SOME TROPICAL HIGH TANNIN SORGHUMS AND THEIR EFFECTS ON BROILER PERFORMANCE

ODUHO G.W, BAKER D.H.

Abstract

Red or brown high tannin sorghum (HTS) cultivars form the predominant cereal grain grown in Kenya around the shores of Lake Victoria. A study was conducted to evaluate the feeding value of the HTS grain cultivars to broiler chickens. Analysis of tannin levels in these sorghums gave a concentration in the range of 3.22 to 7.40 % Catechin Equivalent (CE) and a mean of 4.52 % CE as compared to Low tannin sorghums (LTS) which had a range of 1.26 to 3.44 % CE and a mean of 2.78 % CE. Chicks on a 62 % HTS diet (3.70 % CE) showed a significant ($P<0.05$) reduction in feed intake of 10.5% and a reduced weight gain of 14.6 % compared to those on a 62 % LTS diets (0.63 % CE). An attempt to use three LTS diets with graded levels (0,0.05, 0.10 %) of tannic acid to create a standard curve as a biological assay to estimate the concentration of sorghum tannins was unsuccessful. The HTS and Medium Tannin Sorghum (MTS) produced performance values that fell beyond the curves. This indicated that the biological forms of tannins in sorghum are not identical to tannic acid in their effects in the chick. A tannin binder polyvinylpyrrolidone (PVP) gave significantly ($P<0.05$) better weight gains when added to the HTS diets at 0.05 % than at 0.25 %. The addition of intact protein from sunflower and fishmeal to HTS diets supplemented with crystalline lysine (0.5 %) plus methionine (0.3 %) were effective in enhancing the utilization of HTS by broiler chicks. Isocaloric and isonitrogenous diets of 62 % HTS (3.05 % CE) gave broiler chick performance that was equal to that of chicks on a 62 % maize diet (0.6 % CE).

Key words: Sorghum, tannin, PVP binder, broiler chicks.

INTRODUCTION

Grain sorghums can be divided into three groups based on the level of tannins as low, medium or high. Dark brown sorghums give higher yields compared to white or light brown sorghums but their use in non-ruminant nutrition is limited by the presence of high levels of tannins (Nelson et.al.,1975). Sorghum is generally deficient in lysine, methionine and threonine and its protein is less digestible than that of maize (Beuer and Dohn, 1972; Sikka and Johari, 1979). However, the bioavailability of these nutrient components to monogastric animals such as chickens varies according to the amount of tannin present in the grains (Nelson et. al., 1975). Some studies have reported that using high tannin sorghum as sole grain source depressed feed intake, body weight gain and feed efficiency in broiler chicks (Mitaru et. al. 1983). However other studies with broiler chicks have shown that low tannin sorghum can be utilized as well as maize when diets are kept isonitrogenous and isocaloric (Chang and Fuller, 1964; Price et. al., 1979). Feed additive binders, with a strong affinity for tannins have been used to bind the tannins, thus preventing them from binding to proteins. Studies by Rayudu et. al., (1970) showed that polymers like polyoxyethylene sorbital monoleate (Tween) and polyvinyl pyrrolidone (PVP) can overcome the toxicity of tannic acid added to chicken diets. Armstrong et.al., (1973) reported that addition of 1 % PVP overcame much of the growth depressing effects of commercial tannic acid added to low tannin diet as well as that of (HTS). Growth or weight gain tends to show a reduction when chicks are fed on HTS diets. However, the reduction in weight gain due to sorghum tannins is not consistent. Studies by Price et. al (1979); and Musharat and Latshan, 1991) reported no significant effect on weight gain when HTS diets were fed to chicks. The effects of sorghum tannins on feed conversion efficiency in chicken tend to be consistent but shows no high or clear correlation with the amount of tannin in the diet. The study reported in this paper consisted of several experiments to test the performance of broiler chickens on diets based on the HTS cultivars grown in Kenya.

MATERIALS AND METHODS

The sorghum cultivars used in the experiments were of white, cream, light brown and dark brown grain colours. In total 42 samples (cultivars or varieties) were collected analyzed and used in the study. The CE method was found to be best in ranking the sorghum by tannin content. The high and low tannin sorghum cultivars and maize (corn) were used to formulate diets designed to meet the nutrient requirements of broiler chicks (NRC 1984).

Chemical Analysis for Tannins: The vanillin – HCl with catechin method was found to be the best in ranking the sorghums by tannin content. Procedure as follows. Sorghum sample of 200mg. is ground to pass a 0.4 mm sieve. Within one day after grinding it is extracted with 10 ml. of methanol in capped, rotating test tubes for 20

minutes and centrifuged. Pipette one ml. sorghum sample aliquots of the extract into two test tubes, then add 5ml of 1 % Vanillin with 8 % HCl reagent to one of the test tubes and 5 ml. of 4 % Vanillin to the other at one minute intervals. The test tubes should remain in the water bath at 30 degrees Celsius until all samples have been analyzed. Determine absorbance after 20 minute at 500 nm. The difference in two absorbance values are then compared to a catechin standard curve. The values are reported as Catechin Equivalents (CE).

Management of chicks: For all the 5 chick experiments, commercial day old broiler chicks of mixed sex (Avian Bovans) were obtained from Kenbrid farms hatchery. The chicks were kept under normal brooding conditions during the first 28 days. During this time supplemental heat was provided to maintain room temperature in the range of 21 to 35 degrees centigrade with 24 hour lighting. Feed and water was provided ad libitum. Chicks were kept in experimental cages. During the first 7 days of life a maize – soybean diet was fed to the chicks. On day 8 chicks were individually weighed, weigh banded and assigned to the dietary treatments. Experimental diets were formulated to meet the nutrient requirements of broiler chicks (NRC, 1984). The experimental periods lasted 14 or 21 days. Feed intake and body weight gain were measured and feed conversion efficiency calculated as the performance indicators.

Experiment 1: Effects of HTS and LTS on the performance of broiler chicks - Two Basal sorghum diets; one purely High Tannin Sorghum (HTS) and the other a Low Tannin Sorghum (LTS) were used (Table 2). Each treatment consisted of 5 replicates (cages) with 5 chicks per replicate. Chicks were individually weighed on day 8 and 50 of them within the middle range weight (initial average weight of 96 grams) wing banded and randomly assigned to the two dietary treatments. The experiment lasted 14 days thus being terminated when the chicks were 22 days old.

Experiment 2: Evaluation of a biological assay using chicks and tannic acid to establish a standard curve for determining sorghum tannin concentrations. Since the broiler chick is sensitive to tannic acid, this experiment aimed at using graded concentrations of the acid to establish a standard growth curve with broilers and subsequently to use such a curve to predict sorghum tannin concentrations. A basal diet of LTS (Table 2) was used. To this diet was added graded levels of tannic acid at 0, 0.05 and 0.10 % to form the dietary treatments 1, 2, and 3 respectively. Three other treatments were also included i.e treatment 4 which was a HTS diet with a tannin binder (PVP) added at 0.05 %; treatment 5 which was formulated to provide 0.025 % sorghum tannin and treatment 6 which was formulated to provide 0.05 % sorghum tannins. The objective was to test if the broiler performance in treatment 4,5, and 6 would fall within the tannic acid standard curve established by treatments 1 to 3. The assay was 6 treatment diets by 4 replicates with 5 chicks per replicate. A total of 120 chicks of initial average body weight 97.8 grams were used. The experiment lasted 14 days.

Experiment 3: Evaluated the effect of plant and fish protein sources in improving HTS diets for broiler chicks. By calculation, 62 % of sorghum in the broiler diet, provides about 2000 kcal. ME/kg (8.4 MJ.ME/kg). The rest of the energy in the diet came from the protein sources. This experiment therefore tested the effect of a plant protein (sunflower) and a fish protein (high in lysine and methionine) in improving the nutritive value of HTS. The trial consisted of 5 dietary treatments replicated 3 times with 5 chicks per replicate. The basal HTS diet used is in Table 2. The basal diet was manipulated as follows: - Treatment one was an HTS diet balanced for energy, minerals and vitamins but low in protein 10 %. Treatments two and five modified this diet by increasing the protein level to 15%. No attempts were made to balance for lysine in the diets. A total of 75 chicks of initial average body weight of 102 grams were used. The experiment lasted 14 days.

Experiment 4: The effect of supplementing HTS diets with lysine and methionine on broiler performance. To treatment one to three was added corn oil, 0.5 % lysine and 0.3 % methionine. These levels were to adjust and satisfy energy, protein, methionine and lysine requirements in treatments one to three. The trial was the 5 treatment diets by 4 replicates with 4 chicks per replicate. A total of 80 chicks of average 98.6 grams initial body weight were used. The experiment lasted 14 days.

Experiment 5: To determine the optimal substitution level of HTS for white maize as an energy source in broiler chick diets. This experiment was to test if the HTS can be an effective substitute for maize as an energy source for broiler chicken. The substitution was calculated based on energy and protein levels to make the treatment diets as nearly isocaloric and isonitrogenous as possible (Table 2). The experiment consisted of 6 treatment diets replicated 3 times with 5 chicks per replicate. A total of 90 chicks of initial average weight of 99 grams were used. The experiment lasted 21 days. Statistical Analysis - The data from the 5 experiments were subjected to analysis of variance using the SAS, (1997) programme. The means were tested for significance and separated by Least Significant Difference (LSD) procedure (Steel and Torrie, 1980).

RESULTS

Analysis of sorghum tannins – Results of table 1 indicates the catechin method was effective in separating and ranking the sorghum cultivars. Experiment 1- The results in Table 3 indicate that HTS significantly ($P<0.05$) lowered chick performance in weight gain and feed intake but not feed conversion efficiency. The chicks on HTS diet performed less than the ones on LTS diet by 14.6 % in weight gain and 10.5

% in feed intake. Experiment 2 - The results in Table 4 indicate that graded levels of tannic acid (0, 0.05 and 0.10 %) to the LTS diet did give a negative trend of weight gain, feed intake and feed efficiency. However addition of HTS to provide 0.025 or 0.05 % tannins improved performance in weight gains, feed intake and efficiency that fell above the standard curve of tannic acid treatment. The tannic acid curves of weight gain or feed intake were therefore not useful in estimating the tannin concentration in HTS. Use of the tannin binder PVP significantly ($P<0.05$) improved chick performance on the HTS diet beyond the LTS diet.

Experiment 3 - The results in Table 5 indicate that intact protein from sunflower or fishmeal greatly improves HTS for broiler chicks. Experiment 4 - The results in Table 6 shows that the performances in weight gain and feed intake of treatments one and two were not significantly different. This is an indication that sorghum proteins are efficiently utilized when the deficiencies of lysine and methionine are corrected. Experiment 5 - The results in Table 7 showed no significant differences ($P<0.05$) in weight gains, feed intake and conversion efficiency at any level of substitution. The HTS diets gave broiler chick performance that was equal to performance on maize (corn).

DISCUSSION

In experiment one, chicks on the 62 % HTS diet (3.70 % CE) showed significantly poor performance in feed intake and weight gains than the ones on 62% LTS (0.63 %CE). The HTS feed intake was 10.5 % and weight gain 14.6 % less than the ones on LTS. The reduction in feed intake of HTS due to tannins is in agreement with the results of Mitaru et. al. (1983) and Ibrahim et. al. (1988). The reduction in weight gains is in agreement with the studies of Douglass et. al. (1990b); but not with the studies of Rostagno et. al. (1973); and Price et. al. (1979). In experiment 2 graded levels of tannic acid added to an LTS diet (0.61 % CE) did not give useful standard curves for a biological assay to estimate the concentration of sorghum tannins, since the MTS and HTS used produced performance values that fell above the curves. The results suggest that the biological forms of tannins in sorghum did not produce similar effects in broilers chicks as tannic acid. The tannin binder PVP gave significantly better weight gains when added to the HTS diet at 0.5 % than at 0.25%. Featherston et. al. (1982) demonstrated that addition of 1% PVP to a sorghum based diet improved weight gain and nitrogen retention in broiler chicks. Results of experiment 3 demonstrated that intact proteins from sunflower and fishmeal are effective in enhancing the utilization of HTS by broiler chicks. Likewise experiment 4 results demonstrated that HTS proteins are efficiently utilized when its deficiency of lysine and methionine are corrected. Non-chemical methods of detoxifying HTS therefore include increasing the dietary proteins level (Armstrong et. al. 1974a). In experiment 5 the 62 % HTS diet (3.05 %CE) performed equal to 62 % maize diet (0.6 % CE). This indicates that in balanced diets that are isocaloric and isonitrogenous the HTS will give broiler chick performance that is equal to that on maize. The high tannin sorghum varieties grown in (the Lake Victoria region) have average tannin concentration of 4.5 %CE. These sorghums account for about 60 % of all sorghums grown in the region. These HTS when mixed in feeds at 62 %, the tannin concentration in the diets analyze at about 3.0 to 3.5 % CE. It seems that these levels produces no adverse effects to broiler chicks when there is adequate protein from sunflower and fishmeal or supplementation with lysine and methionine.

ACKNOWLEDGEMENTS

The funds for this research were provided by the World Bank and Kenya Government under the U. I. P., Cr 2309. Egerton University, Njoro provided the necessary facilities for the research.

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Received for publication on January 6 , 2003
Accepted for publication on May 25, 2005

Tab. 1. : Results of tannin analysis of 42 sorghum cultivars using the catechin method:

Color Classification	Percent of all sorghums	Tannin Estimate	% CE Range	% CE Mean	S.D.	C.V.
Red/Brown	57	High	3.22-7.40	4.52	1.03	22.78
Medium-light brown	26	Medium	2.44-5.48	3.06	1.26	41.00
Cream	16	Low	1.26-3.44	2.78	1.57	56.00
White	1	Trace	0.08-1.56	0.82	0.05	6.00

C.V. = Coefficient of variation CE = Catechin Equivalents
S.D. = Standard deviation

Tab. 2. : Composition of diets used to determine the optimal substitution levels of HTS for maize in broiler chick diets. Substitution on energy and protein basis.

Ingredients		Diets g/kg.							
		HTS	LTS	1	2	3	4	5	6
White maize		-	-	620	370	289	203	120	-
HTS		620	-	-	250	333	413	500	620
LTS		-	620	-	-	-	-	-	-
Sunflower meal		200	200	-	-	-	-	-	-
Corn gluten meal	-	-	275	270	265	260	260	255	
Fishmeal (R. argentea)		100	100	50	50	50	50	50	50
Mineral mixture[1]	50	50	25	25	25	25	25	25	
Corn Oil	28	28	25	30	32	34	36	38	
Vitamin mixture[2]	2	2	2	2	2	2	2	2	
Filing material (sand)		-	-	3	3	4	6	7	10
Calculated Analysis									
CP %		21.00	21.00	23.59	23.79	23.66	23.52	23.69	23.63
ME (MJ/kg)		12.68	12.68	13.55	13.44	13.41	13.33	13.30	13.31
Methionine %		0.42	0.42	0.5	0.5	0.5	0.5	0.5	0.5
Lysine %		1.10	1.10	1.2	1.2	1.2	1.2	1.2	1.2
Tannin % CE Analyzed		3.7	063	-	1.23	1.64	2.05	2.46	3.05

1. Mineral mixture[1] provided per kg diet: Calcium, 15g; Iron, 18.4mg; Manganese, 50.4mg; Zinc, 50mg; Cobalt, 0.8mg; Iodine, 1.6mg; Copper, 11mg, Selenium, 0.08mg; Nacl, 8.5g.
2. Vitamin mixture[2] provided per kg diet: thiamine HCL, 20mg; riboflavin, 10mg; D-ca pantothenate, 30mg; Vitamin B12, 0.04mg; Pyridoxine HCL, 6.0mg; D-biotin, 0.9mg; folic acid, 4mg; ascorbic acid, 240mg; retinyl acetate, 180 ug; D3, 15ug.

Tab. 3. : Performance of broiler chicks on HTS and LTS diets during 14 days.

Treatment	Weight gain	Feed intake	Feed conversion
Diet	g/chick	g/chick	g/kg feed
HTS	193 a	671 a	287 a
LTS	226 b	750 b	301 a
S.E.M	5.4	12.6	8.8

Means in the same column with different letters are significantly different (P<0.05)
S.E.M. Standard Error of Mean.

Tab. 4. : Performance of broiler chicks on LTS diets with graded levels of tannic acid or PVP during 14 days.

Treatment	Weight gain	Feed intake	Feed conversion
Diet	g/chick	g/chick	g/kg feed
LTS+ 0 % TA	211 a	628 a	310 a
LTS + 0.05 % TA	140 b	652 a	215 c
LTS + 0.10 % TA	85 c	584 b	146 d
HTS + 0.5 % PVP	236 ad	669 a	366 a
LTS+ HTS 0.025%ST	253 d	697 c	382 a
LTS+ HTS 0.05% ST	231 ad	63` a	366 a
S.E.M	12.54	23.60	15.64

Means in the same column with different letters are significantly different (P<0.05)
TA – Tannic acid; ST – Sorghum tannin S.E.M. Standard Error of Mean.

Tab. 5. : Performance of broiler chicks on HTS diets supplemented with protein from sunflower or fish meal during 14 days.

Treatment	Weight gain	Feed intake	Feed conversion
Diet	g/chick	g/chick	g/kg feed
HTS + No protein	-13 a	371 a	-35 a
HTS + sunflower	199 b	600 a	332 b
HTS + fish meal	243 c	658 b	368 bc
HTS55%+7%LTS+sun +fish	264 c	650 b	378 bc
HTS48+14%LTS +sun.+fish	256 c	647 b	396 c
S.E.M	9.6	15.0	24

Means in the same column with different letters are significantly different (P<0.05)
Sun =Sunflower S.D. = Standard Deviation.

Tab. 6. : Performance of broiler chicks on HTS diets of experiment 3 supplemented with lysine 0.5 % and 0.3 % methionine.

Treatment	Weight gain	Feed intake	Feed conversion
Diet	g/chick	g/chick	g/kg feed
HTS + Lys. + Met	202 a	595 a	338 a
HTS + Sun + Lys.+ Met	216 a	620 a	348 ab
HTS + fish + Lys. Met	250 b	667 b	375 b
HTS + Sun + Fishmeal	266 b	702 c	379 b
HTS + Sun.+ Fishmeal	270 b	685 b	394 bc
S.E.M	11.80	15.4	23.0

Means in the same column with different letters are significantly different (P<0.05)
Sun =Sunflower S.E.M. = Standard Error of mean. Lys= Lysine; Met= Methionine

Tab. 7. : Effects of sorghum and maize inclusion levels on the performance of broiler chicks during 21 days.

Treatment Diet figures in percent	Weight gain g/chick	Feed intake g/chick	Feed conversion g/kg feed
1. Maize 62%	370 a	917 a	400 a
2. Maize 37.0 + 25.0 HTS	364 a	901 a	400 a
3. Maize 28.9 + 33.3 HTS	334 a	961 a	350 b
4. Maize 20.3 + 41.3 HTS	361 a	949 a	380 ab
5. Maize 12.0 + 50.0 HTS	343 a	865 a	390 a
6. HTS 62 %	358 a	877 a	400 a
S.E.M	18.6	39.7	21

Means in the same column with different letters are significantly different ($P<0.05$)
S.E.M. = Standard Error of mean.

Corresponding author:

Dr.Oduho, G.W
Animal Science Department,
Egerton University, P.O. Box 536,
Njoro, Kenya.