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Growth Performance, Immune Response, Blood serum parameters, Nutrient Digestibility and Carcass Traits of Broiler Chicken as Affected by Dietary Supplementation of Garlic Extract (Allicin)

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Key words:
Garlic extract, allicin, growth performance, immune response, nutrient digestibility, broiler.

ABSTRACT

Two hundred day old chicks were used and allotted into equal five groups fed on the basal diet supplemented by 0.0, 25, 50, 75 and 100 mg allicin/Kg diet respectively for five continuous weeks. Dietary allicin supplementation at 25, 50 and 75mg/kg diet significantly ($P \leq 0.05$) improved final body weight and total gain by about (6.87%, 12.76% and, 10.13%) and (6.9%, 13.03% and 10.3%) respectively when compared with control broiler chick group. In contrast high level (100mg/Kg) addition of allicin non significantly ($P \geq 0.05$) decreased final body weight and total gain of broiler chicks by about 1.13 % and 1.2% respectively, when compared with control one. Allicin supplementation increased feed intake of broiler chicken while, 25, 50 or 75 mg allicin/Kg diet improved feed conversion ratio, protein efficiency ratio, efficiency of energy utilization and performance index when compared with control. In contrast high inclusion rate of allicin deteriorate the mentioned parameters. Allicin supplementation at different levels in broiler chicken ration had no significant effect on WBCs counts, and increased RBCs, Hb%, PCV%, blood serum units and reduced blood serum triglycerides and total cholesterol concentrations when compared with the control. On the other hand, allicin supplementation at 25, 50 or 75 mg/Kg diet improve kidney and liver functions through reduction of blood serum creatnine, GOT, GPT and ALP concentrations when compared with the control, while higher level showed adverse effect. Moreover, it was observed that allicin supplementation improved broiler chicken immune response through increased nutrophil percentage and weight of immune organs when compared with the control one. Dietary allicin supplementation at 25, 50 or 75 mg/Kg diet improved organic matter, crude protein and ether extract digestion, while high inclusion level exhibited lower digestibility percentage and numerically improved dressing percentage of broiler chicken, while had no effect on liver, gizzard, heart weight when compared with the control. Allicin supplementation at 50 mg/Kg diet improved economic efficiency of broiler chick's production.

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1. INTRODUCTION:

Today, the non-prescriptive use of antibiotics in poultry feeds is facing serious criticism. There are some important reasons that restrict the use of antibiotics such as the drug resistance in bacteria and the drug residues in meat. These effects have eliminated or severely limited their use in many countries because of concerns related to development of antibiotic-resistant human pathogenic bacteria and legislative action to limit their use in probable many other countries. A complete ban on antibiotics in poultry feeds was brought into force on 1st January, 2006 by the European Union; thus, all of the antibiotics used at sub-therapeutic levels for growth promotion (antibiotic growth promoters, AGP's) were withdrawn Cervantes (2006) & Michard (2008). To overcome the poor performance and the increase susceptibility to diseases that will emanate from the removal of antibiotics from birds' diets, attempts have been made to find other alternatives. The utilization of growth promoters of natural origin such as probiotics, yeast cultures, organic acids, prebiotics, enzymes, botanicals including extracts and essential oils of some herbs and spices therefore becomes of concern in recent years Iji et al. (2001); Hooge (2006) ; Ayasan (2013) & Elagib et al. (2013).

Allicin is an organosulfur compound extracted from garlic, a species in the family Alliaceae and allicin has a characteristically pungent smell and exhibits antibacterial, antifungal, anti-inflammatory and antioxidant properties Bautista et al. (2005), Vaidya et al. (2009) & Block et al. (2010)

elucidated the mechanism of the antioxidant or anti-stress action of allicin, such as trapping free radicals. Allicin decomposes to form 2-propene sulfenic acid, and this compound is capable of binding the free-radicals as an anti-stress agent. Allicin has been found to lower serum and liver cholesterol Qureshi et al. (1983), inhibit bacterial growth Cavallito et al. (1994) and reduce oxidative stress Choudhary (2008).

In broilers, it was reported that garlic, as a natural feed additive, improved broiler growth and feed conversion ratio (FCR), and decreased mortality rate Tollba & Hassan (2003). Amagase et al. (2001) & Demir et al. (2003) stated that improvement of broiler performance and carcass merits can be achieved by supplementation of diets with garlic powder. Lewis et al. (2003) showed that addition of plant ex-tracts to broilers' diet has some effects on performance and microbial activity of intestinal tract but, none of them were significant. Moreover, Cho et al. (2006) concluded that allicin has immune-stimulatory effect on birds. Demir et al. (2003) attributed the strong stimulating effect of garlic to the immune system of broilers primarily to the bioactive components of garlic together with sulphur containing compounds such as alliin and allicin. The objective of the present study is to through light on the effect of different dietary allicin supplementation on growth performance, immune response, nutrient digestibility, some blood biochemical parameters and carcass traits of broiler chicken.

2. MATERIALS AND METHODES

This study was conducted at Nutrition and veterinary Clinical Nutrition Department, Faculty of Vet. Med. Alex. Uni. Egypt to investigate the possible of different dietary allicin supplementation on growth performance, immune response, some carcass characteristics of broiler chickens.

Birds, accommodation and management: A total of 200 non sexed one day old Arber Acer chicks were used in this experiment. The chicks were individually weighed and wing-banded and randomly allotted into 5 equal groups (40 chicks per each). The chicks were housed in a clean well ventilated room, previously disinfected with formalin. The room was provided with electric heaters to adjust the environmental temperature according to the age of the birds. Feeds and water were supplied ad-libitum. Prophylactic measures against the most common infectious diseases were carried out. The chicks were vaccinated against Newcastle disease with different types of Newcastle disease vaccine and Infectious Bursal disease as presented in table, 1.

Table (1) Vaccination program of broiler chicks:

Age of chicks (days)	Vaccine	Route of administration
7	Hitchner + IB[1]	Eye drops
12	IBD(Intermediate)[2]	Drinking water
17	La Sota[3] + IBD[2]	Drinking water
22	IBD (Mild Strain)	Drinking water
27	La Sota[3] + IBD_2	Drinking water

[1]-Hichner Fort Dodge Animal Health Batch NO: 1084264A, 2-IBD intermediate strain CEVA Sante Animale Batch NO: 1609T2D2A . 3- La Sota, ISO S.P.A, batch NO: 0533D

2.1. Experimental design and feeding program:

Broiler chicken were fed on commercial starter, grower and finisher diets from El-Fager Co. and considered as basal diet which composed from corn, soybean, corn gluten, vegetable oil, mineral and vitamin mixture at different percentage. Chemical analysis of the basal diet used in the experiment are presented in tables 2. Experimental period lasted for five continuous weeks. First group fed on the basal diet without any supplementation and considered as control, while groups 2 – 4 fed on the same basal diet with 0.1, 0.2, 0.3 and 0.4 kg garlin/ton (representative 25, 50, 75 and 100 mg allicin/Kg) feed respectively and the applied experimental design is shown in table 3.

2.2. Measurements:

Body weight development, body weight gain and feed intake of broiler chicks in different groups were weekly recorded. Relative growth rate (RGR) , Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER) and Efficiency of Energy Utilization (EEU) were calculated according to Lambert et al. (1936) ; McDonald et al. (1987) & North (1981) respectively.

Table 2: Chemical analysis of the used basal diet used for feeding during the first experiment.

Items %	Feed Type		
	Starter diet	**Grower diet**	Finisher diet
Moisture	12.21	11.98	13.22
Crude protein	22.65	20.87	19.16
Ether extract	5.28	5.76	5.74
Crude fibre	2.79	2.85	2.93
Ash	6.88	6.85	7.03
NFE*	50.19	51.69	51.92
Calcium	1.090	1.19	0.89
Phosphorus	0.62	0.68	0.61
ME Kcal/kg diet**	3067.3	3109.1	3074.9
Calorie/protein ratio***	135.4	148.9	160.2

* NFE= Nitrogen free extract (calculated by difference "100-(moisture% + CP% + EE% + CF% + ash%)". **Calculated according to Lodhi et al. (1976) as follows: Metabolizable energy MJ/Kg = 1.549+ (CP%*0.102) + (EE %*0.275) + (NFE%*0.148) + (CF%*0.034). ***Calorie/protein ratio = ME kcal/CP%

Table 3: Outline of the experimental design.

Groups No.	Diet type	Supplementation Garlin*	Allicin supplementation*
1	Basle diet (BD)	---	0.0
2	"""	0.1 g/Kg	25 mg/kg
3	"""	0.2 g/Kg	50 mg/kg
4	"""	0.3 g/Kg	75 mg/kg
5	"""	0.4 g/Kg	100 g/kg

* A natural product produced by Hefel Royal Eagle Imp & Exp Co., ltd (China) and it is consider garlic extract contain 25% allicin.

2.3. Chemical analysis:

Analytical DM contents of feed , fecal and egg shell samples were determined by oven-drying at 105oC for 48 h AOAC (1990). Ash contents of feed and feces samples were determined by incineration at 550oC overnight, and the OM content was calculated as the difference between 100 and the percentage of ash AOAC (1990). Crude fiber were determined by digestion of the sample for 30 min. by using 1.25% H2SO4 after hot water washing, digested for 30 min. by using 1.25% NaOH, washing and filtration into the crucible, dried and ignition. Crude protein in feed and egg shell samples were determined by using Kjeldahl method according to Randhir & Pradhan (1981) and ether extract was determined according to Bligh & Dyer (1959) technique as modified by Hanson and Olly (1963). The fecal nitrogen was determined following the procedures outlined by Jakobsen et al. (1960).

2.5. Digestibility coefficient determination:

Digestibility of nutrients is one of the most important parameters in feed evaluation studies. Digestibility can be determined by accurately measuring feed intake and fecal output. Sample collection: During last week of the experimental period (5th week of experiment I and 6th week of the experiment II), the excreta were quantitatively collected for 5 days successive days during which feed consumption data were also recorded. The excreta then dried in hot air oven, following this, excreta was allowed to equilibrate in moisture with the air before being weighed, then finally ground and stored until chemical analysis for determination of nutrients was performed.

2.6. Evaluation of immune response:

Immune response of birds was estimated by a group of parameters including Phagocytic activity, phagocytic index, and differential leukocytic count

Phagocytic activity and phagocytic index: These parameters were determined according to Kawahara et al. (1991). Fifty micrograms of Candida albicans culture was added to 1 ml of citrated blood collected at the end of experiment (35 days). Treated blood samples were put in shaker water bath at 23 – 25o C for 3 – 5 hrs. Smears of blood were made and then stained with Geimsa stain. Phagocytosis was estimated by determining the proportion of macrophages which contain intracellular yeast cells in a random sample of 300 macrophages and expressed as percentage of phagocytic activity (PA). The number of phagocytized candida cells was

counted in the phagocytic cells to calculate the phagocytic index according to the following equations : Phagocytic activity (PA) = Macrophages containing yeast/Total number of Macrophages X100. Phagocytic index (PI)= Number of cells phagocytized/Number of phagocytic cells.

2.7. Differential leukocytic count:

This test was done at the end of experiment. Blood film was prepared according to the method described by Lucky (1977). Ten drops from May-Grunwald stain stock solution were added to equal amount of distilled water on a dry unfixed smear then mixed and left for 1 minute for staining. The dye was decanted without rinsing. Diluted Geimsa stain was poured over the film as counter stain and left for 20 minutes then rinsed in water current and examined by oil emersion lens. The percentage and absolute value for each type of cells were calculated according to Schalm (1986).

2.8. Blood samples:

At the end of the experimental period, blood samples were taken from 5 birds from each groups. The blood samples were left to drop on the side of the tube to prevent destruction of RBCs. Each blood sample was left to coagulate at room temp. Separation of serum was carried out by centrifugation of coagulated blood at 3000 rpm for 10 min. The clear serum was transferred carefully to clean and dry vials and kept in deep freezer until analysis for determination of serum glucose, total serum protein, albumin and globulin according to Trinder (1969), Doumas et al. (1981), Reinhold (1953) & Coles (1974) respectively.

2.9. Carcass characteristic:

At the end of the experimental period, 5 chicks from each groups were randomly selected and scarified to calculate the dressing percentages, also collect the liver, heart, gizzard, spleen, bursa, thymus gland, abdominal fat and Total edible carcass (TEC) and relative weight of each organ was calculated as follows: Relative weight = (organ weight/Live body weight) X 100.

2.10. Economic efficiency:

Total production costs were calculated including prices of one-day broiler chicks at the start of the experiment, feeding, veterinary care, labors, management and housing. Selling price was calculated by multiplying total live weight of the broiler chicks produced by the price unit weight commonly offered in the Market, and the economic efficiency was estimated as following: Economical efficiency% = Net revenue/ Total production cost X100.

Statistical analysis:

The analysis of variance for the obtained data was performed using Statistical Analysis System ,SAS (1996) to assess significant differences.

3. RESULTS AND DISCUSSION:

3.1. Body weight development (BWD)

Effect of dietary garlic extract supplementation on body weight development of broiler chicken are presented in table 4. Statistical analysis of the obtained data revealed that no significant difference between experimental groups at the start of the experiment. Also, it was found that various levels of garlic extract supplementation had no significant ($P \geq 0.05$) effect on body weight of broiler chicks at 1st, 2nd and 3rd weeks of age when compared with untreated group.

On the other hand dietary garlic extract supplementation at 0.1, 0.2 and 0.3mg/kg diet significantly ($P \leq 0.05$) improved final body weight by about 6.87 , 12.76, 10.13 % when compared with control broiler chick group. In contrast high level (0.4 mg/Kg) addition of garlic extract non significantly ($P \geq 0.05$) decreased final body weight of broiler chicks by about 1.13 % when compared with control one. This result was in agreements with Raeesi et al. (2010), Mansoub & Nezhady (2011), Kumar et al. (2005) & Afsharmanesh et al. (2008) who found positive effects of Garlic supplementation on broiler performance . On the other hand Onibi et al. (2009) and found no significant ($P<0.05$) differences among treatments that received different levels of garlic.

The highest body weight (2329.75 g) was obtained by broiler chick group fed on the basal diet supplemented by 0.2 mg garlic extract/Kg diet, followed by (2275.35 g) those fed on the basal diet supplemented by 0.3 mg garlic extract/Kg diet, followed by (2208.00 g) those fed on the basal diet supplemented by 0.1 mg garlic extract/Kg diet, followed by (2066.15 g) those fed on the basal diet without supplementation and the worst final body weight (2042.82 g) was obtained by broiler chicks group fed on the basal diet supplemented by 0.4 mg garlic extract/kg diet.

Table (4): Effect of dietary garlic extract supplementation on body weight development (g/bird) of broiler chicks).

AGE/ WEEKS	ALLICIN SUPPLEMENTATION (MG/KG)				
	Control	**25**	**50**	**75**	**100**
0	45.98±0.30[a]	46.43±0.39[a]	46.18±0.38[a]	46.23±0.40[a]	45.85±0.40[a]
1	178.75±2.70[a]	171.88±3.43[a]	176.00±2.87[a]	173.88±3.57[a]	179.00±2.91[a]
2	507.13±8.76[a]	514.13±8.82[a]	516.00±9.32[a]	507.38±8.17[a]	517.50±8.61[a]
3	1150.38±21.30[a]	1120.00±12.88[a]	1123.13±13.07[a]	1130.00±16.95[a]	1112.25±13.51[a]
4	1683.46±31.64[a]	1611.13±23.69[ab]	1593.50±28.42[b]	1600.75±31.66[b]	1494.36±22.53[c]
5	2066.15±30.82[c]	2208.00±22.55[b]	2329.75±30.62[a]	2275.35±30.18[ab]	2042.82±17.75[c]
RTC*	100	106.87	112.76	110.13	98.87

*Final Wt RTC= final body weight relative to control. Values are means ± standard error.
Mean values with different letters at the same row differ significantly at ($p \leq 0.05$).

3.2. Growth performance and Feed efficiency

It was observed that allicin supplementation at 25, 50, 75 or 100mg/Kg diet significantly increased body gain (table,5) throughout the whole experimental period by about 6.9%, 13.03% and 10.3% respectively when compared with control. In contrast higher level (100mg/Kg diet) of garlic extract supplementation non significantly ($P \geq 0.05$) reduced body gain throughout the whole experimental period by about 1.2% when compared with control. These results are in line with those reported by Ahmad (2005) who reported higher weight gain in broilers fed rations supplemented with garlic. These results might be due to the good health status of the birds, which may be caused by the addition of garlic, and might also be due to the chemical composition of garlic Reuter (1995), Onibi et al. (2009) & Fadlalla et al. (2010), however, reported that garlic powder had no significant effect on the body weight gain and feed conversion ratio of birds. Windisch et al. (2008) work on the proven effects of phytobiotic feed additives in different poultry species, indicated a reduced feed intake, and improved feed conversion ratio. Pourali et al. (2010) suggested that allicin in garlic promotes the performance of the intestinal flora thereby improving digestion and enhancing the utilization of energy, leading to improved growth. Similar, observations were made Onu & Aja (2011), in their study on weaned rabbits, they noted that these herbs may have controlled and limited the growth and colonization of numerous pathogenic and nonpathogenic species of bacteria in the gut leading to improved translation of feed to meat. Ramakrishna et al. (2003) also suggested that garlic supplementation enhances the activity of pancreatic enzymes and provides an environment for better absorption of nutrients.

Dietary, allicin supplementation at 25, 50, 75 or 100 mg/Kg diet increased feed intake throughout the whole experimental period by about 2.6%, 2.7%, 2,9% and 2.9% respectively when compared with control group. The present data are in harmony with those obtained by Adjei et al. (2015) they stated that daily feed intake of birds on T2 (0.10 g/kg allicin) was significantly ($p<0.05$) better than T3 and T4 in the inclusion levels of 0.15 and 0.20 g/kg respectively and T0 (control) and T1 (supplemented with antibiotics). The highest total feed intake was recorded by T2 which was statistically ($p<0.05$) significant from T1, T3 and T4 but similar ($p>0.05$) to the control (T0). The lowest level of dietary allicin inclusion (0.10 g/kg) recorded an increase in feed intake. This is in contrast with Raeesi et al. (2010) who reported that the control group at the end of the experiment significantly consumed more feed than the other groups, except those which were supplemented with 0.5 % garlic powder.

It was observed that allicin supplementation at 25, 50 or 75mg/Kg diet significantly ($P \leq 0.05$) improved FCR, PER, EUU and PI of broiler chicks throughout the whole experimental period when compared with control one, while high level (0.4mgKg diet) of allicin supplementation non significantly ($P \geq 0.05$) deteriorate FCR, PER, EEU and PI of broiler chicks throughout the whole experimental period when compared with untreated chicks group. These results are consistent with the finding of Soliman (2000); El-Gamry et al. (2002); Tollba & Hassan (2003) & Ziton (2009) who mentioned that, addition of garlic powder in broilers diet improved significantly the feed conversion ratio of the broilers.

Table (5): Effect of dietary allicin supplementation on growth performance and feed efficiency parameters of broiler chicks).

ITEMS	DIETARY ALLICIN SUPPLEMENTATION (MG/KG)				
	Control	25	50	75	100
Initial Wt. (g)	45.98±0.30[a]	46.43±0.39[a]	46.18±0.38[a]	46.23±0.40[a]	45.85±0.40[a]
Final Wt. (g/bird))	2066.15±30.82[c]	2208.00±22.55[b]	2329.75±30.62[a]	2275.35±30.18[ab]	2042.82±17.75[c]
Total weight gain (g/bird)	2020.28±30.57[c]	2161.58±22.21b	2283.58±30.31a	2229.13±29.81ab	1997.08±17.39c
Wt gain RTC[1]	100	106.99	113.03	110.34	98.85
Total FI (g/bird)	3351.95	3438.49	3442.9	3452.25	3451.48
Feed intake RTC	100	102.6	102.7	102.9	102.9
Average FCR[2]	1.67±0.02[a]	1.60±0.02[b]	1.52±0.03[b]	1.56±0.02[b]	1.73±0.01[a]
FCR RTC	100	95.8	91.02	93.4	103.4
Average PER[3]	2.82±0.04[b]	2.95±0.03[a]	3.10±0.04[a]	3.02±0.04[a]	2.72±0.02[b]
Average EEU[4]	5.09	4.86	4.64	4.75	5.28
Average PI[5]	125.59±3.79[c]	139.37±3.02[b]	155.58±3.88[a]	147.94±4.07[ab]	118.54±2.11[c]

Values are means ± standard error. Mean values with different letters at the same row differ significantly at ($p \leq 0.05$). [1] weight gain relative to control. [2]= average feed conversion ratio. [3]=average protein efficiency ratio. [4] =average efficiency of energy utilization. [5]= performance index.

3.5. Blood pictures:

Effect of dietary garlic extract supplementation on some blood pictures are presented in table 6. Statistical analysis of the obtained data indicated that garlic extract supplementation at different levels had no significant effect on TWBCs counts when compared with the control, while garlic extract supplementation at levels 0.1, 0.2, 0.3 or 0.4 mg/Kg diet increased RBCs counts by about 3.2%, 16.1%, 25.8% and 12.9% respectively when compared with the control.

Moreover, it was observed that garlic extract non significantly increased Hb concentration and PCV% by about (6.3% and 6.3%), (7.5% and 4.2%), (8.8% and 8.8) and (8.8% and 5.9%) respectively when compared with the control. The increase in PCV, Hb, and RBC contents of the blood of birds fed the test ingredients is an indication of improved oxygen carrying capacity of the cells which translated to a better availability of nutrients to the birds consequently affecting their well-being. The present data are in harmony with those obtained by Vivian U. Oleforuh-Okoleh et al. (2015) observed that Significant ($p<0.01$) increases were observed in hemoglobin concentration, packed cell volume, white blood cell, and red blood cell of the ginger and garlic treated birds. Also, these results are in agreement with the findings of Elnagar et al. (2003) who reported an increase in RBCs count for birds fed diet with garlic extract compared to the control birds.

Also, Eid and Iraqi. (2014) reported that highly significant ($p<0.0001$) on count of white blood cells (WBC). The group fed on diet of GP200 had the highest ($P<0.05$) count of WBC (28.5×103), followed by group fed on GP150 (28.0×103). The same trend was observed for means of count for red blood cells (RBC). Means count of RBC were highest in the group fed on GP200 diet (2.85×106) and the lowest (2.73×106) was for group fed on GP0 diet. In this concern, Jamroz et al. (2003) explained that the 80% concentration of garlic had inhibition effects on the E.coli, Salmonella and Staphylococcus, thus white blood cells count are increased. An opposite results was reported by Ologhobo et al. (2008) & Onyimonyi et al. (2012) who found that dried garlic incorporation into the ration of broilers did not affect the normal hematological integrity of the birds.

Table (6): Effect of dietary garlic extract supplementation on some blood picture of broiler chicks.

ITEMS	ALLICIN SUPPLEMENTATION (MG/KG)				
	Control	25	50	75	100
TWBCs ((X10^6)	22.13±0.35[a]	21.13±0.40[a]	21.63±0.42[a]	22.13±0.48[a]	21.38±0.32[a]
TRBCs (X10^3)	1.24±0.05[b]	1.28±0.05[b]	1.44±0.07[ab]	1.56±0.03[a]	1.40±0.05[ab]
Hb %	10.00±0.38[a]	10.63±0.26[a]	10.75±0.45[a]	10.88±0.35[a]	10.88±0.23[a]
PCV%	29.75±1.00[b]	31.63±0.46[ab]	31.00±0.57[ab]	32.38±0.78[a]	31.50±0.71[ab]

Values are means ± standard error. Mean values with different letters at the same row differ significantly at ($p \leq 0.05$).

Table (7): Effect of dietary garlic extract supplementation on some blood serum biochemical parameters of broiler chicks.

ITEMS	DIETARY ALLICIN SUPPLEMENTATION (MG/KG)				
	Control	25	50	75	100
Total protein (g/dl)	5.78±0.59[b]	5.60±0.53[b]	6.05±0.77[a]	5.51±1.11[b]	5.99±0.64[b]
Albumin (g/dl)	4.72±0.29[b]	4.87±0.35[b]	5.00±0.53[a]	3.86±1.32[c]	4.92±0.50[b]
Globulin (g/dl)	1.06±0.41[a]	0.73±0.53[c]	1.05±0.95[a]	1.65±1.02[a]	1.07±0.36[a]
Alb./glob. ratio	4.53±1.64[a]	6.97±3.06[a]	4.74±1.62[a]	2.63±1.05[b]	4.69±1.22[a]
Glucose (mg/dl)	86.28±17.16[c]	82.53±19.62[c]	85.91±14.49[d]	98.39±2.90[a]	89.65±14.53[b]

Values are means ± standard error. Mean values with different letters at the same row differ significantly at ($p \leq 0.05$).

3.6. Blood serum units:

Effect of dietary garlic extract (allicin) supplementation on some blood parameters are presented in table 7. Statistical analysis of the obtained data revealed that garlic extract (allicin) supplementation at 50mg/kg diet significantly increased blood serum total protein and albumin concentrations by about 4.7 and 5.9% respectively, while allicin supplementation at 25, 75 or 100mg/Kg had no significant effect on blood serum total protein and albumin concentrations when compared with the control except 75mg/Kg diet significantly reduced blood serum albumin concentration. Moreover, allicin supplementation had no significant effect on globulin blood serum concentration when compared with the control except with the lower inclusion level of allicin (25mg/kg) significantly reduced blood serum globulin concentration when compared with the control one. The present data are in harmony with those obtained by Vivian U. Oleforuh-Okoleh et al. (2015) while there was significant increase in the total protein, albumin, and globulin of the ginger or garlic treated birds ($p < 0.01$) when compared with the control one..

Regarding blood serum glucose concentration, it was observed that allicin supplementation at 25, 50, 75 or 100mg/Kg diet reduced blood serum concentration by about 4.3%, 3.3%, and 6.5% respectively when compared with the control. These findings are similar to those of Shalaby et al. (2006) and Kamal & Daoud (2003) whom observed significant reduction in serum glucose concentration due to garlic supplementation. The significant reduction in glucose due to A. sativum supplementation in diets might be due to allicin and sulfur compounds of garlic. In addition, several ginger components exhibit serotonin receptor-blocking activity Huang et al. (1991); Abdel-Aziz et al. (2005). This hypoglycemic action of ginger may be due to these effects involving serotonin receptors, an increase in pancreatic secretion of insulin from beta cells or release of bound insulin.

Blood serum lipids: Effect of dietary garlic extract supplementation on blood serum lipids concentration is presented in table 8. Statistical analysis of the obtained data indicated that garlic extract supplementation at 0.2, 0.3 or 0.4 mg/Kg diet significantly reduced blood serum triglycerides concentration by about 25.7%, 7.5% and 19.0% respectively when compared with the control. However, lower inclusion level of garlic extract (0.1mg/kg) increased ($P \leq 0.05$) blood serum triglycerides concentration by about 1.2% when compared with the control.

Results of the present study are in agreement to Hokanson & Austin (1996), who reported significant reduction in the level of triglyceride in rats by garlic paste. Our findings are also supported by the work of Leng et al. (2004), who worked on the effect of barbery on lipid profile and found that berbery infusion significantly reduced the triglyceride level in blood. Thomson and Ali (2003) supported our results by reporting triglyceride lowering property of garlic, which is component of the present mixture. Regarding blood serum total cholesterol concentration, it was observed that garlic extract supplementation (0.1, 0.2, 0.3 or 0.4 mg/Kg diet) significantly reduced cholesterol concentration of broiler chickens by about 12.9%, 11.9%, 7.9% and 14.2% respectively when compared with the control.

Table (8): Effect of dietary garlic extract supplementation on some blood serum lipids concentrations of broiler chicks.

ITEMS	DIETARY ALLICIN (MG/KG) SUPPLEMENTATION				
	Control	25	50	75	100
Triglyceride (mg/dl)	197.34±28.00[b]	199.73±31.33[a]	146.62±65.98[e]	182.56±40.82[c]	159.78±35.98[d]
Cholesterol (mg/dl)	194.76±39.67[a]	169.55±33.08[d]	171.55±25.72[c]	179.21±30.25[b]	169.67±31.28[d]

Values are means ± standard error. Mean values with different letters at the same row differ significantly at ($p \leq 0.05$).

This data in agreement with those obtained by Mansoub (2011) who reported reductions in total cholesterol when broilers supplemented with 1 g/kg garlic. The results of present study is, also, in agreement with Stanacev et al. (2011) who reported that garlic manifested hypocholesterolemic effects on chickens through inhibition of the most important enzymes that participate in the synthesis of cholesterol and lipids. Konjufca et al. (1997) reported that garlic reduced plasma cholesterol by decreasing the activity of 3-hydroxy-3-methlyglutaryl reductase. Allicin has been proposed as the active compound in garlic responsible for health promotion and hypocholesterolaemic benefits Lawson (1998).

Liver and kidney functions serum parameters: Effect of dietary allicin supplementation on some kidney and liver blood serum parameters of broiler chicken are presented in table 9. Statistical analysis of the obtained data indicated that allicin supplementation at 25mg/Kg diet significantly reduced blood serum uric acid concentration when compared with the control, while 100mg of allicin supplementation non significantly reduced blood serum uric concentration. In contrast, dietary supplementation of allicin at 50 or 75 mg/kg diet significantly increased blood serum uric acid concentration when compared with the control. On the other hand, it was observed that allicin supplementation significantly reduced blood serum creatinine concentration when compared with the control. The present data indicated that garlic extract (allicin) had renal protection role against some stress factors and improve its healthy condition, which is probably through its excellent antioxidant properties and highly nutritional values.

Regarding enzymatic profile, it was observed that allicin supplementation at 25, 50 or 75 mg/kg of broiler diet significantly reduced GPT blood serum concentration by about 7.5%, 12.7% and 8.6% respectively, while higher inclusion rate of allicin (100mg/Kg) increased ($P \leq 0.05$) GPT blood serum concentration by about 3.1% when compared with the control. Regarding GOT blood serum concentration, it was cleared that allicin inclusion in broiler ration had no clear line on GOT blood serum concentration as 25 or 100 allicin mg/kg significantly increased GOT and 50mg allicin had no significant effect while, 75 mg allicin reduced GOT serum concentration when compared with the control one. On the other hand, garlic extract supplementation at 50, 75 and 100mg/Kg significantly reduced blood serum ALP concentration while, 75mg allicin increased its concentration when compared with the control. Generally the lowest enzymatic profile was noticed in broiler chick group fed on the basal diet supplemented by 50 mg allicin/Kg diet and highest levels of allicin increased liver enzymatic profile. These results can be attributed to garlic extract, which may cause stabilized cell membrane and protect the liver against deleterious agents and free radical-mediated toxic damages to the liver cells. This is reflected in the reduction of liver enzymes. This data are in harmony with those obtained by Kumar et al. (2013) who observed that serum glutamate oxaloacetate transaminase (SGOT) concentration, and serum glutamate pyruvate transaminase (SGPT) concentration decreased significantly ($P \leq 0.05$) of broiler chicken due to A. sativum supplementation in different treatment group as compared to control group at 28th and 42nd days.

Table (9): Effect of dietary garlic extract supplementation on some kidney and liver blood serum function parameters of broiler chicks.

	DIETARY ALLICIN (MG/KG) SUPPLEMENTATION				
ITEMS	Control	25	50	75	100
Uric acid (mg/dl)	5.93 ± 1.03^{b}	4.91 ± 2.25^{c}	6.22 ± 0.97^{a}	6.18 ± 1.02^{a}	5.98 ± 0.99^{b}
Creatinine (mg/dl)	1.35 ± 0.47^{a}	0.90 ± 0.20^{e}	0.95 ± 0.21^{d}	1.08 ± 0.31^{c}	1.20 ± 0.29^{b}
GPT (µ/L)	113.75 ± 11.03^{b}	105.25 ± 14.61^{c}	99.25 ± 4.78^{d}	104.0 ± 4.16^{c}	117.25 ± 14.15^{a}
GOT (µ/L)	27.75 ± 7.37^{b}	29.88 ± 5.27^{a}	27.88 ± 4.09^{b}	25.25 ± 3.86^{c}	29.63 ± 1.25^{a}
ALP (µ/L)	1068.25 ± 112.16^{b}	1051.0 ± 62.51^{c}	874.5 ± 83.23^{e}	1109.5 ± 82.48^{a}	1022.25 ± 69.79^{d}

Values are means ± standard error. Mean values with different letters at the same row differ significantly at ($p \leq 0.05$).

3.7. Differntial leucocytic counts:

Effect of dietary allicin supplementation on differential leucocytic counts of broiler chicks are presented in table 10. It was observed that allicin supplementation at 25, 50, 75 or 100 mg/Kg had no significant effect on lymphocytes, monocyte, esinophil and basophil percentages of broiler chicken when compared with the control, while the highest percent of lymphocytes, esinophil and basophil was observed with higher inclusion of allicin in the broiler diet. On the other hand, 50mg of allicin/Kg diet exhibited non significantly

(P≥0.05) increase of neutophil and hetrophil percentage by about 1.1% and 4.7% respectively and consequently had higher H/L ratio when compared with control one, while higher inclusion levels (100mg/kg) non significantly (P≥0.05) reduced neutrophil and hetrophil percentage by about 5.2% and 6.4% respectively and reduced H/L ratio when compared with the control.

This indicates that garlic extract supplementation at 50mg/Kg in broiler chicken ration stimulate immunity of broiler chicken while, higher inclusion level (100mg/kg) had negative effect. These data are in agreement with those obtained by Eid & Iraqi. (2014) reported that improvement of broiler chicks immune system and significant increase of lymphocytes", heterophyles "H" and H/L ratio with garlic extract supplementation.. The slight rise in neutrophil and heterophyle counts observed in garlic extract supplemented groups may be due to immunostimulatory effect of garlic. These results disagree with findings of Ologhobo et al. (2008) & Onyimonyi et al. (2012). They showed that dried garlic incorporation into the ration of broilers did not affect the normal hematological integrity of the birds.

Table (10): Effect of dietary garlic extract supplementation on differential leuckocytic counts of broiler chicks.

	DIETARY ALLICIN SUPPLEMENTATION (MG/KG)				
ITEMS %	Control	25	50	75	100
Lymphocyte (L)	44.88±0.67^{ab}	45.63±0.50^{a}	43.63±0.60^{b}	45.25±0.37^{a}	45.88±0.35^{a}
Monocyte	10.75±0.31^{a}	10.50±0.42^{a}	11.00±0.19^{a}	10.50±0.33^{a}	10.50±0.33^{a}
Esinophil	10.13±0.48^{a}	10.50±0.46^{a}	10.75±0.16^{a}	11.13±0.30^{a}	11.00±0.27^{a}
Basophil	0.63±0.18^{a}	0.50±0.19^{a}	0.63±0.18^{a}	0.75±0.16^{a}	0.75±0.16^{a}
Neutrophil	33.63±0.96^{a}	32.88±0.83^{a}	34.00±0.27^{a}	32.38±0.62^{a}	31.88±0.55^{a}
Hetrophil (H)	21.25±0.53^{ab}	21.25±0.37^{ab}	22.25±0.65^{a}	21.38±0.32^{a}	19.88±0.35^{b}
H/L ratio	47.35	46.57	50.99	47.25	43.33

Values are means ± standard error. Mean values with different letters at the same row differ significantly at (p ≤0.05).

3.8. Phagocytosis:

Effect of dietary garlic extract supplementation on phagocytosis of broiler chicken is presented in table 11. Statistical analysis of the obtained data indicated that garlic extract supplementation at 0.1, 0.2, 0.3 or 0.4 mg/Kg diet increased phagocytic activity by about 2.2%, 10.5%, 22.5% and 6.7% respectively when compared with the control one. However, garlic extract supplementation reduced phagocytic index when compared with control.

The present data showed that immune response of broiler chicks improved with increasing allicin levels while the highest inclusion rate (0.4mg/Kg) reduced immune response compared with other garlic extract levels of broiler chicks ration. Scientists have reported that addition of garlic extract to a macrophage culture of laying hens at 50 μg/mL tended to enhance Sheep red blood cells uptake; on the other hand, high concentration of the extract (200 μg/mL) inhibited phagocytosis Dorhoi et al.

(2006). Experiments in humans and mice revealed that addition of aged garlic extract to a culture enhances the phagocytosis of peritoneal cells and increases the production of interleukin (IL)-2, IL-12, interferon-y and tumor necrosis factor-a from spleenocytes Kyo et al. (2001), and the addition of different garlic extracts enhances the engulfment ability of phagocytes Romano et al. (1997), as well as the secretary metabolism of macrophages Gomez-Flores et al. (2000).

Table (11): Effect of dietary garlic extract supplementation on phagocytosis of broiler chicks.

ITEMS	Dietary allicin supplementation (mg/kg)				
	Control	25	50	75	100
Phagocytic activity	16.63±0.37^{c}	17.00±0.33^{bc}	18.38±0.68^{b}	20.38±0.50^{a}	17.75±0.45^{bc}
Phagocytic index	1.70±0.04^{a}	1.68±0.03^{a}	1.40±0.06^{b}	1.65±0.06^{a}	1.48±0.04^{b}

Values are means ± standard error. Mean values with different letters at the same row differ significantly at (p ≤0.05).

3.9. Immune organs

Effect of dietary garlic extract supplementation on some immune organs of broiler chicks are presented in table 12. Statistical analysis of the obtained data revealed that garlic extract supplementation at 0.1, 0..2, 0.3 or 0.4 mg/Kg diet

non significantly increased spleen weight and relative weight when compared with the control. Regarding thymus gland and bursa weight and relative weight, it was observed that garlic extract supplementation at 0.2 mg/Kg diet significantly increased both thymus gland and bursa weight or relative weight, while garlic extract supplementation at 0.1 or 0.3 mg/Kg diet non significantly increased weight or relative weight of thymus gland and bursa, while higher inclusion level of garlic extract (0.4mg/Kg diet) reduced thymus gland and bursa weight or relative weight when compared with the control one. It can concluded that supplementation of garlic extract at 0.2mg/Kg diet more immune stimulant the lower or higher inclusion levels.

The present data are in harmony with those obtained by Elagib et al. (2013) stated that both bursa and thymus showed no significant difference ($P \geq 0.05$) between the different treatments. Spleen weight was decreased significantly ($P < 0.05$) in birds fed 3 and 5% level compared to 0% level. No structural changes observed in the shape of bursa, spleen and the thymus of the different groups.

Table (12): Effect of dietary garlic extract supplementation on some immune organs of broiler chicks.

ITEMS	DIETARY GARLIC EXTRACT SUPPLEMENTATION (MG/KG)				
	Control	25	50	75	100
Spleen weight	3.55± 0.65^{a}	4.28±0.39^{a}	3.95±0.46^{a}	3.98±0.50^{a}	4.48±0.87^{a}
Spleen relative weight	0.17±0.03^{a}	0.19±0.02^{a}	0.17±0.02^{a}	0.18±0.02^{a}	0.23±0.05^{a}
Thymus gland weight	5.35±0.79^{b}	6.10±0.29^{b}	9.05±1.21^{a}	5.65±1.03^{b}	4.48±0.89^{b}
Thymus relative weight	0.27±0.04^{ab}	0.27±0.01^{ab}	0.38±0.05^{a}	0.25±0.04^{b}	0.22±0.04^{b}
Bursa weight	3.03±0.16^{ab}	3.08±0.14^{ab}	3.85±0.72^{a}	2.33±0.20^{b}	2.53±0.28^{b}
Bursa relative weight	0.15±0.01^{ab}	0.14±0.01^{ab}	0.16±0.03^{a}	0.11±0.01^{b}	0.13±0.02^{ab}

Values are means ± standard error.

Mean values with different letters at the same row differ significantly at ($p \leq 0.05$).

3.10. Nutrient digestibility

Effect of dietary garlic extract supplementation on nutrient digestibility of broiler chicks are presented in table 13. Statistical analysis of the present data revealed that garlic extract supplementation at 0.1, 0.2 or 0.3 mg/Kg diet improved dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) and ash digestibility's percent by about (3.7%, 1.7%, 10.2%, 2.0% and 40.3), (1.7%, 1.4%, 10.4%, 6.9% and 48.1%) and (0.2%, 1.5%, 2.2%, 1.2% and 18.3%) respectively when compared with the control. On the other hand, higher inclusion levels of garlic extract (0.4 mg/Kg diet) reduced organic matter, crude protein and ether extract digestibility when compared with the control. Moreover 0.1 and 0.2 mg/kg addition of garlic extract more stimulant for nutrient digestibility than higher inclusion levels of garlic extract in broiler chicken ration.

These findings are in agreement with previous research of Hernandes et al. (2004) who showed that plant extract supplementation improved apparent whole tract digestibility of the nutrients. The improvement of total tract digestibility in broilers fed different levels of GP was probably due to herbal effects in increasing the microbial population especially the number of bacteria such as E. coli, Clostridium spp. and Enterococci.

The efficacy of any dietary feed additives observed under less hygienic housing conditions, especially under the separate floor pens equipped with wood shaving litter stimulates the activity of the feed additives. The isoprene derivatives, flavonoids, glucosinolates and other plant metabolites may affect the physiological and chemical function of the digestive tract. The stabilizing effect on intestinal microflora may be associated with intermediate nutrient metabolism Bratta et al. (1998) & Jamroz et al. (2003). The active principles of essential oils act as a digestibility enhancer, balancing the gut microbial ecosystem and stimulating the secretion of endogenous digestive enzymes and thus improving growth performance in poultry Lavkova et al. (2001).

Table (13): Effect of dietary garlic extract supplementation on nutrient digestibility (%) of broiler chicks.

ITEMS (%)	DIETARY ALLICIN (MG/KG) SUPPLEMENTATION				
	Control	25	50	75	100
Dry matter	89.96±1.99[b]	93.31±0.37[a]	91.46±1.28[ab]	90.15±2.56[b]	89.95±2.18[c]
Organic matter	93.29±2.22[ab]	94.90±0.21[ab]	94.57±0.32[a]	94.69±2.99[b]	92.03±2.09[b]
Crude protein	80.58±3.87[b]	88.76±1.12[a]	88.98±1.75[a]	82.32±2.85[b]	78.35±3.34[b]
Ether extract	88.84±8.45[b]	90.61±5.06[a]	95.02±3.32[a]	89.92±10.11[b]	77.98±6.81[b]
Ash%	51.89±11.98[b]	72.80±2.66[a]	76.87±2.86[a]	61.40±11.35[b]	56.03±7.94[b]

Values are means ± standard error. Mean values with different letters at the same row differ significantly at ($p \leq 0.05$).

3.11. Carcass traits

Effect of dietary garlic extract supplementation on some carcass traits of broiler chickens are presented in table 14. It was observed that garlic extract supplementation had no significant effect on dressing percent of broiler chicks, while the highest dressing value (73.09% and 73.16%) was observed by chicks fed on the basal diet supplemented by 0.2 and 0.3 mg/kg diet respectively and the lowest value exhibited by broiler chicks fed on the basal diet with 0.1mg garlic extract /Kg diet. Regarding liver weight and relative weight, it was observed that garlic extract supplementation at 0.1 mg/Kg diet significantly increased liver weight and relative weight when compared with the control one, while liver weight and relative weight decreased with increase of garlic extract supplementation.

Research studies have been focusing on improvement of chicken carcasses in order to meet the food industry standards. The best results are achieved through genetic selection, nutrition and breeding technology, which are reflected in a significant increase of overall carcass masses and the share of meat as well as a reduction of the abdominal fat content in 6-week-old chicks. The lack of garlic extract effect on broilers visceral organs observed in this experiment is similar to that reported by previous research. Javandel et al. (2008) & Onibi et al. (2009) who stated that garlic supplementation had no significant effects on major carcass components and organ characteristics. While the present results are not in line with those obtained by Elagib et al. (2013) they reported that birds fed the diet containing 3% garlic powder attained the highest hot weight, dressed weight, breast weight, fleshed breast weight and fleshed breast percentage, followed by the birds fed 0% level and the lowest was attained by 5% level group. This difference in the results can be due to the different products and levels used in the different experiments. Moreover, it can be reported that garlic extract supplementation at different levels had no significant effect on heart, gizzard and proventiculus weight or relative weight when compared with the control. Similar trend was observed in the inedible visceral organs (small intestine and cecum) relative weights. These findings are in agreement with the findings of Hashish et al. (1995) & Ceylan et al. (1998). Also, Adjei et al. (2015) recorded for bled weight, full gizzard, empty gizzard, dressed weight, heart weight, neck weight, shank weight, full intestine weight, empty intestine weight and abdominal fat weight of the experimental birds fed on allicin supplemented diets and also those of the control birds were statistically ($p>0.05$) not significant.

Table (14): Effect of dietary garlic extract supplementation on dressing percent, some organs weight (g) and relative weight of broiler chicks.

ITEMS	DIETARY ALLICIN (MG/KG) SUPPLEMENTATION				
	Control	25	50	75	100
Dressing percent	71.76±2.76[a]	69.65±2.58[a]	73.09±0.58[a]	73.16±0.33[a]	72.43±0.57[a]
Liver weight	58.28± 2.08[ab]	66.35±4.54[a]	61.30±5.16[ab]	62.88±2.50[ab]	53.15±1.18[b]
Liver relative weight	2.87± 0.13[a]	2.95±0.21[a]	2.59±0.21[a]	2.79±0.11[a]	2.64±0.06[a]
Gizzard weight	25.55± 0.93[a]	24.48±1.63[a]	27.90±2.22[a]	29.25±2.76[a]	27.63±1.47[a]
Gizzard relative weight	1.27±0.09[a]	1.09±0.08[a]	1.18±0.10[a]	1.30±0.13[a]	1.38±0.08[a]
Heart weight	10.98±0.47[a]	10.83±1.02[a]	11.15±0.91[a]	10.93±0.71[a]	9.45±0.35[a]
Heart relative weight	0.54± 0.02[a]	0.48±0.05[a]	0.47±0.04[a]	0.49±0.03[a]	0.47±0.02[a]
Provent. Weight	7.59±1.04[a]	7.53±0.31[a]	9.28±0.68[a]	9.03±0.70[a]	7.40±0.63[a]
Provent. relative weight	0.37±0.05[a]	0.34±0.01[a]	0.39±0.03[a]	0.40±0.03[a]	0.37±0.02[a]

Values are means ± standard error. Mean values with different letters at the same row differ significantly at ($p \leq 0.05$).

Economic efficiency of production: Effect of dietary allicin supplementation on economic efficiency of broiler production is presented in table 15. The present data indicated that allicin supplementation in broiler ration numerically increased total cost of broiler production. On the other hand, it was observed that allicin supplementation at 25, 50 or 75 mg/kg diet in broiler chicken ration increased returns by about 6.9%, 13.0% and 10.3% respectively when compared with the control, while higher supplementation rate of allicin (100mg/kg) reduced return by about 1.1% when compared with the control. It was noticed that allicin supplementation at 25, 50 or 75 mg/kg diet increased net income and income/cost % from 401.97 LE and 55.1% for control diet to (466.49 LE and 62.7%), (532.06 LE and 71.2%) and (498.26 LE and 66.4%) respectively while, higher allicin level reduced the same parameters to 366.27 LE and 48.7%.

The best income/cost ratio was obtained by broiler chicks group fed on the basal diet supplemented by 50 mg allicin/kg diet (71.2%) followed by those fed on the basal diet supplemented by 75 mg allicin (66.4%), followed by broiler chicks group fed on the basal diet supplemented by 25 mg allicin/Kg (62.7%), followed by control group which fed on the basal diet without allicin supplementation (55.1%) while the worst income/cost ratio was obtained by broiler chicks group fed on the basal diet supplemented by 100mg allicin/kg diet (48.7%). The economic efficiency improvement may be related to higher body weight achieved by broiler chicks fed on the basal diet with 25, 50 or 75 mg allicin supplementation. The present data are in agreement with those obtained by Oleforuh-Okoleh et al. (2014) they found that garlic extract supplementation had the highest revenue and net return, and also gave the least cost-benefit ratio. The best income/cost ratio, implying that it is the best diet from the economic point of view; since reaching the highest body weight or maximum egg production in return for each unit of feed intake is the aim of raising commercial poultry Raeesi et al. (2010).

Table (15): Effect of dietary garlic extract (allicin) supplementation on economical efficiency of broiler chicks production.

ITEMS	DIETARY ALLICIN (MG/KG) SUPPLEMENTATION				
	Control	25	50	75	100
Chicks number	40	40	40	40	40
Chicks price (LE)	160	160	160	160	160
Feed costs (LE)*	489.38	502.01	502.66	504.02	503.91
Allicin (LE)	____	1.98	4.08	6.03	8.18
Other costs (LE)**	80	80	80	80	80
Total costs (LE)	729.38	743.99	746.74	750.05	752.09
Returns (LE)***	1131.35	1210.48	1278.8	1248.31	1118.36
Net income (LE)	401.97	466.49	532.06	498.26	366.27
Benefit / cost ratio %	155.1	162.7	171.2	166.4	148.7
Income / cost %	55.1	62.7	71.3	66.4	48.7

*feed price (LE/Kg) X total feed intake . **Managemental cost including veterinary care, drug used, workers and housing. ***number of birds sold X live weight X market price (14LE/live Kg).

4. CONCLUSION

It can be concluded that .dietary garlic extract (allicin) supplementation at 50 mg/Kg diet improve growth performance, feed efficiency, nutrient digestibility and economical efficiency of broiler chicken production. Lower or higher inclusion rate of allicin in broiler chicken ration than 50 mg/Kg diet consider uneconomically for broiler chicken production when compared with recommended one.

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