Effect of Mixture of Neem and Bitter Leaf Extract Inclusion in the Drinking Water on the Growth and Carcass Characteristics of Broiler Chicken

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Abstract: A study was conducted to evaluate the efficacy of neem and bitter leaf extracts in drinking water as a natural feed additive for broiler chicken on feed intake, body weight gain, feed conversion ratio (FCR) and carcass cut parameters. Unsexed one hundred ninety-two days-old Cobb 500 broiler chicks with an initial weight of 42.16±0.65 gm (mean± SD) were randomly distributed to the four treatments each with three replications in a Completely Randomized Design (CRD). The treatments were inclusion of neem and bitter (powder a mixture of 1:1 ratio) extracts at 0 ml, 2 ml, 4ml and 6 ml per litter of water for T_1, T_2, T_3 and T_4, respectively. Commercial broilers diet that contained 22 and 18% CP and 3050 and 3250 kcal/kg ME for starter and finisher phases. Feed and water were offered ad libitum throughout the experimental period. Feed offered and refused were recorded every day and feed intake (FI) was calculated as the difference between the two. At the end of the trial, four broiler chickens were randomly picked up (2 male and 2 female) from each replication and slaughtered for carcass evaluation. Average daily feed intake during the entire period was 104.49, 116.07, 118.65 and 122.32 g/bird (SEM=2.03) for T_1, T_2, T_3 and T_4, respectively, and it was significantly higher ($P<0.05$) for T_4 compared to other treatment groups. Body weight (BW) gain during the entire experimental period was 45.95, 56.72, 57.92 and 61.95 g/bird/day (SEM = 1.88) for T_1, T_2, T_3 and T_4, respectively and significantly higher for birds that treat under T_4. Feed conversion ratio (FCR) during the entire period was 2.28, 2.04, 2.04 and 1.97 (SEM = 0.04) for T_1, T_2, T_3 and T_4, respectively and also best for T_4. Dressed weight was 1663.84, 1983.60, 2092.90 and 2267.60 g (SEM = 65.58) for T_1, T_2, T_3 and T_4, respectively, and it was higher in T_4 than other treatments. Giblets (heart, liver, and gizzard) and crop were significantly higher ($P<0.05$) for T_4. It was concluded that inclusion of neem and bitter leaf extracts in 6 ml/1 L of drinking water has a good natural feed additive for broiler production.

Keywords: *Bitter leaf, Broiler chicken, Carcass, Feed additives, Growth, Neem leaf*

Introduction

Feed additives are ingredients added to poultry diets to enhance production efficiency, improve health, reduce morbidity, increase their growth rate, better-feed conversion efficiency, greater livability and thereby lowered mortality in poultry birds. These feed additives are termed as "growth promoters" and are often called non-nutrient feed additives (FAO, 2013). Medicinal plants extracts were developed for use in food as natural antimicrobials (Hsieh and Mau, 2001). Many researchers tried to use herbal substances as natural growth performance enhancers in poultry nutrition instead of the antibiotic growth promoters (AGP) which are banned in many countries (Jang *et al.*, 2008). Medicinal plant leave has attracted worldwide prominence due to its vast range of medicinal properties like antibacterial, antifungal, hepatoprotective, antiviral and antiprotozoal and antiparasite (Kale *et al.*, 2003; Jawad *et al.*, 2014). Also, leaves extracts promote growth and feed efficiency of birds because of their antibacterial properties (Prasannabalaji *et al.,* 2012; Vivian *et al.*, 2015).

Neem (*Azadirachta indica)* and bitter (*Vernonia amygdalina)* leaves extract has an immune stimulant effect that activates the cell-mediated immune response and therefore, creates an enhanced response to any future challenges occurred by disease organisms. Bioactive compounds in neem leaf azadirachtins, nimocinol, isomeldenin, azadirachtol, gedunin, nimbin, nimolicinol, odoratone, azadironolide, isoazadironolide, naheedin and mahmoodin as well as in bitter leaf compounds like vernodalinol, vernolepin, vernomygdin, hydroxyvernolide, vernolide and vernodalol are used as immunity booster (Oluwaseun *et al.*, 2017; Shakib, 2020). So, inclusion neem and bitter leaves to immune suppressed birds can activates cell mediate immune responses for increased humoral effect (Owen *et al.*, 2011; Vivian *et al.*, 2015). The leaves of neem and bitter contained varying concentrations of chemical, elemental and macronutrient components. They can serve as good sources of useful elements and bioactive compounds. Bitter leaves could have also better anti-oxidant properties than neem leaves. Both plants contained minimal concentration of phytochemicals, is not in a harmful level (Offor, 2014; Lillehoj *et al.*, 2018). Over the years, antibiotics have played an important role in fighting infectious diseases and stimulating poultry growth.

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Concerns have been raised that the use of antibiotics as therapeutics and for growth promotion could lead to a problem of increasing resistance in bacteria of humans and animals. The use of drugs has been discontinued due to their possible role in the occurrence of antimicrobial resistance in humans (Ratcliff, 2000; Patrick *et al*., 2003). Continuous feeding of antibiotics to chicken results in the accumulation of antibiotic residues in meat that can be transferred to humans (Muhammed *et al*., 2009). The use of antibiotics in farm animals resulted in a dramatic increase in the deaths and illnesses associated with antibiotic resistance (Newman, 2002). Interest has developed in many countries in the collection and extended use of medical plant extract for an alternative production purpose (Griggs and Jacob, 2005). Since consumers are aware of the residual effects of antibiotics in poultry meat they demand drug-free food products. This has led to the search for alternative natural growth enhancers such as plants and their extracts. Therefore, the current experiment was conducted to determine the effect of neem and bitter leaves infusion as a natural feed additive on feed intake, growth, carcass cut characteristics and partial budget analysis of broilers.

Materials and Methods

Collection and Preparation of Leaf Extracts and Rations

The experiment was conducted at Haramaya University Poultry Farm. Mature leaves of neem and bitter from trees were collected from Dire Dawa, Ethiopia. The leaf was dried under-shade then ground into a thoroughly at Haramaya University feed processing plant. The powder was packed in a polyethylene bag and preserved in the feed storage room until used it with water for Cobb 500 broiler chicken. Then 30 grams of each leaf *(Azadirachta indica* and *Vernonia amygdalina)* powder (total 60 g powder a mixture of neem and bitter leaf at 1:1 ratio) was added to one liter of distilled water, shook and placed overnight at room temperature following the procedures of Mollah *et al*. (2012), then it filtered every morning and prepared every evening on the daily basis throughout the study. Treatment 1 was the control which was given water only, and T_2, T_3, and T_4 were given 2 ml, 4 ml, 6 ml a mixture of neem and bitter leaf extracts per liter of drinking water, respectively. The base for this infusion level is depend on the infusion level of studies of individual leaf, first one is 50 g of ground dried bitter leaf is infused in 1 L of water and given to the chicks at level of T_1 (0), 25 (T_2), 50 (T_3) and 75 ml (T_4) per of drinking water (Vivian *et al*., 2015). The second is a 40 g ground dry neem leaf is infused in one liter of distilled water and given to the chicks at 30 ml, 40 ml and 50 ml per Liter of drinking water (Durrani *et al*., 2008). This study wants to see mixture (combined effect) of two herbs at low inclusion and the higher levels is for further research to be conducted by other research.

The starter (a day old to 3 weeks) and finisher (3 weeks up to slaughtering /42 days) broiler diets that were formulated from maize grain, wheat short, soybean meal, noug seed cake, salt, vitamin premix, limestone, and dicalcium phosphate purchased from Alema feed processing private company.

Management of Experimental Animals

The experimental house was cleaned and disinfected before the experimental animals arrived. The pens, watering and feeding troughs were thoroughly cleaned, disinfected and with commercial disinfectant labeled for use in the poultry farm and the pens were sprayed against external parasites before the commencement of the actual experiment. Each pen was equipped with a 250-watt heat bulb. For this experiment the chicks were purchased from Alema farm. The experiment was conducted for a total of 42 days. The chicks were vaccinated against Newcastle Disease on day 7 Hitchner Bioactive1 (HB1) by the ocular route and on day 21 (Lasota) was given through drinking water. They were also vaccinated for Gumboro on days 14 and 28 through drinking water. Other health precautions and disease control measures were taken throughout the study period. Vitamins were given to chicks through drinking water to recover from stress of transportation and early age acclimatization problems according to the manufacturer's recommendation.

Experimental Design and Treatments

The completely randomized design was used. One hundred ninety two Cobb 500 broiler breed were grouped into four treatments and three replicates, with 16 chicks per replicate. The same starter and finisher commercial broilers diets and water were offered *ad libitum* irrespective of the treatments throughout the experimental period.

Measurements

Feed intake: About 2.5 times body weight of chicks feed was weighed divide in two and offered twice a day and orts were collected the next day in the morning and weighed after removing external contaminants by visual inspection. Feed intake was calculated as the difference between offered and leftover. Average daily feed intake was determined by dividing total feed intake for the number of experimental days.

Body weight gain and feed conversion ratio: Body weight (BW) gain was measured every week by weighing the chicks with sensitive balance. Body weight was measured by weighing the broilers individually from initial to final throughout entire period. The body weight change per pen was summarized for starter as well as finisher phases and the entire experiment period for analysis. The BW of birds was computed by subtracted mean initial BW from the mean final BW. Average daily BW gain (ADG) was determined as the difference of mean final and mean initial BWs divide by the number of experimental days. The feed conversion

ratio (FCR) was determined by dividing the daily feed intake to a daily BW gain (ADG).

Carcass cuts evaluation: At the end of the experiment, four birds from each replication were picked up randomly then starved for 12 hours, and weighed immediately before being slaughtered to determine the slaughter weight. Birds were then eviscerated and carcass cuts and non-edible offal components determined according to the procedure described by Kekeocha (1985). Dressed weight was measured after the removal of blood and feather and the dressing percentage was calculated as the proportion of dressed carcass weight to the slaughter weight. Eviscerated carcass weight was the weight of dressed weight after removing shank, head, kidney, lungs, pancreas, crop, proventriculus, small intestine, large intestine, caeca and urogenital tracts. The eviscerated percentage was determined as the proportion of slaughter weight. Drumstick, thigh, breast meat, heart, gizzard and liver were separated, weighed and calculated as a percentage of slaughter weight. Fat around the proventriculus, gizzard, against the abdominal wall and the cloacae were separated, weighed and expressed as a percentage of slaughter weight.

Partial Budget Analysis

The net profits from broiler were calculated based on the cost of feed that each bird consumed from the respective treatments and the other costs. Net benefit of neem and bitter mixture extracts was analyzed by under taking consideration of the whole feed expense according to the principles developed (Upton, 1979). The partial budget analysis encompassed calculation of the variable cost and benefits. Partial budget measured the chicken cost, feed and others if any and the profit after the experiment, or differences between gains and losses for the proposed change. The costs of feed ingredients and rations given were used to calculate the feed cost for each treatment. Total variable cost encompassed the cost of feeds and other costs. The selling prices of broilers were determined by using the average current market price of broiler carcass per kilogram. Total return (TR) was considered as the difference in sale and purchase price in the partial budget analysis. The net income (NI) was expressed by subtracting total variable cost (TVC) from total return (TR), i.e., NI =TR – TVC. The change in net income (ΔNI) was expressed as the difference between the changes in total return (ΔTR) and total variable cost (ΔTVC). The marginal rate of return (MRR) was calculated as follows;

$$MRR = \frac{\Delta NI}{\Delta TVC}$$

Statistical Analysis

The experimental design employed was Completely Randomized Design (CRD). Data were subjected to analysis of variance (ANOVA) using a general linear model procedure of statistical analysis system (SAS) version 9.1 (SAS, 2008). The least significant difference (LSD) test was used to determine mean differences. The model used was:

$Xij = \mu + Ti + Eij$,
Xij = Any observation made in the experiment,
μ = Overall mean,
Ti = Effect of treatments,
Eij = Random error

Results and Discussion

Chemical Composition of Feed Additives and Experimental Diets

Laboratory analysis for the experimental feed additives and chemical composition of commercial feeds (as Manufacturer) are shown in (Table 1). The proximate composition of neem and bitter leaves powder was in line with Sobayo *et al.* (2006) and Owen *et al.* (2010) report, respectively.

Table 1. Chemical composition (in % dry matter) of neem, bitter leaves and commercial feeds

Feed	DM %	Ash%	EE%	CF%	CP%	ME (Kcal/kgDM)
NLP	90.2	9.25	3.40	8.00	23.40	2716.06
BLP	86.40	11.04	6.80	13.10	21.50	3048.96
Starter diet	90.00	4.40	6.50	5.50	22.00	3050.00
Finisher diet	90.00	4.50	8.00	5.50	18.00	3250.0

DM= Dry mater; EE= Ether extract; CF= Crude fiber; CP= Crude protein; ME= Metabolizable energy; NLP= Neem leaves powder; BLP= Bitter leaves powder.

Feed Intake

The effects of mixtures of neem and bitter leaves extracts on feed intake of broilers during the starter, finisher phases as well as the entire growth period was shown in Table 2. The result showed that, average daily and total feed intake during the starter and finisher phases as well as for the whole experimental period showed significant ($P<0.05$) difference among treatments. The results obtained for feed intake were in agreement with the result of Singh *et al.* (2015), who reported higher feed intake with change in weeks. However, the current result did not agree with the finding noted by Vivian *et al.* (2015) who reported that a group of birds treated with *Vernonia amygdalina* leaf infusion in drinking water a level of 25 ml, 50 ml and 75 ml per liter of drinking water was not significantly different in daily feed intake among the four treatment groups. The high feed intake at higher levels of infusion of extracts of neem and bitter leaves could be related to the beneficial effect of bioactive compound

like bioactive compounds like flavonoids, quercetin and phenols in neem and bitter leaf in enhancing the gastro intestinal enzyme production thereby improving digestion and could help in intestinal parasites digestion that could cause decreased utilization of feed (Ezeonu *et al.,* 2012; Vivian *et al*., 2015).

Table 2. Inclusion of neem and bitter leaf extracts in drinking water on feed intake of broilers during the starter and finisher phases as well as the entire growth period

Parameters	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Starter phase (0-21 days of age)						
Feed Intake (g)	1151.48^{c}	1285.98^{b}	1296.08^{ab}	1316.31^{a}	19.92	.0001
Daily Feed Intake (g/bird/day)	54.83^{c}	61.23^{b}	61.71^{ab}	62.68^{a}	0.94	.0001
Finisher phase (22- 42 days of age)						
Feed Intake (g)	3132.98^{c}	3473.16^{b}	3568.56^{b}	3698.95^{a}	64.64	.0009
Daily Feed Intake (g/bird/day)	156.64^{c}	173.65^{b}	178.42^{b}	184.97^{a}	3.23	.0009
Entire period (0-42 days of age)						
Feed Intake (g)	4284.46^{c}	4759.14^{b}	4864.64^{ab}	5015.26^{a}	83.63	.0003
Daily Feed Intake (g/bird/day)	104.49^{c}	116.07^{b}	118.65^{b}	122.32^{a}	2.03	.0003

^{abc}Means within a row with different superscript letters are significantly different;(P<0.05); SEM= Standard error of the mean; T_1= 0 ml of neem and bitter leaves extract; T_2= 2 ml of neem and bitter leaves extract added to 1 L of water; T_3= 4 ml of neem and bitter leaves extract added to 1 L of water; T_4= 6 ml of neem and bitter leaves extract added to 1 L of water.

Body Weight Gain

The growth rate of the experimental chicks during the starter, finisher and the entire growth period was shown in Table 3. Body weight change and average daily weight gain was affected by mixture of neem and bitter leaf extracts infusion at different level (P<0.05). The lower body weight of broilers at 0 ml of neem and bitter leaves extracts in drinking water might be related to the feed intake. These results coincide with those of Chakravarty and Prasad (1991) who achieved a high BW gain as compared to birds in the control group when offered neem leaf extract to broilers from 1 to 6 weeks. This finding is in line with Nusrat *et al.* (2015) who reported a higher BW gain for broiler chickens that consumed neem leaves infusion in drinking water.

This result was in line with the report by Sese *et al.* (2013) who reported that, the experiment conducted on neem leaves extracts the final BW gain ranges from 1733 to 2283 g, also Vivian *et al* (2015) showed, the BW of broilers fed bitter leaf ranges from 1966.43 g to 2380 g. Also, current result has an agreement with the finding of Ndelekwute *et al.* (2017) who reported that bitter leaf meal is a good ingredient to be included in the diets of finisher broiler chickens. Similar author reported that final BW weight, daily BW gain and total feed intake were higher in the group of birds that consumed a diet containing 75 g bitter leaf meal per kg diet at the finisher phase. This study agrees with the finding of Odoemelam *et al.,* (2013), reported the inclusion of bitter leaf in broiler diets leads to improvement in body weight. Similarly, the current study report agrees with the finding of Sarker *et al.* (2014), who reported on the supplementation with 1% aqueous extract of neem leaves. Similarly, Khatun *et al.* (2014) reported that the combination of neem and tulsi leaves extract at 1-3 ml/L drinking water causes a significant increase in live body weight and improvement in weight gain and feed efficiency as compared to that of the control group of the broiler. In contrast to the present findings, Mohammed and Zakariyau (2012) observed that the inclusion of bitter leaf as a feed additive at the level of 900 g on broiler diet did not significantly improved weight gain of broiler chicken. The probable reason for this increment of BW of broiler chicken in the present study might be due to creation of an environment that the regulate the intestinal tract environment and which results in better utilization of feed and eventually weight gain.

Feed Conversion Ratio

Feed conversion ratio of broilers infusion of different levels of mixtures of neem and bitter leaves extracts during the starter phase, finisher phase and the entire growth period was shown in Table 4. There was significant difference (P<0.05) in feed conversion ratio among treatments during the starter phase. Starter phase chickens in control group shows lower FCR than other groups (T_2, T_3 and T_4) at (P<0.05). But during finisher phase and the entire period, FCR of T_4 was significantly lower (P<0.05) than that of T_1 and displayed lower FCR numerically than T_2 and T_3 in finisher phase and the entire experiment period. The improvement observed in BW gain is positively correlated with better FCR observed in the treated group. The lower the FCR the higher it is for the birds to convert feed consumed to meat. The results of this study showed that inclusion of different levels of mixtures of neem and bitter leaves extracts improved FCR of the chicken except starter phase. The result is in line with the findings of Tangka (2003) and Durunna *et al.* (2011), who reported improved growth performance of animals that fed bitter leaf. Similar to this finding, Ansari *et al.* (2008) also observed the FCR of broilers that fed on neem leaf was significantly improved as compared to other treatments. Similar to the present study, Hernandez *et al.* (2004) reported the better FCR due to the effect of medicinal plant leaf extract that increase production of digestive enzymes

and improved utilization of digestive products through enhanced liver function. The result of this study might be due to anti-protozoal and immune-stimulatory properties of neem leaves that help to reduce the microbial load and improved the performance (Wankar *et al.,* 2009), which was in agreement with the present results too.

Table 3. Inclusion of neem and bitter leaf extracts in drinking water on body weight change of broilers during the starter and finisher phases as well as the entire growth period

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SEM	P-value
Starter phase:						
Initial BW (g)	40.87	41.95	41.69	42.42	0.29	.280
Final BW (g)	814.55^{c}	836.72^{b}	845.97^{b}	863.91^{a}	5.72	.0006
Total BW gain (g/bird)	773.67^{c}	794.76^{b}	804.27^{b}	821.42^{a}	5.55	.0005
Average BW gain (g/bird/day)	36.84^{c}	37.84^{b}	38.29^{b}	39.11^{a}	0.26	.0005
Finisher phase:						
Final BW (g)	1924.95^{c}	2367.63^{b}	2416.53^{ab}	2582.67^{a}	77.16	.0003
Total BW gain (g/bird)	1151.28^{c}	1572.87^{b}	1612.26^{ab}	1761.24^{a}	72.27	.0006
Average BW gain (g/bird/day)	57.56^{c}	78.64^{b}	80.61^{ab}	88.06^{a}	3.61	.0006
Entire Period:						
Final BW (g)	1924.95^{c}	2367.63^{b}	2416.53^{ab}	2582.67^{a}	77.16	.0003
Total BW gain (g/bird)	1884.07^{c}	2325.38^{b}	2374.84^{ab}	2540.17^{a}	77.00	.0003
Average BW gain (g/bird/day)	45.95^{b}	56.72^{a}	57.92^{a}	61.95^{a}	1.88	.0003

BW= Body weight; T_1= 0 ml of neem and bitter leaves extract; T_2= 2 ml of neem and bitter leaves extract added to 1 L of water; T_3= 4 ml of neem and bitter leaves extract added to 1 L of water; T_4= 6 ml of neem and bitter leaves extract added to 1 L of water.

The better FCR of the broiler chickens that infused neem and bitter leaves extracts in the present study might be attributed to the antibacterial properties of these supplements, which resulted in better absorption of nutrients present in the gut and finally leads to the improvement in the FCR of the rations (Ezeonu *et al.,* 2012; Vivian *et al.*, 2015). The starter phase high FCR for infused treatments than control may be the age of the birds and later they adapted the extract.

Table 4. Inclusion of neem and bitter leaf extracts in drinking water on feed conversion ratios of broilers during the starter and finisher phases as well as the entire growth period

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SEM	P-value
Feed conversion ratio:						
Starter phase	1.48^{b}	1.61^{a}	1.61^{a}	1.60^{a}	0.018	0.0004
Finisher phase	2.74^{a}	2.21^{b}	2.21^{b}	2.11^{b}	0.080	0.011
Entire period	2.28^{a}	2.04^{b}	2.04^{b}	1.97^{b}	0.040	0.040

^{a,b} Means within a row with different superscript letters are significantly different, ($P<0.05$); SEM= Standard error of the mean; T_1= 0 ml of neem and bitter leaves extract; T_2= 2 ml of neem and bitter leaves extract added to 1 L of water; T_3= 4 ml of neem and bitter leaves extract added to 1 L of water; T_4= 6ml of neem and bitter leaves extract added to 1 L of water.

Carcass Parameters

The results of the carcass parameters of the birds given 0, 2, 4 and 6 ml of bitter and neem leaf mixing extract are shown in Table 5. There were significant variations ($p<0.05$) between the experimental treatments in slaughtered weight, carcass weight, dressing percentage, drumstick weight, thigh weight, breast weight, and giblets weights (Table 5). In agreement with the present findings, Odoemelam *et al.* (2013) also reported the inclusion of bitter leaf in broiler diets leads to improvement in dressing percentage and significantly promoted a higher dressed weight and carcass quality. Based on previous study, the higher BW gain in broiler chickens that drunk 2% extract prepared from 6.67 g neem, 6.67 g papaya leaf powder and 6.67 g turmeric added to 1000 ml of distilled water might be due to its diversified effect on intestinal micro-flora, thereby avoiding stressful conditions (Nusrat *et al.*, 2015).

The present study on the weight of giblets (heart, liver and gizzard) (Table 6) of broiler chickens was in line with Sobayo *et al.* (2016), who reported that the inclusion of neem leaf meal in birds had significantly influenced the gizzard, liver and heart weights. In this study, there were no significant differences ($P>0.05$) in proventriculus, large intestine, small intestine and caeca weight as well as the lengths (Table 6) among treatments. The decreased in abdominal fat percentage (Table 5) observed in this study with increasing levels of leaf extract might be due to the polyphonols content of leave (Fouad and El-Senousey, 2014). The significant difference of organ parts (Table 6) is related to body weight gain.

Table 5. Inclusion of neem and bitter leaf extracts in drinking water on carcass yield characteristics of broilers

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SEM	P-value
Slaughter weight (g)	1924.95^{c}	2367.63^{b}	2416.53^{ab}	2582.67^{a}	77.16	0.0002
Dressing weight (g)	1663.84^{c}	1983.60^{b}	2092.90^{b}	2267.60^{a}	69.61	0.0002
Dressing percentage (%)	86.45^{a}	83.81^{b}	86.60^{a}	87.78^{a}	0.52	0.022
Eviscerating weight (g)	1364.53^{c}	1679.10^{b}	1732.32^{b}	1968.81^{a}	69.60	0.0007
Eviscerating percentage (%)	70.89^{b}	70.91^{b}	71.69^{b}	76.13^{a}	0.75	0.006
Carcass weight (g)	1331.96^{c}	1622.01^{b}	1674.27^{b}	1899.70^{a}	65.58	0.0008
Carcass percentage (%)	68.50^{b}	69.22^{b}	69.28^{b}	73.45^{a}	0.69	0.015
Breast weight (g)	464.47^{c}	591.13^{b}	633.92^{b}	697.02^{a}	26.65	0.0001
Breast (%)	24.11^{b}	24.98^{b}	26.22^{b}	26.98^{a}	0.36	0.0009
Thigh weight (g)	176.48^{d}	218.60^{c}	251.05^{b}	273.25^{a}	11.34	0.0001
Thigh (%)	9.18^{b}	9.23^{b}	10.39^{a}	10.57^{a}	0.20	0.0002
Drumstick weight (g)	154.05^{c}	195.38^{b}	213.58^{b}	246.53^{a}	10.61	0.0002
Drumstick (%)	8.01^{c}	8.26^{bc}	8.83^{b}	9.53^{a}	0.19	0.0040
Abdominal fat weight (g)	41.00	41.00	40.67	40.67	0.22	0.53
Abdominal fat (%)	2.13^{a}	1.73^{b}	1.68^{c}	1.61^{c}	0.06	0.0001

^{a,b,c} Means within a row with different superscript letters are significantly different, (P<0.05); SEM= Standard error of the mean; T_1= 0 ml of neem and bitter leaves extract; T_2= 2 ml of neem and bitter leaves extract added to 1 L of water; T_3= 4 ml of neem and bitter leaves extract added to 1 L of water; T_4= 6 ml of neem and bitter leaves extract added to 1 L of water.

Table 6. Inclusion of neem and bitter leaf extracts in drinking water on the organ parts weight and length of broilers

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SEM	P-value
Heart weight (g)	9.05^{b}	10.33^{ab}	11.41^{a}	11.55^{a}	0.37	0.03
Heart (%)	0.45	0.44	0.47	0.46	0.01	0.85
Liver weight (g)	33.65^{b}	36.43^{ab}	39.53^{a}	38.70^{a}	0.81	0.01
Liver (%)	1.68^{a}	1.56^{ab}	1.63^{b}	1.53^{b}	0.02	0.07
Gizzard weight (g)	30.76^{c}	33.56^{b}	35.08^{ab}	36.83^{a}	0.74	0.003
Esophagus weight (g)	5.28^{b}	5.45^{b}	6.00^{ab}	6.79^{a}	0.22	0.02
Esophagus length (cm)	15.16^{c}	15.50^{bc}	16.56^{ab}	17.57^{a}	0.33	0.01
Crop weight (g)	3.57^{b}	4.65^{a}	4.83^{a}	5.01^{a}	0.193	0.005
Crop length (cm)	2.83^{b}	3.50^{ab}	3.57^{ab}	4.15^{a}	0.176	0.03
Proventriculus weight (g)	8.18	9.23	9.55	9.00	0.2762	0.38
Proventriculus length (cm)	4.83	4.75	4.58	4.58	0.102	0.82
Small intestine weight (g)	58.15	72.63	64.65	55.48	3.399	0.31
Small intestine length (cm)	159.83	171.00	164.33	180.33	3.60089	0.21
Large intestine weight (g)	3.40	4.00	5.57	4.48	0.55436	0.63
Large intestine Length(cm)	10.16	11.75	11.83	11.25	0.37563	0.42
Ceaca weight (g)	11.35	14.88	13.66	12.78	0.74199	0.44
Ceaca Length(cm)	17.16	16.66	17.33	16.41	0.60573	0.96

^{a,b,c} Means within a row with different superscript letters are significantly different, (P<0.05); SEM= Standard error of the mean; T_1= 0 ml of neem and bitter leaves extract; T_2= 2 ml of neem and bitter leaves extract added to 1 L of water; T_3= 4 ml of neem and bitter leaves extract added to 1 L of water; T_4= 6 ml of neem and bitter leaves extract added to 1 L of water.

Partial Budget Analysis

Partial budget analysis of the experiment is given in Table 7. Based on the total variable costs, purchasing and selling prices of broiler, the highest total income is gained from 6ml of neem with bitter leaf extract mixture per litter of water (T4). These values are directly related with weight gain, body conditions of bird and the prices of experimental feeds. The best net income is gained in T4 followed by T3 and marginal rate of return income was obtained for T4 ration followed by T2. Therefore, T4 appeared to be economical in economic parameters used in the study. The chicks' sale to feed cost ratio was estimated as additional parameter to see the importance of neem and bitter leaves extract mixture diluted with one litter of water in different level for broilers during both starter and finisher phases. The birds in T4 score highest chicks' sale to feed cost than other group. The lower ratio of chick's sale to feed cost was resulted from low body weight gain and low feed cost. Therefore, the results of this study indicated that Administering 6ml mixtures of neem and bitter leaves extract diluted with one litter of water is potentially profitable than the addition 2ml and 4ml mixtures of neem and bitter leaves extract. The present experiment was in line with Owen *et al.* (2010), who suggested that

Vernonia amygadlin leaf meal used in broiler finishers diets can conveniently replace up to 15% of expensive sources of protein without compromising performance and lowering production costs.

Table 7. Partial budget analysis for broilers allow to drink mixtures of neem and bitter leaves extract during the 1- 42 days of age

Variables	Treatments			
	T_1	T_2	T_3	T_4
Purchase price/bird (birr)	25.00	25.00	25.00	25.00
Price/kg of carcass (supermarket)	150.00	150.00	150.00	150.00
Selling price/bird (birr)	186.75	194.75	196.45	198.75
Feed cost/bird (birr)	43.90	45.05	45.75	46.10
Other cost/bird (birr)	1.10	1.10	1.10	1.10
TVC/bird (birr)	45.00	46.15	46.85	47.20
TR (birr)	161.75	169.75	171.45	173.75
NR (birr)	116.75	123.60	124.60	126.55
ΔNR	0.00	6.85	1.00	1.95
ΔTVC	0.00	1.15	1.02	0.35
MRR	0.00	5.96	0.98	5.57

ETB= Ethiopian Birr; TR= Total return; NR= Net return; ⊿TVC= Change in total variable cost; ⊿NR= Change in net return; MRR= Marginal rate of return; T_1= 0ml of neem and bitter leaf extract; T_2= 2ml of neem and bitter leaf infusion; T_3= 4ml of neem and bitter leaf extract; T_4= 6ml of neem and bitter leaf extract.

Conclusion

Based on the results of the present study, it can be concluded that inclusion of neem and bitter leaf extracts at a higher proportion (6 ml mixtures of neem and bitter leaf extracts per one litter of water) for broiler improved body weight, FCR, and carcass parameters, economically feasible and it can be a good growth promoter for broiler production. Further study may be warranted to test the mixture of neem and bitter leaves extract infusion above 6 ml per liter of drinking water.

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Conflict of Interests

The authors declare that they have no competing interests.

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