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Effect of *Aloe barbadense* Leaf and Gel Aqueous Extracts During the Starter and Finishing Phases of Broiler Production

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Abstract: Leaf and gel extracts of *Aloe barbadense* are added to the drinking water in local broiler production to reduce mortality and enhance broiler performance. In this study, 420 day-old chicks (Aber Acres) were randomly divided into 7 groups of 60 chicks of mixed sexes of 20 per replicate (3 replicates per group). The experiment used a 2 x 3 x 3 randomized design with three experimental treatments of either Aloe vera (*Aloe barbadense*) gel T1, T2, T3, or leaf (T4, T5, or T6) and one control. Across the 42-day grow-out period, there were no significant differences ($p>0.05$) in feed intake (FI), water consumption (WI), average daily gain (ADG), or feed-conversion ratios (FCR) across treatments. At the end of 21 days, however, the lowest FCR indicator of best performance was found in the T6 20 mL-treated leaf extract group. However, both the 20 mL leaf and 15 mL gel extracts were likely to produce birds of similar weights as traditionally formulated feeds for broilers. Therefore, poultry producers should include a moderate level of Aloe vera gel and the highest leaf extracts in the drinking water, as these extracts may prove to be more cost effective than manufactured feeds for optimal broiler performance. It may also be more cost effective for the poultry producer to use the 20 mL leaf and gel extracts as a means of reducing overall mortality. The finding that compounds in Aloe vera foster less bone deposition and greater muscle accretion in female broilers warrants further investigation.

Key words: Aloe vera gel, leaf, mortality, FCR, dressing percentage, leg and breast, meat-to-bone ratio

INTRODUCTION

Trinidad and Tobago are two adjacent islands located northeast of the Venezuelan coast. The republic is located between latitudes 10° and 11° north and spans a longitude of 61° west, which has a combined area of 5070 km square and a population of approximately 1.3 million inhabitants (CSO, 2011). The dry season is from January to May/June and wet season is from July to December with sporadic rainfall patterns in both seasons.

The poultry industry comprises over 3000 traditional cottage or small-scale poultry processors, four conventional processing plants and over 500 contract farmers. The Trinidad and Tobago Poultry Association has reported that the industry produces an excess of 40 million heads of finished broilers per annum, or 80,000 tonnes, with a value of approximately 1.4 billion Trinidad and Tobago dollars (Phillip, 2011). The Trinidad and Tobago population consumes approximately one million heads of chickens per week; however, since 2014, corn, soybean and wheat prices of raw materials for feed manufacture have increased by 20 to 30%. Feed is approximately 70% of the cost of a chicken for production at the farm gate (Phillip, 2014). Management practices that reduce feed cost of production would benefit poultry producers.

Aloe vera (*Aloe barbadense*) is native to Africa but also grows naturally in the Middle East, Australia and the West Indies, including Trinidad, where it is easily available to poultry farmers. Several studies have shown that broilers kept on conventional diets supplemented with Aloe water have improved weight gains without significant improvement in feed conversion ratios (FCR) (Christaki and Florou Paneri, 2010; Olupona *et al*., 2009; Delmar *et al*., 2009; Darabighane *et al*., 2011); however, in other additional, broilers administered Aloe extracts had both improved weight gains and feed intake (Wang *et al*., 2007; Mehala and Moorthy, 2008a; Mehala and Moorthy, 2008b). Extracts containing Aloe and turmeric (*Curcuma longa*) have also produced an improved FCR in early growth (Mehala and Moorthy, 2008b), whereas dressed weights of breast, leg and thigh weights have been improved at higher Aloe vera concentrations combined with other naturopathics like clove (Olupona *et al*., 2009; Doley *et al*., 2014; Tariq *et al*., 2015). However, in these studies, abdominal, breast, or thigh fat weights did not differ in broilers administered Aloe vera-treated water compared to those on non-treated water.

Some studies have also shown that inclusion of Aloe vera powder in broiler diets results in an increase in haemagglutination inhibition titres associated with the

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Newcastle disease virus (NDV), whereas other studies reported a reduction in mortality and severity of clinical signs in the acute phase of infection (Waihenyaa *et al*., 2002; Akhtar *et al*., 2012). Additional studies have demonstrated that Aloe vera extracts produce a significant reduction in oocyst counts and intestinal lesions due to coccidiosis (Akhtar *et al*., 2012; Durrani *et al*., 2008; Dongjean Yima *et al*., 2011). Therefore, this plant has the potential to be an antiviral agent, anticoccidial and, as shown recently, may also act as a substitute for antibiotics in growth promotion in poultry production (Amaechi and Iheanetu, 2014).

In Trinidad, small-scale rural poultry producers traditionally use Aloe vera as a diarrhoeic and growth-enhancer in broiler production. Similarly, contracted poultry large scale producers traditionally grind whole leaves of the *Aloe barbadense* (Aloes) plant and place the macerated extract into a pair of suspended 'socks' into 500 gallons water tanks to dispense the Aloe vera water during the first four weeks of the starter phase of broiler production (Lans *et al*., 2007). A preliminary comparison without replicated treatment of the use of the gel into the drinking water indicated an improvement in broiler performance in the starter phase of production (Mohammed, 2015). The purpose of this experiment was to compare growth rates, FCR and carcass evaluation in six batches of broilers using different volumes of Aloe vera leaf and gel extracts per unit volume of the drinking water.

MATERIALS AND METHODS

A total of 420 day-old broiler chicks (Aber Acres) were randomly divided into 7 groups of 60 chicks of mixed sexes, 20 per replicate (3 replicates per group). The experiment was a 2 X 3 X 3 randomized design with 2 experimental treatments of either Aloe vera (*Aloe barbadense*) macerated whole gel or whole leaf including one control without treatment. Both gel (T1, T2 and T3) and leaf (T4, T5 and T6) treatments were included at 10, 15 and 20 mL per 3 litres via a graduated 25 gallon water-dispensing plumbing system and randomly assigned to 6 groups compared with the control to which only drinking water was dispensed. The gel extract consisted mainly of the inner gel and adhering latex. The whole leaf consisted of the hard outer rind and yellow latex plus inner gel. Both whole leaf and gel extracts were subjected to a high speed warring blender added to the 25 gallons of drinking water and stirred several times on a daily basis, using a six-foot long flat surface wooden device.

The pens were oriented east to west. Pen space per bird was approximately 0.09 m^2. Pens were fitted with 48 inches extractor fans on either end. The day-old chicks were vaccinated with Marex-Gumboro-Fowl pox vaccine subcutaneously and with Newcastle/Bronchitis vaccine administered intraocularly. The starter ration was fed up to the third week then gradually changed over to the finisher ration for the three weeks. Birds were reared in an open-sided naturally ventilated broiler house in floor pens on wood shavings/rice husk litter. Litter was turned every 5 days to protect against ammonia production in the house. Fixed amounts of feed were provided according to the manufacturer's recommendations and water was provided *ad libitum* throughout the experimental period.

Average weight, feed intake, average daily gain (ADG) and feed conversion ratio (FCR) were determined for all birds in each of the 7 groups to avoid confounding due to sex. Average weights and feed intake measurements were taken at weekly intervals. Weight gain was calculated as the difference between the final and initial live weight. Feed intake was calculated as the difference between the amount of feed supplied to the birds and the amount of feed refused. Feed conversion ratio was calculated as the ratio between feed intake and live weight gain. At the end of six weeks, 4 birds (2 cocks and 2 hens) per replicate were fasted overnight, weighed live, suspended through tapered killing cones and slaughtered humanely at a nearby 'pluck shop abattoir,' with a single cut severing the carotid artery and jugular vein. Birds were then dressed, eviscerated and cut into parts for measurements of carcass evaluation at the Institute. Carcass measurements included weights of breast muscle and leg and thigh muscle that corresponded meat-to-bone ratios. Dressing percentage was calculated by dividing the carcass weight by live weight.

The ethical approval for this study was received from the School of Veterinary Medicine at the University of the West Indies.

Statistical analysis: Data were analyzed using the General Linear Model (GML) of Minitab Software 16 (Minitab 16, 2011). Means were compared using Tukey's post hoc test. Statistical model:

$$Y_{IJKl} = \mu+Ti+Sj+(Ti\times Sj)+E_{ijk}$$

where, Y_{ijkl} = live weight, feed intake, ADG, FCR, dressing percentage, meat: bone ratio from 0:6 weeks, μ = overall mean; Ti = effect of ith treatment water; Sj = effect of sex, (Ti x Sj) = treat by sex interaction; E_{IJK} = random error associated with $_{ijk}$. Differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

The annual accumulated rainfall for May to June 2014 in the area of this study was approximately 200 mm and the maximum and minimum temperatures were 34 and 22°C, respectively. Table 1 shows the guaranteed analysis of feed nutrients and other ingredients incorporated into the starter and finishing rations fed to

Table 1: Manufacturer-guaranteed feed analysis of the starter and finisher rations fed to both batches of broilers

Feed ingredients	Starter ration (%)	Finisher ration (%)
Crude protein	21	18
Crude fat	4.55	4.75
Crude fibre	4.50	4.50
Lysine	1.14	0.87
Methionine and cysteine	0.75	0.59
Calcium	1.05	0.81
Phosphorus	0.49	0.41
Metabolizable energy (kcal/kg)	2780	2930
Vitamin A (IU/kg)	5500	5500
Sodium Monensin	0.10	-
Amprolium hydrochloride	-	0.0125

broilers. Table 1 also shows the guaranteed feed analysis (Warner Grains Mill Ltd. Trinidad) of the conventional starter and finisher rations (CF) fed to seven batches of broilers.

Performance: Across the 42-day period, no significant differences ($p>0.05$) were found across feed intake (FI), water consumed (WI), average daily gains (ADG), or feed conversion ratios (FCR) across treatments (Table 2). Feed intake increased over time but was not different ($p>0.05$) within treatments (Table 3). Live weights, however, were significantly higher ($p<0.05$) for broilers in the T3 20 mL gel and T6 20 mL leaf extract groups, which was as equally effective as the control diet compared to the remaining treatments (Table 2, 4). Table 3 shows that, at the end of week 1, live weights were higher for the T3 20 mL gel and T5 15 mL leaf extract groups compared with other treatments and are thus recommended for usage during the week of the starter phase. At 21 days, live weights were higher ($p<0.05$) for T2 15 mL gel group and the T6 20 mL leaf group was equally effective compared to control; therefore, it is recommended for usage up to the end of the starter phase (Table 3). At 35 days, the birds were heavier in both T5 and T6 leaf treatment groups, which was as equally effective as the control diet; therefore, it is recommended for usage during the last two weeks of the finishing phase of broiler production. There was a non-significant reduction in FCR over time across treatments at 7d and 35d. At the end of 21 days, however, the lowest FCR indicator of best performance was the T6 20 mL-treated leaf extract (Table 3).

The findings at one week concur with the findings of Mohammed (2015), who suggested that faster growth rates are obtained in the early growth phase of broiler production using a 15 mL gel and a 20 mL leaf treatment. Therefore, both the 20 mL leaf- and 15 mL gel extract-treated water are likely to produce birds of similar weights as traditionally-formulated feed for broilers at the end of a 42 d grow out period. Poultry producers should include moderate gel and high leaf extracts in the drinking water, as these extracts may be more cost effective than complete manufactured feeds for optimal broiler performance.

Water consumption: Water consumption did not differ across treatments at 7 and 21 days. At day 35, water consumption was greater ($p<0.05$) in the control group and T3 gel group, including the T5 and T6 leaf extract groups, compared with other treatments (Table 3). Broiler water intake can be variable and is affected by environmental temperature, diet, water-dispensing systems and intestinal health (Bruno *et al*., 2011). Therefore, the 15 mL leaf and gel extract effects may be, in some way, due to better intestinal health contributing to increased water intakes during 3 weeks in the starter phase.

Mortality: Mortality was highest for the control diet group and lowest for the T2 15 mL gel group (Table 2). At the end of 7 days, the lowest mortality rate was observed in the T1 and T2 gel and T4 and T5 leaf extract groups. The inclusion of leaf and gel Aloe vera aqueous extracts could provide a significant way to reduce mortality up to 7 days in the starter phase of broiler production (Table 3). At 21 days, however, mortality was the lowest (<1%) for T2 15 mL gel and leaf extract groups but highest in the control group (5.8%), with the latter displaying the highest mortality rate. At 35 days, mortality generally increased but was lowest for the 15 mL T2 gel extract group and highest for the T5 15 mL leaf extracts and control groups. At 21 days and 35 days in the transition to finisher and finishing stages of production, it may be most effective to use a lower volume of 15 mL gel and leaf extracts. These treatments could prove beneficial in reducing mortality at the end of the starter phase and at the first two weeks of the finisher phase of broiler production. The reduced mortality for the gel and leaf treatments was likely due to a protection afforded against disease-causing organisms. Controlled studies have shown that Aloe vera extracts have an immune-stimulatory effect against enteric pathogenic bacteria, protozoa and viruses. There may be a synergistic effect pertaining to protozoal infections, however, as the starter and finisher feeds contain coccidiostats at recommended rates (Table 1). It may be more cost effective for the poultry producer to use the 20 mL leaf and gel extracts as a means of reducing overall mortality, a possible result of its immune-stimulatory effect (Akhtar *et al*., 2012; Durrani *et al*., 2008; Dongjean Yima *et al*., 2011).

Carcass evaluation: Dressing percentages, dressed weights, weight of breast meat and bone meat were significantly higher ($p<0.05$) in males than females for all treatments (Table 5). Leg-to-bone ratios were not different across the various treatments, except for the T1 and T2 gel treatments; however, higher meat-to-leg

Table 2: Effect of Aloe vera treatment on overall performance parameters of Broilers for the 42 d period

Treatment	Conc. (ml/L)	Feed intake FI (kg)	Water consumed (L) WI	WI/FI	Live weight (kg)	ADG (kg)	FCR (kg)	Mortality rate (%)
AVLT1	10	40.39[a]	13.67[a]	0.34	2.08[a]	0.04[a]	2.23[a]	2.0[a]
AVLT2	15	40.85[a]	13.76[a]	0.34	2.09[a]	0.04[a]	2.18[a]	0.8[a]
AVLT3	20	39.96[a]	13.96[a]	0.35	2.16[b]	0.04[a]	2.18[a]	3.1[ab]
AVGT4	10	41.02[a]	13.86[a]	0.34	2.12[a]	0.04[a]	2.26[a]	2.5[ab]
AVGT5	15	39.43[a]	14.04[a]	0.36	2.13[a]	0.04[a]	2.21[a]	3.6[ab]
AVGT6	20	40.13[a]	13.71[a]	0.34	2.21[b]	0.04[a]	2.15[a]	3.3[ab]
Control	-	38.95[a]	13.89[a]	0.36	2.21[b]	0.04[a]	2.19[a]	5.8[b]
SEM		4.576	1.652		0.052	0.002	0.103	0.875

[ab]Means in the same column within a parameter with different superscripts differ significantly; p<0.05. ADG: Average daily gain, AVG: Aloe vera gel, AVL: Aloe vera leaf, Conc.: Concentration, FCR: Feed conversion ratio, SEM: Standard error of mean

Table 3: Effect of Aloe vera treatment and time (days) on performance parameters of broilers

Treatment	Conc. (ml/L)	Days	Feed intake (kg)	Water consumption (L)	Live weight (kg)	ADG (kg)	FCR	Mortality (%)
AVLT1	10	7	9.54	4.5	0.17[a]	0.02	2.84[a]	0[a]
AVLT2	15	7	9.72	4.75	0.17[a]	0.02	2.79[a]	0[a]
AVLT3	20	7	9.73	4.5	0.18[b]	0.02	2.8[a]	1.7[b]
AVGT4	10	7	9.79	4.75	0.17[a]	0.02	2.97[a]	1.7[b]
AVGT5	15	7	9.75	4.81	0.18[b]	0.02	2.72[a]	0[a]
AVGT6	20	7	9.65	4.5	0.17[a]	0.02	2.8[a]	0[a]
Control	-	7	9.72	4.81	0.17[a]	0.02	2.9[a]	1.7[b]
SEM			-	-	0.007	0.001	0.137	1.09
AVLT1	10	21	37.84	11.25	0.84[c]	0.04	2.3[c]	1.7[c]
AVLT2	15	21	37.95	11.25	0.87[d]	0.04	2.2[c]	0[d]
AVLT3	20	21	38.86	12.5	0.84[c]	0.04	2.2[c]	1.7[c]
AVGT4	10	21	38.84	12.25	0.85[c]	0.04	2.3[c]	1.7[c]
AVGT5	15	21	38.41	12	0.84[c]	0.04	2.29[c]	0[d]
AVGT6	20	21	35.45	11.75	0.88[d]	0.04	2.08[d]	3.5[e]
Control	-	21	36.93	11.5	0.87[d]	0.04	2.23[c]	5.0[e]
SEM			-	-	0.015	0.0007	0.048	1.259
AVLT1	10	35	59.2	19.5[f]	1.64[a]	0.05	1.87[f]	5.4[f]
AVLT2	15	35	59.9	19.2[g]	1.61[b]	0.05	1.86[f]	0.0[g]
AVLT3	20	35	58.2	20[h]	1.66[a]	0.05	1.81[f]	3.4[f]
AVGT4	10	35	59.7	19.4[f]	1.63[ab]	0.05	1.89[f]	3.4[f]
AVGT5	15	35	53.9	19.9[h]	1.73[c]	0.05	1.85[f]	10[h]
AVGT6	20	35	59.7	20[h]	1.69[ac]	0.05	1.83[f]	3.4[f]
Control	-	35	56.8	20[h]	1.7[ac]	0.05	1.82[f]	8.4[h]
SEM			-	0.187	0.040	0.001	0.054	2.357

[ab]Means in the same column within a parameter with different superscripts differ significantly; p<0.05. ADG: Average daily gain, AVG: Aloe vera gel, AVL: Aloe vera leaf, Conc.: Concentration, FCR: Feed conversion ratio, SEM: Standard error of mean

Table 4: Effect of Aloe cera treatment on the 42 day carcass characteristics of broilers

Treatment	Conc. (ml/L)	Live weight (kg)	Dressed weight (kg)	Dressing (%)	Breast meat (kg)	Breast: Bone ratio (kg)	Leg/thigh meat (kg)	Leg/thigh: Bone ratio
AVGT1	10	2.08[a]	1.83[a]	88.3[a]	0.421[a]	4.69:1[a]	0.310[a]	3.21:1[a]
AVGT2	15	2.09[a]	1.81[a]	86.6[ab]	0.395[a]	4.22:1[b]	0.284[b]	2.94:1[b]
AVGT3	20	2.16[b]	1.75[b]	81.2[c]	0.448[a]	4.53:1[a]	0.309[a]	3.12:1[ab]
AVLT4	10	2.12[a]	1.81[a]	85.7[abc]	0.419[a]	4.55:1[a]	0.289[b]	2.99:1[ab]
AVLT5	15	2.13[a]	1.79[a]	84.7[abc]	0.418[a]	4.53:1[a]	0.279[b]	2.92:1[ab]
AVLT6	20	2.21[b]	1.79[a]	84.2[abc]	0.417[a]	5.03:1[c]	0.297[ab]	3.01:1[ab]
Control	-	2.21[b]	1.82[a]	82.8[bc]	0.458[a]	4.58:1[a]	0.325[c]	3.36:1[ac]
SEM		0.052	0.036	1.09	0.163	0.32	0.010	0.146

[ab]Means in the same column within a parameter with different superscripts differ significantly; p<0.05. AVG: Aloe vera gel, AVL: Aloe vera leaf, Conc.: Concentration, SEM: Standard error of mean

bone ratios were found in females in the 20 mL gel group, as well as in the 10 mL and 15 mL groups, but not for the control group. Mature males are likely heavier than female broilers since they have a higher protein

Table 5: Effect of Aloe vera treatment and sex on the carcass characteristics of broilers

Treatment	Conc. (ml/L)	Sex	Live weight (kg)	Dressed weight (kg)	Dressing (%)	Breast meat (kg)	Breast: Bone ratio	Leg/thigh meat (kg)	Leg/Thigh: Bone ratio
AVGT1	10	F	1.920[a]	1.720[a]	89.6[a]	0.400[a]	5.02:1[a]	0.276[a]	3.18:1[a]
AVGT1	10	M	2.235[b]	1.939[b]	86.9[b]	0.441[b]	4.37:1[b]	0.343[b]	3.25:1[a]
AVGT2	15	F	1.936[a]	1.705[a]	88.1[a]	0.348[a]	3.66:1[a]	0.257[a]	2.96:1[a]
AVGT2	15	M	2.246[b]	1.905[b]	84.9[b]	0.441[b]	4.78:1[b]	0.310[b]	2.93:1[a]
AVGT3	20	F	2.008[a]	1.636[a]	81.5[a]	0.428[a]	4.3:1[a]	0.300[a]	3.39:1[a]
AVGT3	20	M	2.311[b]	1.86[b]	80.8[a]	0.468[b]	4.76:1[a]	0.318[b]	2.85:1[b]
AVLT4	10	F	2.027[a]	1.754[a]	86.6[a]	0.396[a]	4.38:1[a]	0.278[a]	3.23:1[a]
AVLT4	10	M	2.208[a]	1.867[b]	84.7[b]	0.443[b]	4.71:1[a]	0.299[b]	2.76:1[b]
AVLT5	15	F	2.027[a]	1.739[a]	85.9[a]	0.393[a]	4.51:1[a]	0.272[a]	3.05:1[a]
AVLT5	15	M	2.197[a]	1.833[b]	83.5[b]	0.443[b]	4.54:1[a]	0.286[b]	2.78:1[b]
AVLT6	20	F	2.102[a]	1.765[a]	84[a]	0.397[a]	5.09:1[a]	0.290[a]	3:1[a]
AVLT6	20	M	2.159[a]	1.822[b]	84.5[a]	0.437[b]	4.97:1[a]	0.303[b]	3.02:1[a]
Control	-	F	2.076[a]	1.742[a]	84.2[a]	0.427[a]	4.33:1[a]	0.301[a]	3.3:1[a]
Control	-	M	2.333[b]	1.902[b]	81.5[b]	0.489[b]	4.83:1[b]	0.350[b]	3.4:1[a]
SEM			0.054	0.038	1.545	0.020	0.462	0.012	0.20

[ab]Means in the same column within a parameter with different superscripts differ significantly; p<0.05. AVG: Aloe vera gel, AVL: Aloe vera leaf, Conc.: Concentration, SEM: Standard error of mean

deposition but lower fat deposition during growth (Gous *et al*., 1999; Sakomura *et al*., 2005). In addition, a compound in the 20 mL leaf groups may have fostered better utilization and deposition of amino acids in the breast and leg regions of males compared to females for the building blocks of protein accretion (Nasr and Kheiri, 2012). Therefore, the findings that compounds in the Aloe vera foster lower bone deposition and greater muscle accretion for these treatments in female broilers warrants further investigation. The heavier leg meat in females may be due to a growth-promoting compound called acemannan, a mannose polymer present in Aloe vera (Christaki and Florou Paneri, 2010; Darabighane and Nahashon, 2014). Higher breast and thigh weights have also been found in broilers fed Aloe vera powder combined with clove or yeast dried products (Doley *et al*., 2014; Tariq *et al*., 2015).

Conclusion: Across the 42-day grow-out period, there were no significant differences (p>0.05) across FI, WI, ADG, or FCRs across treatments. At the end of 21 days, however, the T6 20 mL leaf extract group was found to be the lowest FCR indicator of best performance. In addition, the 20 mL leaf and 15 mL gel groups were likely to produce birds of similar weights as traditional formulated feeds for broilers in the finisher stage of production. Therefore, poultry producers should include a moderate concentration of Aloe vera gel and the highest concentration of Aloe vera leaf extracts in drinking water, as these extracts may prove to be more cost effective than complete reliance on manufactured feeds for optimal broiler performance. It may also be cost effective for poultry producers to use the 20 mL leaf and gel extracts as a means of reducing overall mortality. In addition, the finding that compounds in Aloe vera foster less bone deposition and greater muscle accretion in females compared to male broilers warrants further investigation.

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