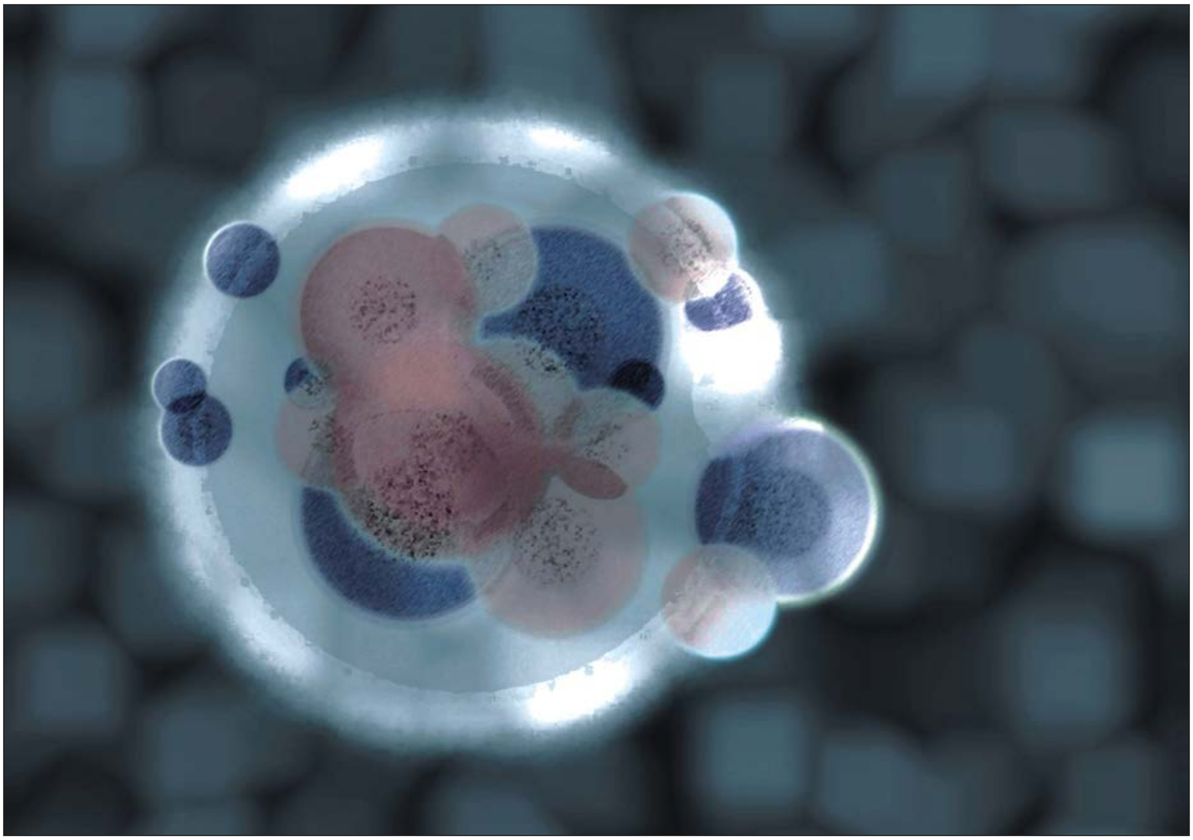

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Research Article
Water Supplementation of *Moringa oleifera* and its Effect on Performance, Blood Antioxidant and Immune Response of Two Broiler Breeds

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Abstract
Background: *Moringa oleifera* extract is mainly used in chicken as a feed additive but their effect as water supplementation on performance, carcass characteristics, immune response and blood antioxidant level were rarely studied. **Material and Methods:** Different broiler breeds were studied using 120 Cobb 500 chicks and 120 Ross 308 chicks which were distributed into 3 treatments (40 birds treatment^{-1}) including birds drink water supplied with 2% *Moringa oleifera* leaves aqueous extract (MW 2%), water supplementation with 3% *Moringa oleifera* leaves aqueous extract (MW 3%) and water without any supplementation (control); moreover chicks of each treatment were distributed into 4 replicates (10 birds replicate^{-1}) from 2-6 weeks. **Results:** *Moringa oleifera* 3% treated chicken recorded significantly higher WG2 and WG3 than Moringa Oleifera 2% however chickens at control groups had significantly worst FCR1 compared to Moringa Oleifera treatments, moreover; the response of both breeds to the higher concentration of *Moringa oleifera* was better. Ross breed groups achieved better results than Cobb breed in performance, total *Lactobacillus* count and immunity against newcastle disease virus vaccine. There were no significant differences between treatments in carcass characteristics and blood total antioxidant capacity. **Conclusion:** The researchers found that benefits from *Moringa oleifera* leaves water supplementation may be obtained at high concentration with better response for Ross over Cobb breed. Many studies should be applied on application of *Moringa oleifera* in drinking water.

Key words: Broilers breeds, *Moringa oleifera*, drinking water, performance, immunity

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Drinking water is double the feed consumption of birds even when they are sick they continue to drinking although feeding cessation. Substances absorption through drinking water is faster and higher than food[1] moreover, addition of materials to water is easier than to food however, application of growth promoters through drinking water is rare. Broiler producers resort to a lot of methods to increase broiler growth rate mainly with using synthetic antibiotics in sub-therapeutic doses as antibiotic growth promoters (AGPs). However, this will increase the cost of production to the high prices of these antibiotics and cause adverse effects both on birds and consumers health due to drugs toxicity, residual effects and development of microbial resistance[2]. Phytobiotics or phytogenics including herbs, spices and plant extracts are the safe and available substitutes to synthetic antibiotics, they are well known for their pharmacological effects and used as feed supplements or medicines in chickens[3-5]. *Moringa oleifera* is one of the most studied phytogenics as a natural alternative to AGPs as it is the most widely cultivated species of the family Moringaceae and now become naturalized in many locations in the tropics. Leaves of the *Moringa* tree are the preferred part for use in animal diets as leaf meal. Researchers studied the effect of dietary *M. oleifera* leaf meal on the growth performance of layer chicks[6], productive performance of laying hens[7], broiler's performance[8,9] and on the growth, carcass and blood indices of weaned rabbits[10], however effect of *M. oleifera* leaves water supplementation was rarely studied. Moreover, the genotype of broiler has a significant effect on live weight[11,12], feed conversion, carcass composition[13-15], carcass weight[16] and abdominal fat[17,18], however the response of different broiler breeds to water *M. oleifera* leaves extract supplementation is unknown.

The aim of this study was to investigate the effect of water supplementation of different levels of *M. oleifera* leaves aqueous extract on productive performance, carcass characters, blood antioxidants level, immune response to NDV vaccine and *Lactobacillus* count in the intestinal tract of different broiler breeds.

MATERIALS AND METHODS

Birds and experimental design: This study was applied in Experimental Poultry Unit, Veterinary Medicine College, Damanhur University within October and November, 2015. About 120 Cobb 500 chicks and 120 Ross 308 chicks were obtained from Arab poultry breeders Company Ommat. Chicks were brooded under gas brooder supplied 33°C at the first week reduced 3°C per week till reaching 24°C. Light supplied for 24 h during the first 48 h of life, then lighting duration reduced to 18 h day^{-1} according to Schwean-Lardner[19]. Chicks were fed with starter ration (23% CP) during first 3 weeks, followed by starter ration (21% CP) from 2 till 6 weeks of age. Experiment initiated at 2 weeks of age where the chicks of each strain were distributed into 3 treatments (40 birds treatment^{-1}) including (1) Birds drink water supplied with 2% *M. oleifera* leaves aqueous extract (MW 2%), (2) Birds drink water supplied with 3% *M. oleifera* leaves aqueous extract (MW 3%) and (3) Birds drink water without any supplementation (control); moreover chicks of each treatment were distributed into 4 replicates (10 birds replicate^{-1}). All chicks were vaccinated with HB1+H120 at 8 days of age; IBD at 12 days and La Sota at 18 days of age and all vaccines were applied through drinking water after following all precautions.

***Moringa* source and preparation:** *Moringa oleifera* leaves used in our experiment were obtained as a powder product from the farm of *Moringa* friends at Sadat city where the plant was analyzed in the Desert Development Center, The American University in Cairo, Research Station in Sadat City, Soil Testing Laboratory according to AOAC[20], the main results were illustrated in Table 1. *Moringa oleifera* leaves aqueous extract was prepared by soaking the leaves powder in distilled water for 24 h using 1:2 ratios (weight/volume), the preparation was then filtered to separate the debris and filtrate, the filtrate placed in a sealed clean container and kept in refrigerator at 4°C until used[21] (Table 1).

Performance traits: During the experiment many performance traits were estimated including weekly body weight to the nearest gram using sensitive scale, weekly body weight gain, feed intake per bird per week, water intake per bird per week, mortality per treatment per week and feed conversion which was estimated according to Lambert *et al.*[22].

Carcass traits: At 6 weeks of age 12 birds treatment^{-1} (3 birds replicate^{-1}) were slaughtered after starvation for 12 h with continued supplying with water. The birds were weighed before slaughtering then weighed again after evisceration to calculate dressing percentage. Carcass weight, abdominal fat weight (including fat around gizzard) and internal organs weights (including intestine, liver, gizzard and heart) were estimated to the nearest gram using sensitive scale.

Table 1: *Moringa oleifera* leaves analysis

DM	Cp	EE	Ash	Ca	P
89.6	7.25	11.7	12.3	2.10	0.77

Carcasses were divided and the weight of thigh, shoulder and left breast were measured.

Total antioxidant capacity estimation: Blood samples (12 samples per group) were collected from wing vein at end of experiment (42 days), serum were separated through centrifugation at 3000 rpm for 15 min and preserved in a deep freezer at -20°C until the time of analysis. Total Antioxidant Capacity (TAC) was measured according to Koracevic *et al.*[23].

***Lactobacillus* count and haemagglutination inhibition test (HI):** *Lactobacillus* count was done using Rogosa agar as a selective medium used for the isolation of lactobacilli according to Rogosa *et al.*[24]. The NDV antigen, la Sota strain, was used to test serum samples collected at 42 days of age (12 samples per group) for antibody titers against NDV as described by Allan *et al.*[25]. The HI titer was expressed as the reciprocal of the highest dilution that causes inhibition of agglutination and Geometric Mean Titer (GMT) was calculated.

Statistical analysis: Body weight data were analyzed three way analysis of co-variance for 2 weeks b.wt., data, however other productive and carcass traits absolute weight data were analyzed two ways analysis of variance by SAS[26], Proc GLM.

RESULTS

Productive performance: Ross breed had significantly higher weekly body weight and weight gain than Cobb breed ($p<0.05$) as illustrated in Table 2 and 3. With respect to effect of *M. oleifera* water supplementation on body weight and weight gain addition of *M. oleifera* leaves aqueous extract to water at 3% concentration did not differ significantly from control treatment. However, MW 2% decreased weekly body weights significantly ($p<0.05$) compared to the two other treatments except with final body weight (W6) where there were no significant differences between the three treatments (1857.47, 1803.47 and 1900.68 g for control; MW 2 and 3%, respectively). Moreover, MW 3% increased WG2 (weight gain from 3-4 weeks) significantly than MW 2% and control treatment (420.62, 364.71 and 390.665 g, respectively $p<0.05$).

Feed conversion ratio: Cobb breed recorded significantly higher FCR from 2-3 weeks than Ross breed (2.45 and 2.09 for Cobb band Ross breeds, respectively $p<0.05$) and this may be attributed to its significantly lower weight gain thereafter the differences between the two breeds will be disappeared till the end of the experiment. *Moringa oleifera* leaves water supplementation either at 2 or 3% decreased FCR than control treatments, however the difference was significant only at FCR1 (2.42 vs 2.20 for control and *M. oleifera* supplied treatments, respectively). Moreover, the response of different breeds to *M. oleifera* supplementation had the same trend of general *M. oleifera* effect as with the two breeds the control treatments recorded higher FCR compared to the two *M. oleifera* treatments Table 3.

Feed intake and water consumption: Ross breed recorded higher average feed intake per bird per week (F/B/W) and water consumption per bird per week (W/B/W) compared to Cobb breed (841.67 vs 695.83 g F/B/W and 1835.83 vs

Table 2: Weekly body weights of broilers in relation to breed and *M. oleifera* concentration

	Weeks				
Items	2	3	4	5	6
Breed					
Cobb	446.54±3.94^{b}	659.89±9.38^{b}	995.84±14.08^{b}	1367.00±22.13^{b}	1673.49±35.78^{b}
Ross	471.22±4.13^{a}	740.18±8.02^{a}	1139.01±12.18^{a}	1611.28±18.54^{a}	2034.25±28.02^{a}
***Moringa* (%)**					
Control	467.50±4.64	731.89±10.54^{a}	1107.51±16.11^{a}	1525.13±25.35^{a}	1857.47±40.90
2%	443.69±5.94	658.35±10.88^{b}	989.48±16.18^{b}	1399.69±24.68^{b}	1803.47±36.59
3%	466.14±4.45	709.87±10.46^{a}	1105.28±15.32^{a}	1542.59±24.46^{a}	1900.68±37.66
Breed×*Moringa*					
Cobb					
Control	443.79±5.63	697.69±16.98	1024.18±26.18	1451.64±39.62	1761.63±68.76^{c}
2%	432.74±7.44	622.13±14.75	918.35±22.03	1247.99±36.36	1591.49±53.22^{d}
3%	462.90±6.16	659.86±16.65	1044.99±23.72	1401.38±38.16	1667.35±58.65^{cd}
Ross					
Control	488.33±4.87	766.08±13.73	1190.84±20.57	1598.62±33.28	1953.31±47.95^{b}
2%	455.00±8.97	694.57±15.59	1060.62±23.24	1551.40±32.72	2015.45±49.03^{ab}
3%	469.00±6.41	759.88±12.59	1165.57±19.35	1683.81±30.48	2134.01±47.84^{a}

Means within the same column under the same category carry different superscripts are significantly different

Table 3: Weight gain and feed conversion ratios of broilers in relation to breed and *M. oleifera* concentration

Items	WG1	WG2	WG3	WG4	FCR1	FCR2	FCR3	FCR4
Breed								
Cobb	218.95±8.21[b]	351.45±13.33[b]	410.97±20.69[b]	395.86±31.85[b]	2.45±0.07[a]	2.21±0.07	1.90±0.09	1.55±0.42
Ross	287.16±7.25[a]	432.54±12.07[a]	498.56±18.73[a]	501.87±26.74[a]	2.09±0.05[b]	2.08±0.06	1.95±0.07	1.71±0.35
***Moringa* (%)**								
Control	275.55±9.27[a]	390.66±15.91[ab]	451.45±25.1	434.50±37.03	2.42±0.07[a]	2.24±0.08	2.03±0.1	1.58±0.49
2%	227.33±9.64[b]	364.71±15.64[b]	468.41±22.94	464.88±31.76	2.20±0.08[b]	2.08±0.08	1.86±0.1	1.77±0.37
3%	256.29±9.55[a]	420.62±15.16[a]	444.45±24.4	447.21±38.88	2.20±0.07[b]	2.11±0.07	1.89±0.11	1.53±0.53
Breed×*Moringa* (%)								
Cobb								
Control	261.58±14.6[b]	332.06±24.92	472.67±38.35[abc]	436.50±59.39	2.63±0.11	2.43±0.15	1.85±0.15	1.54±0.77
2%	191.67±12.99[c]	325.20±20.55	381.82±31.66[c]	380.59±45.55	2.29±0.11	2.12±0.1	1.88±0.15	1.58±0.57
3%	203.61±15[c]	397.11±23.57	378.44±37.13[c]	370.50±59.39	2.43±0.11	2.08±0.11	1.96±0.18	1.54±0.81
Ross								
Control	289.52±11.43[ab]	449.26±19.78	430.24±32.41[bc]	432.50±44.26	2.20±0.08	2.06±0.09	2.20±0.13	1.63±0.63
2%	263.00±14.23[b]	404.21±23.57	555.00±33.21[a]	549.17±44.26	2.10±0.1	2.04±0.12	1.84±0.13	1.75±0.48
3%	308.97±11.82[a]	444.14±19.08	510.45±31.66[a]	523.93±50.19	1.97±0.08	2.13±0.09	1.82±0.12	1.52±0.67

Means within the same column under the same category carry different superscripts are significantly different. WG1: Weight gain from 2-3 weeks, WG2: Weight gain from 3-4 weeks, WG3: Weight gain from 4-5 weeks, WG4: Weight gain from 6-5 weeks, FCR1: Feed conversion from 2-3 weeks, FCR2: Feed conversion from 3-4 weeks, FCR3: Feed conversion from 4-5 weeks, FCR4: Feed conversion from 5-6 weeks

Table 4: Feed intake per bird per week (F/B/W), water intake per bird per week (W/B/W) and mortality (%) per week (M/W) of broilers in relation to breed and *M. oleifera* concentration

Items	F/B/W	W/B/W	M/W
Breed			
Cobb	695.83±41.77[b]	1370.00±138.65[b]	1.33±0.28[a]
Ross	841.67±44.26[a]	1835.83±163.8[a]	0.25±0.18[b]
Treat			
Control	797.50±48.65[a]	1536.25±179.21	0.88±0.35
MW (2%)	745.00±66.68[b]	1576.25±209.51	0.50±0.33
MW (3%)	763.75±63.19[b]	1696.25±231.98	1.00±0.38
Week			
W3	605.00±35.57[c]	871.67±64.78[c]	0.17±0.17
W4	871.67±37.9[a]	1616.67±152.72[b]	0.50±0.34
W5	881.67±42.46[a]	2131.67±121.34[a]	1.33±0.42
W6	716.67±73.97[b]	1791.67±183.78[ab]	1.17±0.48
Breed×Treat			
Cobb			
Control	770.00±74.16[b]	1310.00±218.21	1.25±0.48
MW (2%)	640.00±61.24[c]	1267.50±222.76	1.00±0.58
MW (3%)	677.50±83.4[c]	1532.50±317.37	1.75±0.48
Ross			
Control	825.00±71.0[a]	1762.50±261.04	0.50±0.5
MW (2%)	850.00±98.23[a]	1885.00±302.78	0.00±0.0
MW (3%)	850.00±81.96[a]	1860.00±364.05	0.25±0.25
Breed×Week			
Cobb			
W3	606.67±77.53[e]	753.33±41.77	0.33±0.33
W4	830.00±70.0[cd]	1430.00±285.01	1.00±0.58
W5	790.00±5.77[d]	1900.00±61.10	2.00±0.0
W6	556.67±18.56[e]	1396.67±58.97	2.00±0.58
Ross			
W3	603.33±17.64[e]	990.00±72.34	0.00±0.0
W4	913.33±23.33[ab]	1803.33±23.33	0.00±0.0
W5	973.33±24.04[a]	2363.33±127.32	0.67±0.67
W6	876.67±37.56[bc]	2186.67±96.84	0.33±0.33

Means within the same column under the same category carry different superscripts are significantly different

1370 mL W/B/W for Ross and Cobb, respectively $p<0.05$). On the other hand mortality percentage per week (M/W) was significantly higher with Cobb than Ross breed (1.33 vs 0.25% for Cobb and Ross, respectively), moreover the Total Feed Intake (TFI), Total Water Consumption (TWC) and total mortality (TM) percentage take the same trend of weekly average (Table 4). *Moringa oleifera* water supplementation decreased F/B/W significantly than control treatment with no significant differences between MW 2 and 3% (797.5 vs 745 and 763.75 g for control; MW 2 and 3%, respectively $p<0.05$). However, W/B/W and weekly mortality (%) did not affect significantly with *M. oleifera* supplementation (Table 5). With respect to the effect of breed on feed intake under different *M. oleifera* treatments, researchers observed that Cobb breed was more sensitive to *M. oleifera* supplementation than Ross breed where their weekly feed intake decreased significantly with *M. oleifera* supplementation than control treatment, however Ross breed weekly average feed intake did not affect with *M. oleifera* supplementation this mean that Ross breed is more adapted breed to new management than Cobb breed. Table 4 shows the highest F/B/W, W/B/W and mortality (%) were recorded for W5 (Table 4, 5).

Carcass traits: Ross breed achieved higher carcass weight and carcass cuts weights compared to Cobb breed (Table 6), however the differences were significant only with carcass and shoulder weights (1524.44 and 84.44 vs 1305.56 and 68.89 g for Ross and Cobb carcass and shoulder weights, respectively $p<0.05$). Internal organs weight did not differ significantly

Table 5: Means and standard errors of Total Feed Intake (TFI), Total Weight Gain (TWG), Total Feed Conversion Ratio (TFCR), Total Water Consumption (TWC) and Total Mortality (TM%) of broilers in relation to breed and *M. oleifera* concentration

Levels	TFI	TWG	TFCR	TWC	TM
Breed					
Cobb	2766.36±48.59[b]	1284.55±33.48[b]	2.17±0.05	5413.18±97.07	5.14±0.27
Ross	3350.00±10.91[a]	1593.86±49.88[a]	2.15±0.07	7276.82±50.05	1.18±0.19
Treat					
Control	3214.44±26.010	1475.56±53.68	2.22±0.08	6346.11±214.01	3.17±0.35
W2%	2927.50±107.59	1355.94±58.68	2.18±0.06	6150.63±316.37	2.25±0.51
W3%	2986.00±112.68	1507.00±96.07	2.02±0.07	6654.00±213.92	4.60±0.98
Breed×Treat					
Cobb					
Control	3080	1380.71±62.90	2.26±0.11	5240	5
W2%	2560	1196.11±41.14	2.16±0.07	5070	4
W3%	2710	1305.00±55.41	2.09±0.08	6130	7
Ross					
Control	3300	1535.91±74.63	2.2±0.11	7050	2
W2%	3400	1561.43±65.29	2.2±0.10	7540	0
W3%	3400	1810.00±102.65	1.9±0.11	7440	1

Means within the same column under the same category carry different superscripts are significantly different

Table 6: Means and standard errors of the effect of breed, *M. oleifera* supplementation and their interactions on carcass weight, dressing (%), thigh, breast and shoulder weights of broilers

Items	Carcass weight	Dressing (%)	Thigh	Breast	Shoulder
Breed					
Cobb	1305.56±55.27[b]	0.75±0.01	288.33±13.99[b]	251.67±13.74	68.89±2.17[b]
Ross	1524.44±64.65[a]	0.75±0.01	349.44±9.95[a]	297.78±16.5	84.44±2.56[a]
***Moringa* (%)**					
Control	1389.17±69.83	0.74±0.01	324.17±17.15	274.17±20.18	75.83±3.00
2%	1375.00±92.99	0.76±0.01	314.17±21.96	251.67±15.37	73.33±4.77
3%	1480.83±98.53	0.76±0.01	318.33±21.93	298.33±23.76	80.83±5.07
Breed×*Moringa* (%)					
Cobb					
Control	1360±150.25	0.73±0.01	318.33±36.09	251.67±26.19	70.00±2.89
2%	1215±62.520	0.76±0.01	268.33±8.82	231.67±24.04	63.33±1.67
3%	1341.67±62.74	0.77±0.01	278.33±16.41	271.67±24.55	73.33±4.41
Ross					
Control	1418.33±30.87	0.74±001	330.00±11.55	296.67±29.06	81.67±1.67
2%	1535±117.15	0.75±0.01	360.00±15.28	271.67±14.24	83.33±3.33
3%	1620±158.85	0.75±0.01	358.33±23.15	325.00±38.84	88.33±7.26

Means within the same column under the same category carry different superscripts are significantly different. N = 12 birds per treatment per 3 replicate

between the two breeds except for intestine and heart weights which were significantly higher in Ross than Cobb breed (Table 7). The significantly higher carcass, intestine and heart weights of Ross breed than Cobb breed may be resulted from the significantly higher body weight and feed intake of this breed. Although the differences between treatments in carcass weight, carcass cuts and organs weights were not significant MW 3% treatments recorded higher values than control and MW 2% (Table 6, 7).

Total Antioxidant Capacity (TAC): Ross breed recorded significantly higher TAC compared to Cobb breed (0.09 vs 0.05 $p<0.05$) which ensure its higher benefit by *M. oleifera* component than Cobb breed. However, differences between control treatments and *M. oleifera* treatments were not significant Table 8.

***Lactobacillus* count and HI test:** The effect of *M. oleifera* on immune response, indicated that Ross 308 breed showed a higher beneficial bacterial count in the intestinal tract and also, increased immunity against NDV than Cobb 500 breed (Table 9, 10, Fig. 1).

DISCUSSION

Response of both breeds to MW 3% was better than MW 2%, however the differences in final body weight and weight gain between different treatments were non-significant. These results may be attributed to the high level of substances absorption through water[1] so high *M. oleifera* level (3%) leads to higher absorption of *M. oleifera* benefit contents from water that compensate low feed intake

Table 7: Effect of breed, *Moringa oleifera* supplementation and their interactions on internal organs weight of broilers

Items	Liver	Gizzard	Abdominal fat	Intestine	Heart
Breed					
Cobb	44.00±4.10	30.22±2.31	27.55±2.73	88.11±7.16[b]	6.78±0.49[b]
Ross	48.33±2.09	37.11±3.06	22.22±3.32	111.11±8.24[a]	10.56±1.06[a]
***Moringa* (%)**					
Control	47.33±5.48	36.17±3.18	25.00±3.71	100.83±6.38	7.83±0.79
2%	43.83±4.45	32.17±3.35	26.33±3.23	87.17±12.74	8.33±0.92
3%	47.33±1.5	32.67±4.37	23.33±4.86	110.83±10.28	9.83±1.87
Breed× *Moringa* (%)					
Cobb					
Control	51.67±10.73	36.00±4.04	26.67±1.67	101.67±12.02	6.67±1.2
2%	36.00±5.00	26.00±2.65	28.33±1.2	66.00±9.71	6.67±0.67
3%	44.33±0.33	28.67±3.71	27.67±9.21	96.67±1.67	7.00±1.00
Ross					
Control	43.00±4.04	36.33±5.84	23.33±7.97	100.00±7.64	9.00±0.58
2%	51.67±3.53	38.33±3.33	24.33±6.84	108.33±16.41	10.00±1.00
3%	50.33±1.45	36.67±8.11	19.00±3.79	125.00±18.03	12.67±2.91

Means within the same column under the same category carry different superscripts are significantly different. N = 12 birds per treatment per 3 replicate

Table 8: Total Antioxidant Capacity (TAC μmol mL^{-1}) in all treated chicken groups

Items	TAC
Breed	
Cobb	0.05±0.008[b]
Ross	0.09±0.017[a]
Treatment	
Control	0.09±0.025
WM (2%)	0.05±0.008
WM (3%)	0.06±0.013
Breed×Treatment	
Cobb	
Control	0.06±0.013
WM (2%)	0.05±0.018
WM (3%)	0.05±0.014
Ross	
Control	0.13±0.039
WM (2%)	0.06±0.003
WM (3%)	0.08±0.018

N = 12 birds per treatment per 3 replicate

Table 9: *Lactobacillus* count of intestinal samples at 42 days of age

	Lactobacillus count (CFU mL^{-1})	
Chickens groups	Ross	Cobb
M. oleifera (2%)	2×10^5	8×10^4
M. oleifera (3%)	7×10^6	2×10^5
Control	10^3	2×10^3

Table 10: Serological response for NDV vaccine by HI titers of serum samples collected at 42 days of age (12 samples per chicken group

	Geometric Mean (GM) of HI titers (Log 2)	
NDV	Ross	Cobb
Control	3.0	2.9
M. oleifera (2%)	3.0	3.0
M. oleifera (3%)	3.2	3.0

resulted from its bitter taste and improve weight gain, moreover *M. oleifera* positive effect may be obtained at early ages rather than oldest ages. *Moringa oleifera* received

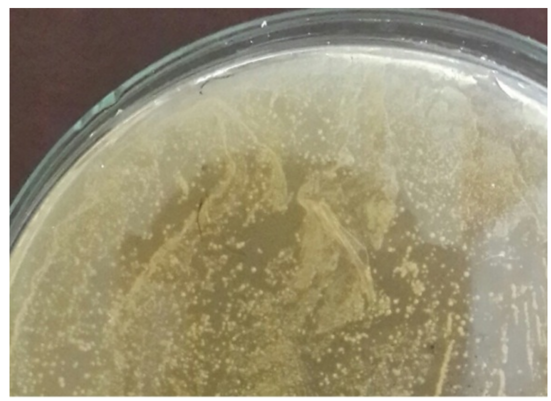

Fig. 1: *Lactobacillus* colonies in *M. oleifera* 3% treated Ross birds

groups recorded lower FCR than control groups and this is a good indicator where under *M. oleifera* treatments birds consumed lower amount of ration per each kilogram meat. Similar results were obtained by Portugaliza and Fernandez[27] where they studied the effect of water supplementation of various levels of *M. oleifera* leaf aqueous extract (30, 60 and 90 mL L^{-1}) on broiler performance, it is found that water supplementation of 30, 60 and 90 mL concentrations of *M. oleifera* aqueous leaf extract had improved the actual live weight, Feed Conversion Ratio (FCR) and return of investment (ROI) of Cobb broilers. However, Banjo[28] added *M. oleifera* leaf meal to broiler rations with metabolizable energy levels ranging from 2800-2900 kcal kg^{-1} at 0, 1, 2 and 3% levels where the birds fed on these diets for 4 weeks, thereafter it is concluded that addition of *M. oleifera* 2% significantly ($p<0.05$) enhanced weight gain however, *Moringa* supplementation did not significantly enhanced feed intake and feed conversion. These conflicting results may be attributed to the use of *M. oleifera* leaf meal as a powder in ration not as an aqueous extract in drinking water as in this experiment.

With respect to breed effect on growth performance there are many studies ensure the significant effect of breed on performance, carcass weight, feed conversion and carcass composition[11,12,15,16]. However, the preference between Cobb 500 and Ross 308 breed was differ between studies where researchers[29-31] take the same trend of this study and recommended response of Ross over Cobb breed for new managements. However, Hristakieva *et al.*[32] concluded opposite results this disagreement may be attributed to the different sources of chicks.

Moringa oleifera water supplementation decreased F/B/W significantly than control treatment with no significant differences between MW 2 and 3%. Similar results were obtained by Onunkwo and George[33] where they attributed their results to the bitter taste of *M. oleifera* leaves meals which resulted in reduced palatability and thus reduce feed intake of the broiler diets.

Carcass cuts weights and internal organs weights were not significantly affected with *M. oleifera* aqueous extract water supplementation and similarly it is concluded that supplying weaned rabbits a diet containing *M. oleifera* leaf meal significantly ($p<0.05$) increased daily weight gain[10] however, it had no significant ($p>0.05$) effect on carcass characteristics. The researchers attributed the improvement of rabbit growth to the higher level of vitamin A in *M. oleifera* leaf meal as reported by Grubben and Denton[34].

The results of TAC in this study did not indicated by Verma *et al.*[35] where it is found that the whole plant extract of *M. oleifera* inhibits the lipid peroxidation in chicken liver homogenates which indicating their antioxidant effect in preserving chicken meat. The cause of disagreement between results may be attributed to the used part of plant as they used whole plant extract, however we used plant leaf aqueous extract only.

The clinical data indicated the better weight gain and FCR in Ross 308 chickens treated with *M. oleifera* (3%) as it has a significant increase in *Lactobacillus* count inducing better feed digestion, absorption, increased digestive enzymes as well as reducing the bad effect of harmful bacteria in the intestinal tract. As some previous data[36] indicated the positive effect of *M. oleifera* (3% dried leaves) on enhancement of duodenum traits, reduced *E. coli* and increased *Lactobacillus* counts in ileum improving the intestinal health of broilers which helped in increasing the production of digestive secretions and nutrient absorption.

The effect of *M. oleifera* on immune response, indicated that Ross 308 breed showed an increased immunity (HI titers) against NDV vaccine than Cobb 500 breed and these data were a confirmation to Eze *et al.*[37], who reported that *M. oleifera* extract increased ND HI titers in the vaccinated chicken groups with NDV vaccines.

CONCLUSION AND FUTURE RECOMMENDATIONS

Ross breed responded better than Cobb breed to new managements and that water supplementation of *M. oleifera* leaves aqueous extract improved weight gain, feed conversion, carcass characteristics, slightly increased the immune response to NDV vaccine and increased *Lactobacillus* count as beneficial bacteria in the intestinal tract, however with concentration not less than 3%. Further studies on water supplementation of *M. oleifera* leaf aqueous extract regarding the antibacterial effect, immunomodulatory effect in the intestinal tract, growth performance and antioxidant effect are required.

SIGNIFICANCE STATEMENTS

The effect of water supplementation *Moringa oleifera* (*M. oleifera*) leaves aqueous extract on productive performance, carcass characters, blood antioxidants level, immune response to Newcastle Disease Virus (NDV) vaccine and *Lactobacillus* count of different broiler breeds were studied. All procedures were carried out in accordance with the recommendations in the guide for the care and use of laboratory animals of the national institutes of health.

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