% and 2.0% produced nearly 100% mortality. Tannic acid was less growth depressing than either pyrocatechol or pyrogallol at 1.0% dietary levels with gallic acid being the least toxic.

The present study was conducted to determine the effects of feeding bird resistant sorghum grains to chicks at a more optimal level of protein and to observe the influence of supplemental methionine at this protein level. The maximal beneficial effect of adding methionine to non-resistant and bird resistant sorghum grain diets and the effect of supplementing a non-resistant sorghum grain diet with tannic acids of varying molecular weights were also investigated.

Experimental Procedure

Male, White Mountain chicks were randomly allotted to treatments at one day of age. Chicks were weighed, wing-banded and placed in electrically heated battery brooders with raised wire floors. Eight chicks were placed in each pen with four replicates per treatment. No two replicates of the same treatment appeared in the same battery or the same deck level of another battery. Feed and water were provided ad libitum during these 21-day studies.

The protein content of the sorghum grain and soybean meal was determined by the Kjeldahl procedure (A.O.A.C., 1960). Tannic acid equivalents of the grains were determined by the Folin-Denis Method as described by Burns (1963). Tannic acid equivalents of the grains used in the first two experiments are as follows: Experiment 1 (RS671, 0.56%; BR64, 1.70%). Experiment 2 (RS610, 1.12%: BR64, 2.02%). Protein contents of the grains are found in the tables for each experiment.

In Experiment 1, a non-resistant sorghum grain (RS671) was compared on an isonitrogenous basis to bird resistant sorghum grain (BR64) at 16 and 20% dietary protein levels (Table 1). The experiment was conducted to determine if the bird resistant sorghum had the same detrimental effects on chick performance at a more optimal level of protein (20%) as observed in previous experiments at sub-optimal levels of protein (14-16%) by Rostagno et al., 1973 and Armstrong et al., 1973. The effect of supplemental DL-methionine was also studied in this experiment. Isolated soy protein was added at the expense of glucose monohydrate to bring the protein level up to the 20% level.

In Experiment 2, non-resistant sorghum RS610 with and without supplemental tannic acid was compared on an isonitrogenous basis with bird resistant sorghum BR64 at a 14.8% dietary protein level (Table 2). DL-methionine was added at levels of 0, 0.15 and 0.30% of the diets to determine the maximal response from supplemental methionine.

Experiment 3 was conducted to study the effects of adding commercial tannic acid of different molecular weights to a non-resistant sorghum grain mixture and to determine the effects of supplemental DL-methionine (Table 4). The non-resistant sorghum grain mixture was composed of 57% RS610 and 43% RS671. The description and identification of the different tannic acids used in this study are found in Table 3.

Analysis of variance (Steel and Torrie, 1960) was used to statistically analyze final chick weight gain and feed conversion. In testing the main effects, the treatment X replication interaction was used. Individual treatment differences were tested by the Newman-Keuls Multiple range test (Steel and Torrie, 1960).

Results and Discussion

In Experiment 1, non-resistant sorghum RS671 produced significantly better ($P < 0.05$) chick weight gain and feed conversion than bird resistant sorghum BR64 when compared at the 16% dietary protein level (Table 1). These results agree with previous studies in our laboratories (Rostagno et al., 1973; Armstrong et al., 1973) in that bird resistant sorghum grains supported poorer chick performance than non-resistant sorghum grains when present in sorghum-soybean meal diets at sub-optimal levels of protein. Similar trends were noted at 20% protein, although the differences in weight gain were not significant. Sorghum RS610 supported approximately 13% better growth and significantly ($P < 0.05$) better feed conversion than BR64. These results indicate that the inferiority of bird resistant sorghum grains is manifested even at a more optimal protein level.

Another objective of this experiment was to observe the effects of supplementing these diets with 0.15% DL-methionine. A significant improvement ($P < 0.05$) in both weight gain and feed conversion was observed when these diets were supplemented with methionine (Table 1). In agreement with previous studies (Armstrong et al., 1973), the response from the supplemental methionine was of a greater magnitude

with bird resistant sorghum BR64 than non-resistant sorghum RS671 at both dietary protein levels. After methionine supplementation, the weight gains of chicks fed sorghum BR64 (Diets 6 and 8) were comparable to that of chicks fed sorghum RS610 (Diets 2 and 4) at both protein levels; however, the feed conversion for sorghum RS610 plus methionine at both protein levels was significantly better ($P < 0.05$) than the comparable BR64 plus methionine diets.

As previously observed, non-resistant sorghum RS610 supported significantly better ($P < 0.05$) chick performance than did bird resistant sorghum grain BR64 when fed to chicks at a sub-optimal level of protein Experiment 2(Table 2). The addition of 1% tannic acid to the sorghum RS610 diet (Diet 4) significantly ($P < 0.05$) reduced both chick weight gain and feed conversion with the weight gain being similar to that observed with sorghum BR64. Supplementation of sorghums RS610 and BR64 with 0.15% DL-methionine resulted in a significant improvement ($P < 0.05$) in weight gain as compared with the unsupplemented sorghum grain diets. However, the improvement observed was of a greater magnitude with sorghum BR64 than with sorghum RS610 as was previously noted. The 0.15% supplemental methionine also resulted in a significant ($P < 0.05$) improvement in feed conversion with the BR64 sorghum grain diet. The addition of 0.30% DL-methionine to the RS610 and BR64 diets resulted in similar chick performance as observed with these same diets supplemented with 0.15% methionine. Methionine addition at both levels to the RS610 plus tannic acid diet did not result in significant ($P > 0.05$) improvements in chick weight gain; however, there was a significant improvement ($P < 0.05$) in feed conversion as compared with the unsupplemented RS610 plus tannic acid diet. This lack of response to methionine in diets containing commercial tannic acid as opposed to the positive response noted in high tannin sorghum grain diets agrees with previous studies (Armstrong et al., 1973).

The identification and description of the tannins used in Experiment 3 are

presented in Table 3. Tannic acid B is a pentagallic ester of quinic acid, tannic acid C is an ester of gallic acid and glucose in a nominal 6:1 ratio and tannic acid D is a similar ester in a nominal 8:1 ratio.[2] No additional information was available concerning the other tannic acids studied.

The addition of 1.0% tannic acid from any source to the non-resistant sorghum grain mixture caused significant ($P < 0.05$) decreases in weight gains as compared with the unsupplemented sorghum grain control (Table 4). Although there appeared to be some differences among tannic acid sources, particularly gallo tannin D, none of the differences were statistically significant ($P > 0.05$). The addition of tannic acid also resulted in consistently poorer feed conversion as compared with the control diet (Diet 1) and the differences were significant ($P < 0.05$) for tannic acids A, C and D.

In all cases, the diets containing tannic acid which were supplemented with methionine produced significantly ($P < 0.05$) poorer weight gains than the methionine supplemented control diet (Diet 2). The methionine supplemented tannic acid diets also consistently supported poorer weight gains than the unsupplemented control diet (Diet 1), but the difference was significant ($P < 0.05$) only for tannic acid D (Diet 10). Methionine addition to the control or the tannic acid supplemented diets consistently improved weight gain and feed conversion, but the differences were significant ($P < 0.05$) only with the weight gains observed with the control diet (Diet 2) and the diet containing tannic acid A (Diet 4). Feed conversion of chicks fed all diets containing tannic acid plus methionine was significantly poorer ($P < 0.05$) than the corresponding control diet (Diet 2). From the results, it is difficult to draw conclusions concerning the effects of the characteristics and molecular weights of these tannic acids on chick performance. However, it would appear that tannic acid D (gallo tannin) is somewhat inferior to the other compounds.

These studies have indicated that bird resistant sorghum grain depresses chick performance when 20% as well as 16% protein diets are fed. The addition of 0.15% DL-methionine to the diet provides a practical means of overcoming the depressed chick growth. Feed efficiency of chick fed bird resistant sorghum grain diets supplemented with methionine may still be somewhat inferior to that of chicks fed non-resistant sorghum grain diets supplemented with methionine.

Acknowledgements

The authors wish to acknowledge the cooperation of Dr. J. D. Axtell a Mr. D. L. Oswalt, Department of Agronomy, Purdue University in providing t sorghum grain used in these studies. They also wish to acknowledge the co operation of the Mallinckrodt Chemical Works in providing the experimental gallo tannin used in Experiment 3.

Footnotes

[1]Journal paper number , Purdue University Agricultural Experiment Station. This investigation supported in part by the U.S. Agency for International Development under contract csd/1175- "Inheritance and Improvement of Protein Quality and Content of Sorghum bicolor (Linn.) Moench."

[2]Mallinckrodt Chemical Works, St. Louis, Missouri 63160.

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Table 1. Composition of diets and the effect of bird resistant and non-resistant sorghum grains on the weight gain and feed conversion of chicks fed diets containing 16 and 20% dietary protein (Experiment 1).

Ingredients (%)	Diets							
	1	2	3	4	5	6	7	8
Sorghum RS671 (10.5)[1]	54.87	54.87	54.87	54.87	-	-	-	-
Sorghum BR64 (8.8)[1]	-	-	-	-	65.39	65.39	65.39	65.39
Corn oil	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Premix[2]	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88
Soybean meal (51.4)	19.96	19.96	19.96	19.96	19.96	19.96	19.96	19.96
DL-methionine[3]	-	.15	-	.15	-	.15	-	.15
Isolated soy protein (86.5)	-	-	4.62	4.62	-	-	4.62	4.62
Glucose monohydrate	15.29	15.14	10.67	10.52	4.77	4.62	.15	-
Total protein (%)	16.0	16.0	20.0	20.0	16.0	16.0	20.0	20.0
Weight gain (g)[4]	227[c]	290[b]	305[b]	406[a]	179[d]	280[b]	269[b]	387[a]
Feed/gain ratios (g)[4]	1.93[b]	1.70[d]	1.63[e]	1.44[g]	2.29[a]	1.87[bc]	1.84[c]	1.56[f]

[1]Figures in parentheses represent the protein contents expressed as a percentage of air-dried feedstuff.

[2]The premix provided the following ingredients (in %); dicalcium phosphate, 2.1; limestone, 1.5; sodium chloride (iodized), 0.45; manganese sulfate $\cdot H_2O$, 0.01692; zinc oxide, 0.006; butylated hydroxytoluene, 0.0125; vitamin supplement, 0.7935. The vitamin supplement contained the following in units/kg.[3]: choline chloride, 2000 mg.; vitamin A, 5000 I.U.; vitamin D_3, 2250 I.C.U.; riboflavin, 8.8 mg.; calcium pantothenate, 17.6 mg.; niacin, 39.6 mg.; d-alpha tocopherol acetate, 8.8 I.U.; menadione sodium bisulfite, 1.4 mg.; vitamin B_{12}, 11.0 µg.

[3]98% pure

[4]Mean values for 21-day old chicks. Means bearing the same superscripts are not significantly different ($P > 0.05$).

Table 2. Composition of diets and the effects of dietary additions of tannic acid and methionine on the performance of chicks fed sorghum grain diets. (Experiment 2).

Ingredients (%)	Diets 1	2	3	4	5	6	7	8	9
Sorghum RS610 (11.3)[1]	52.25	52.25	52.25	52.25	52.25	52.2	-	-	-
Sorghum BR64 (8.1)[1]	-	-	-	-	-	-	72.25	72.25	72.25
Corn oil	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Premix[2]	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88
Soybean meal (50.2)	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75
DL-methionine[3]	-	.15	.30	-	.15	.30	-	.15	.30
Tannic acid[4]	-	-	-	1.0	1.0	1.0	-	-	-
Glucose monohydrate	20.30	20.15	20.00	19.30	19.15	19.00	.30	.15	-
Weight gain (g)[5]	211[b]	256[a]	230[ab]	133[c]	160[c]	166[c]	139[c]	245[ab]	255[a]
Feed/gain ratios (g)[5]	1.88[d]	1.76[d]	1.78[d]	2.34[b]	2.11[c]	2.04[c]	2.66[a]	2.09[c]	2.06[c]

[1,2,3]See footnotes in Table 1.

[4]Fluffy powde. molecular weight 1701, Nutritional Biochemicals Corporation, Cleveland, Ohio 44128

[5]See footnote 4 in Table 1.

Table 3. Identification and description of the tannic acids used in Experiment 3.

Identification used in this Experiment	Molecular weight	Source and Description
A	-	Fluffy Powder, Sigma Chemical Company, St. Louis, Missouri 63160
B	950	Purified Powder, Mallinckrodt Chemical Works, St. Louis, Missouri 63160
C	1150	Fluffy Powder, Mallinckrodt Chemical Works
D	1450	Experimental Gallo Tannin, Mallinckrodt Chemical Works
-	1701	Fluffy Powder, Nutritional Biochemicals Corporation, Cleveland, Ohio 44128

Table 4. Composition of diets and the effects of tannic acid of various molecular weights on the feeding value of non-resistant sorghum grains (Experiment 3).

Ingredients (%)	Diets											
	1	2	3	4	5	6	7	8	9	10	11	12
Sorghum grain (9.9)[1,5]	71.12	71.12	71.12	71.12	71.12	71.12	71.12	71.12	71.12	71.12	71.12	71.12
Corn oil	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Premix[2]	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88
Soybean meal (51.4)	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75
Glucose monohydrate	1.15	1.00	.15	-	.15	-	.15	-	.15		.15	
DL-methionine[3]	-	.15	-	.15	-	.15	-	.15	-	.15	-	.15
Tannic acid A	-	-	1.0	1.0	-	-	-	-	-	-	-	-
Tannic acid B	-	-	-	-	1.0	1.0	-	-	-	-	-	-
Tannic acid C	-	-	-	-	-	-	1.0	1.0	-	-	-	-
Tannic acid D	-	-	-	-	-	-	-	-	1.0	1.0	-	-
Tannic acid E	-	-	-	-	-	-	-	-	-	-	1.0	1.0
Weight gain (g)[4]	194^{b}	238^{a}	138^{ef}	181^{bc}	152^{cdf}	167^{bcde}	152^{cdf}	168^{bcde}	124^{f}	132^{f}	144^{df}	174^{bcd}
Feed/gain ratios (g)[4]	1.87^{cd}	1.78^{d}	2.12^{b}	2.00^{bc}	2.08^{bc}	2.01^{bc}	2.16^{b}	2.03^{bc}	2.37^{a}	2.23^{ab}	2.08^{bc}	2.01^{bc}

[1,2,3,4]See footnotes in Table 1.

[5]Non-resistant sorghum grain mixture: RS610, 57%; and RS671, 43%.