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EFFECT OF GARLIC AS FEED ADDITIVE ON PERFORMANCE, CARCASS CHARACTERISTICS, AND MEAT QUALITY OF MUSCOVY DUCKS REARED IN DIFFERENT STOCKING DENSITIES

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ABSTRACT

This study was carried out to evaluate the effect of supplementing diet with different garlic powder concentrations (300 and 600gm/Ton) on performance, carcass characteristics and meat quality (fat %) of Muscovy ducks exposed to different stocking densities; standard stocking density (4 birds/m^2) and high stocking density (8 birds/m^2). A total number of 180 one -day -old Muscovy ducklings were used in this experiment. Birds were randomly allocated into 18 symmetrical pens classified into 6 treatment groups (3 replicate / treatment). Groups (C, SS+G_{300}, SS+G_{600}) raised on standard stocking density and fed on basal diet supplemented with (0 , 300 and 600 g. garlic powder,/ton feed) respectively while groups (HS, HS+G_{300}, HS+G_{600}) raised on high stocking density and fed on basal diet supplemented with (0 , 300 and 600 g. garlic powder/ton feed) respectively. The data of growth performance indicated that supplementation of garlic (600 gm / ton) significantly ($p > 0.05$) improved performance (body weight gain and FCR) of ducks in standard stocking density (SS+G_{600}) group and high stocking density in (HS+G_{600}) group. Concerning carcass characteristic and meat quality, results indicated that, garlic supplementation reduced fat % in thigh and breast muscles. It can be concluded that, adding garlic powder to duck ration can effectively compensate the negative effects of the high stocking density in Muscovy ducks.

Keywords: Carcass characteristics, garlic, Muscovy ducks, performance, stocking density

INTRODUCTION

World duck production has increased considerably since 1993, and meat production has risen from 1.72 to 4.34 million tons (**Deman, 2014).** Ducks are capable of increasing the much needed animal protein on

account of their reputation for fast growth and efficient feed conversion (**Ahaotu and Aghasu (2015)**. The performance and welfare of ducks are affected by different factors like environment, nutrition, management, and genetic makeup **(Estevez, 2007)**. Stocking density is an important factor affecting duck production and welfare, but economic profit may come at the cost of reduced bird performance, health, and welfare if densities are excessive (**Xie. et al .,2014),** as high stocking density led to physical restriction of birds movement as locomotors behaviour so effect the access of birds to feed and water **(Estevez, et al., 1997** and **SCAHAW, 2000)**, decrease growth performance **(Simitzis et al., 2012; Tong et al., 2012),** carcass traits **(Dozier et al., 2005 and Dozier et al., 2006) ,** meat quality **(Osman, 1993) .** But a higher profitability per kilogram of poultry can be obtained by increasing the stocking density if the performance of birds remains constant (**Feddes et al., 2002**).

The utilization of plants of natural origin (phytobiotics) as growth promoters considered a practical and achievable way in recent years (**Grashorn, 2010; Yang et al., 2015**). A large variety of plant compounds (phytobiotics) such as garlic were used as growth promoters **(Farhad *et al*., 2011 and Ismoyowati et al., 2015)** .In poultry, garlic has been shown to improves growth and Feed Conversion Ratio (FCR), and decreased mortality rate (**Lewis *et al*., 2003 and Tollba and Hassan ., 2003) and Bampidis, *et al*., 2005)** also induce hypocholesterolemia (**Yeh and Liin 2001 and Yoo et al., 2011)** which important in improving the fat composition and overall appearance of duck meat **(Dwiloka., et al 2015)** which can provide more benefits for human health.

Researches about the effect of garlic on productive performance and carcass characteristics of Muscovy ducks on different stocking density was scarce .Therefore, the current study was conducted to assess the effects of different concentration of garlic powder supplementation on productive performance, carcass characteristics, meat quality (fat %) of Muscovy ducks in different stocking density.

MATERIAL AND METHODS

Birds and housing

The present study was carried out at the poultry research unit at the Department of Veterinary Hygiene and Management, Faculty of

Veterinary Medicine, Cairo University. A total number of 180 one day old Muscovy ducks (Carina moschata) of both sexes were divided into 6 groups in 3 replicates of 10 ducks in standard stocking density groups and 20 duck in high stocking density group. All ducks were weighed before the start of experiment to take the initial weight then brooded at about 35 °C using gas heater during the 1st week of brooding period then gradually reduced 3 °C / week till reaching 25 °C at 4th week of age till the end of the study, Continuous lighting program of 23 h light and 1 h dark was maintained by the natural day light and continued by artificial light throughout the experimental period and good ventilation was maintained through the experiment. (**Coates et al., 2000).**

The experimental birds were reared in floor litter system with wood shaving (10 cm depth) at separate pens of identical size (3 m length x 2.50 m width x 3 m height) which was thoroughly cleaned, washed and disinfected before arrival of duckling; Fresh clean water and feed was supplied ad libitum throughout the experimental period. The ducks were fed A starter diet of (23.34 CP and 3020.80 kcal/kg ME) that have been used from 0–4 weeks while grower diet of (19.26 CP and 3250.37 kcal/kg ME) were fed from 5 - 10 weeks (end of trials). The basal starter and grower diets were formulated to meet the nutrient requirements of Muscovy ducks according to the recommendation of the national research council **(NRC, 1994).**

Experimental design

Birds were randomly allocated into 18 symmetrical pens classified into 6 groups and each group was represented by three replicates / group. The 1st group fed on basal diet with standard stocking density [control (C) group], the 2nd group fed on basal diet with high stocking density (HS group), the 3rd group fed on basal diet with 300 g. garlic powder / ton feed with standard stocking density ($SS+G_{300}$ group), the 4th group fed on basal diet with 300 g. garlic powder / ton feed with high stocking density ($HS+G_{300}$ group), the 5th group fed on basal diet with 600 g. garlic powder / ton feed with standard stocking density ($SS+G_{600}$) group), the 6th group fed on basal diet with 600 g. garlic powder / ton feed with high stocking density ($HS+G_{600}$ group).

Parameters measured
Performance Parameters:

A random sample of 5 birds from each replicate were weighted individually every week using large- pan beam balance to obtain the average body weight then average weekly weight gain was calculated through the following equation:

Average weight gain = (W2-W1)

Where:
W2= average body weight in a particular week
W1 = a average body weight in a previous week

The feed consumption was calculated weekly for each group throughout the experimental period. Feed conversion was calculated weekly by dividing the average feed consumption / ducks / week on the average body weight gain / ducks / week. **(Sheng-Qiu et al., 2013**). The mortality rate was recorded daily throughout the experimental period.

Carcass and organ characteristics:

At the end of the experiment, Feed was withdrawn 12 h before slaughter and 5 birds from each replicate were taken randomly and slaughtered for their dressing percentage and organ weight (heart, liver, and gizzard). **(Ahaotu and Agbasu, 2015).**

Meat quality measurements (fat %):

At the end of the experiment three birds from each replicate were randomly chosen and were slaughtered by severing of jagular vein then thigh (Biceps femoris) and breast (Pectoralis major) muscle samples were taken from each carcass and then analyzed individually to determine the fat percentage of the breast and thigh muscles (**Galal., et al ., 2011)** by Soxhlet method. **(AOAC, 1995).**

Statistical analysis

Parametrical statistical test were applied (ANOVA) after exploration of data. Descriptive statistics are represented by means ± standard error (SE). The least significance difference (LSD) was used for significance among groups at significance level ($p < 0.05$) **IBM CORP (2013)**.

RESULTS

Table (1): The effect of different garlic powder concentrations on body weight of, Muscovy ducks exposed to different stocking density

	(C)	HS	SS+ G_{300}	HS+ G_{300}	SS+ G_{600}	HS+ G_{600}
Day 1	51.67± 0.29	52.19± 0.35	52.13± 0.30	51.16± 0.15	52.17± 0.39	52.44± 0.37
W1	141.67± 1.65^{a}	134.28± 0.94^{b}	144.96± 1.24^{a}	137.50± 0.83^{b}	150.33± 1.70^{c}	137.16± 1.95^{b}
W2	321.58± 4.01^{ad}	306.00± 2.17^{b}	329.75± 4.17^{a}	311,00± 1.85^{bd}	359.50± 4.74^{c}	314.69± 1.35^{d}
W3	591.25± 9.66^{ad}	553.13± 2.20^{b}	603.08± 6.29^{a}	562.13± 9.31^{bd}	654.42± 4.75^{c}	580.94± 8.37^{d}
W4	934.58± 11.11^{a}	854.06± 8.54^{b}	948.33± 13.32^{a}	872.81± 11.96^{b}	1019.1± 12.71^{c}	915.94± 10.78^{a}
W5	1395.0± 6.71^{a}	1274.0± 13.25^{b}	1416.2± 10.22^{a}	1307.1± 8.54^{c}	1495.0± 13.05^{d}	1371.8± 9.24^{a}
W6	1864.1± 25.48^{a}	1716.2± 13.85^{b}	1889.1± 10.66^{a}	1755.4± 9.55^{b}	1990.8± 9.54^{c}	1835.0± 7.50^{a}
W7	2311.6± 7.82^{a}	2125.9± 7.89^{b}	2345.4± 14.35^{c}	2170.0± 6.43^{d}	2461.2± 7.41^{e}	2278.13± 4.82^{f}
W8	2681.6± 14.27^{a}	2476.8± 13.58^{b}	2720.8± 9.48^{c}	2534.6± 9.32^{d}	2860.4± 12.74^{e}	2645.9± 12.89^{f}
W9	3020.0± 18.74^{a}	2759.3± 14.62^{b}	3068.7± 13.98^{c}	2827.1± 12.32^{d}	3225.0± 7.04^{e}	2980.6± 12.06^{f}
W10	3348.1± 24.37^{a}	3026.8± 27.88^{b}	3400.4± 17,95^{a}	3100.9± 25.37^{c}	3570.8± 7.49^{d}	3306.8± 20.48^{a}

Different small alphabet within the same row denotes statistically difference at 0.05. Similar letters denote there was no statistical significant difference

Table (2): The effect of different garlic powder concentrations on body weight gain of Muscovy ducks exposed to different stocking density

	(C)	(HS)	(SS+G_{300})	(HS+G_{300})	(SS+G_{600})	(HS+G_{600})
W1	90.00 ± 0.76^{a}	82.09 ± 0.47^{b}	92.83 ± 0.97^{c}	86.34 ± 0.70^{d}	98.17 ± 0.78^{e}	84.75 ± 0.46^{d}
W2	179.92± 0.55^{a}	171.72 ± 0.45^{b}	184.79 ± 1.18^{c}	173.50 ± 0.86^{d}	209.17 ± 1.11^{e}	177.53 ± 0.57^{a}
W3	270.08 ± 2.52^{a}	247.13 ± 1.28^{b}	273.33 ± 2.41^{ae}	256.75 ± 1.88^{c}	294.92 ± 1.21^{d}	266.25 ± 2.21^{e}
W4	345.42 ± 2.08^{a}	300.94 ± 3.46^{b}	355.58 ± 6.01^{ac}	310.69 ± 2.24^{b}	364.75 ± 3.26^{c}	335.00 ± 2.82^{d}
W5	460.42 ± 3.56^{a}	420.00 ± 1.44^{b}	476.67 ± 3.00^{c}	434.38 ± 1.99^{d}	475.83 ± 3.00^{c}	455.94 ± 6.63^{a}
W6	469.17 ± 1.53^{ae}	442.19 ± 2.48^{b}	472.92 ± 2.82^{a}	448.75 ± 3.93^{b}	495.83 ± 2.63^{c}	463.13 ± 2.82^{e}
W7	447.50 ± 2.27^{a}	409.69 ± 2.13^{b}	456.25 ± 1.72^{c}	414.06 ± 3.24^{b}	470.42 ± 2.45^{d}	443.13 ± 2.54^{a}
W8	370.00 ± 1.90^{a}	350.94 ± 1.85^{b}	371.44 ± 3.78^{a}	364.69 ± 2.96^{a}	399.08 ± 4.12^{c}	367.82 ± 1.58^{a}
W9	338.34 ± 2.27^{a}	282.50 ± 1.73^{b}	351.53 ± 6.71^{c}	289.83 ± 3.93^{b}	364.48 ± 2.45^{d}	334.69 ± 3.51^{a}
W10	328.08 ± 3.49^{a}	267.50 ± 1.99^{b}	331.67 ± 3.00^{a}	272.82 ± 5.18^{b}	345.38 ± 2.27^{c}	326.25 ± 5.32^{a}

Different small alphabet within the same row denotes statistically difference at 0.05. Similar letters denote there was no statistical significant difference

Table (3) The effect of different garlic powder concentrations on weekly feed intake of Muscovy ducks exposed to different stocking density

	(C)	(HS)	(SS+G_{300})	(HS+G_{300})	(SS+G_{600})	(HS-G_{600})
W1	105.00 ± 2.56^{a}	98.04 ± 2.65^{ab}	103.11 ± 2.61^{ab}	96.81 ± 2.85^{bc}	95.31 ± 2.83^{bc}	89.43 ± 2.88^{c}
W2	269.40 ± 2.56^{a}	256.97 ± 2.60^{bc}	261.31 ± 2.58^{c}	253.40 ± 2.63^{b}	259.25 ± 2.73^{bc}	242.24 ± 2.84^{d}
W3	474.73 ± 2.83^{ac}	465.15 ± 4.04^{b}	466.31 ± 3.20^{ab}	464.49 ± 4.35^{b}	482.23 ± 2.90^{c}	457.63 ± 4.18^{b}
W4	793.29 ± 4.37^{a}	750.61 ± 4.04^{b}	782.58 ± 3.01^{c}	746.31 ± 3.20^{b}	773.47 ± 3.44^{c}	733.04 ± 2.98^{d}
W5	1107.58 ± 4.05^{a}	1060.85 ± 2.64^{b}	1094.70 ± 2.60^{c}	1051.86 ± 2.56^{d}	1078.00 ± 2.50^{e}	1048.43 ± 2.93^{d}
W6	1145.97 ± 3.00^{a}	1121.61 ± 4.04^{b}	1140.65 ± 3.40^{ac}	1092.81 ± 2.58^{d}	1132.11 ± 3.00^{c}	1087.91 ± 4.50^{d}
W7	1181.11 ± 3.00^{a}	1128.30 ± 3.89^{b}	1166.41 ± 2.81^{c}	1121.54 ± 2.56^{be}	1149.63 ± 2.55^{d}	1114.86 ± 3.91^{e}
W8	1212.54 ± 4.29^{a}	1161.27 ± 5.20^{b}	1209.92 ± 2.99^{a}	1145.97 ± 4.15^{c}	1183.81 ± 2.58^{d}	1135.61 ± 4.04^{c}
W9	1221.48 ± 4.21^{a}	1177.23 ± 2.61^{b}	1221.09 ± 3.58^{a}	1169.81 ± 2.58^{b}	1211.81 ± 2.58^{c}	1168.58 ± 2.85^{b}
W10	1246.81 ± 2.58^{a}	1206.31 ± 2.56^{b}	1237.39 ± 3.40^{c}	1198.54 ± 4.07^{b}	1229.69 ± 3.31^{c}	1188.18 ± 3.01^{d}

Different small alphabet within the same row denotes statistically difference at 0.05. Similar letters denote there was no statistical significant difference

Table (4): The effect of different garlic powder concentrations on FCR of Muscovy ducks exposed to different stocking density

	(C)	(HS)	(SS+G_{300})	(HS+G_{300})	(SS+G_{600})	(HS+G_{600})
W1	1.17 ± 0.03^{a}	1.19 ± 0.03^{a}	1.11 ± 0.02^{ac}	1.18 ± 0.07^{a}	0.97 ± 0.03^{b}	1.05 ± 0.03^{bc}
W2	1.50 ± 0.01^{a}	1.50 ± 0.01^{a}	1.41 ± 0.02^{b}	1.51 ± 0.02^{a}	1.24 ± 0.01^{c}	1.36 ± 0.01^{d}
W3	1.76 ± 0.01^{a}	1.88 ± 0.01^{b}	1.71± 0.02^{c}	1.82 0.03^{d}	1.64 ± 0.01^{e}	1.72 ± 0.01^{ac}
W4	2.30 ± 0.02^{a}	2.50 ± 0.04^{b}	2.20 ± 0.04^{c}	2.40 ± 0.01^{d}	2.12 ± 0.03^{c}	2.19 ± 0.02^{c}
W5	2.41 ± 0.01^{a}	2.53 ± 0.01^{b}	2.30 ± 0.01^{c}	2.42 ± 0.01^{a}	2.27 ± 0.02^{c}	2.30 ± 0.03^{c}
W6	2.44 ± 0.01^{a}	2.54 ± 0.01^{b}	2.41 ± 0.01^{a}	2.44 ± 0.02^{a}	2.28 ± 0.01^{c}	2.35 ± 0.02^{d}
W7	2.64 ± 0.02^{a}	2.75 ± 0.01^{b}	2.56 ± 0.01^{c}	2.71 ± 0.02^{b}	2.44 ± 0.01^{d}	2.52 ± 0.02^{c}
W8	3.28 ± 0.01^{a}	3.31 ± 0.03^{a}	3.26 ± 0.03^{a}	3.14 ± 0.02^{b}	2.97 ± 0.03^{c}	3.09 ± 0.01^{b}
W9	3.61 ± 0.03^{a}	4.17 ± 0.03^{b}	3.48 ± 0.07^{c}	4.05 ± 0.05^{d}	3.32 ± 0.02^{e}	3.49 ± 0.03^{ac}
W10	3.80 ± 0.04^{a}	4.51 ± 0.03^{b}	3.73 ± 0.03^{ad}	4.40 ± 0.09^{b}	3.56 ± 0.02^{c}	3.65 ± 0.06^{cd}

Different small alphabet within the same row denotes statistically difference at 0.05. Similar letters denote there was no statistical significant difference

Table (5): The effect of different garlic powder concentrations on carcass characteristics of Muscovy ducks exposed to different stocking density

	(C)	(HS)	(SS+G_{300})	(HS-G_{300})	(SS+G_{600})	(HS+G_{600})
Dressing %	77.50± 0.39[a]	76.27± 0.16[b]	78.03± 0.38[a]	76.44± 0.25[b]	78.23± 0.62[a]	77.37± 0.34[a]
Gizzard weight	81.32± 5.80	71.19± 2.65[a]	83.62± 6.58[a]	74.87± 2.56[a]	87.25± 4.22[a]	80.10± 2.66[a]
Liver weight	72.95± 4.69[a]	62.85± 2.64[a]	73.39± 4.43[a]	64.86± 3.24[a]	77.07± 4.73[a]	69.23± 3.11[a]
Heart weight	17.75± 1.36[a]	15.23± 0.49[a]	18.24± 1.72[a]	15.54± 0.60[a]	19.06± 1.62[a]	16.71± 0.69[a]

Table (6): The effect of different garlic powder concentrations on meat quality (fat %) of Muscovy ducks exposed to different stocking density

	(C)	(HS)	(SS+G_{300})	(HS+G_{300})	(SS+G_{600})	(HS+G_{600})
Breast muscle fat %	1.56±0.04[a]	1.52±0.12[ab]	1.44±0.07[ab]	1.26±0.12[b]	0.85±0.11[c]	0.71±0.07[c]
Thigh muscle fat %	2.44±0.48[a]	2.37±0.17[a]	2.22±0.10[a]	2.17±0.13[ab]	1.46±0.09[bc]	1.49±0.18[b]

DISCUSSION

Body weight and body weight gain

Results in Table (1) showed that the body weight of muscovy ducks significantly increased ($p < 0.05$) gradually from 1st week till the end of the experiment at 10th week of age where SS+G_{600} group showed significantly ($p < 0.05$) higher final body weight however the final body weight of (HS+G_{600}) group not significantly ($p < 0.05$) different from control group and (SS+G_{300}) group, on the other hand (HS+G_{300}) group and (HS) group showed the lower final body weight .The significant decrease in live body weight throughout the experiment due to increasing of stocking density as in (HS) group and (HS+G_{300}) group may be attributed to the decrease in feed intake and nutrient utilization at all growing age which not allowing them to grow to their potential (**Taboosha ,2014)** our findings are

in agreement with some previous evaluations which showed a linear decrease in BW with increasing population density (**Dozier et al., 2005, Xie et al., 2014 and Ahaotu and Agbasu (2015**) but not in agreement with **Feddes et al. (2002)** who reported similar body weight of broiler reared at densities of 12, 18, and 24 birds/m^2 and **Buijs et al. (2009**) who found no difference in final BW at 39 d of age as stocking density increased.

However, on the other hand supplementation of garlic (600 gm / ton) increase the body weight of ducks in standard stocking density as in ($SS+G_{600}$) and could effectively compensate the decrease in BW under high stocking density as in ($HS+G_{600}$) due to the growth promoting effect of garlic which be attributed to allicin (an organosulfur compound) contained in garlic that promotes the performances of the intestinal flora thereby enhance digestion which increase body weight of ducks (**Pourali et al , 2010)** , these results in line with **El-Ghamry et al. (2004)** who reported that addition of fresh garlic 2% could enhance the productive performance and improved body weight of Muscovy ducks and also with (**Brzóska et al., (2015**) , **El-katcha et al (2016)** but in contrary with studies of **Ghazalah and Ibrahim (1996**) who mentioned that supplementation of garlic oil (1.25 mg/100g body weight) reduce body weight in Muscovy ducks and with **Ismoyowati et al.,(2015)** who found that there was no significant effects of inclusion of 1 % of garlic on B.W of ducks during the growing period.

Concerning with body weight gain as in Table (2)**,** it was obvious that BWG significantly increased ($p \leq 0.05$) till reach maximum value at 6^{th} week of age and then decreased gradually till the end of the experiment, the highest BWG was recorded in ($SS+G_{600}$) group followed by ($SS+G_{300}$) group, (C) group, ($HS+G_{600}$) group while the lowest BWG was recorded in (HS) group then ($HS+G_{300}$) group respectively. These results, showed that ducks housed at high stocking density as in (HS group) and ($HS+G_{300}$) had lower body weight gain which may be explained through decreasing of time spent resting and increase disturbance in the groups of high stocking density (**Febrer et al., 2006**) which enable the birds to gain less body weight than those of lower stocking density, it agreed with (**Taboosha ,2014** , **Xie et al., (2014** and **Cengiz et al., 2015)** who showed that the final BWG decreased significantly when stocking density increased but in

contrast with (**Ravindran et al.,2006)** who found no differences in average weight gain between the 3 density treatments (16, 20, and 24 birds/m^2)·,

concerning garlic supplementation (600gm /ton feed), increase body weight gain in high stocking density group ($HS+G_{600}$) group and led the highest body weight gain in standard stocking density group ($SS+G_{600}$) group which may be due to the fact that allicin (active principle of garlic) control of growth and colonization of various pathogenic microorganisms in the gut of birds so when the load of these bacteria in the intestine is low, birds may absorb more nutrients, thus leading to the improvement in weight gain of the birds **(Bedford , 2000) ,** these results agreed with **Bidura (1999)** who demonstrated an increase in live body weight gain of growing duck aged 0 – 8 weeks compared to control one when diet supplemented with 3% and 6 % garlic leaf and also with (**Bampidis, et al., 2005 and Abd El Azim et al., 2009)** while disagreed with **Ismoyowati et al.,(2015)** who found that weight gain of ducklings were not affected by inclusion of 1 % of garlic .

Feed intake and feed conversion ratio (FCR):

The results in Table (3) showed that the weekly feed intakes significantly ($p \leq 0.05$) increased gradually from 1st week till the end of the experiment where groups of high stocking density showed lower feed intake with the lowest mean recorded in ($HS+G_{600}$) group followed by ($HS+G_{300}$) group and (HS) group,. On the other hand the higher feed intake observed in groups of standard stocking density but ($SS+G_{600}$) group fed lower amount of feed than ($SS+G_{300}$) group and (C) group , feed intake decreased with increasing stocking density due to reduction of access of birds to feed (**Feddes et al., 2002)** , these agreed with **Osman (1993) and Baeza et al. (2003)** who found reduction of feed intake at high stocking density in Muscovy and Pekin ducks.

However decreasing of feed intake by garlic supplementation especially in groups supplemented with (600 gm/ton feed) may be attributed to the effect of garlic supplementation in fulfill the nutrient requirement of birds by increase absorptive capacity of nutrients ,these results agreed with **Ibrahim et al., (2004)** who found that a decrease in feed consumption in all supplemented groups of muscovy ducks specially in groups received diet supplemented with 3% garlic or 1% onion + 3%

garlic (5.2% - 4.6%) respectively but disagreed with **Kırkpınar et al., (2011**) who found that feed intake of broilers not affected by supplementation of garlic oil (300 mg/kg) and **Oladele et al (2012)** who showed that feed intake was higher in garlic supplemented broilers (0.125% , 0.25% and 0.5%) than in control group .

Feed conversion ratio in Table (4) revealed that there was a significance ($p < 0.05$) difference in the FCR between groups. FCR increased with age to reach the highest value at the end of the experiment. It was noticed that groups supplemented with the higher concentration of garlic showed the best FCR as in ($SS+G_{600}$) group and ($HS+G_{600}$) group while the worst FCR was observed in HS group and $HS-G_{300}$ group respectively. it was obvious that ducks reared at standard stocking density convert their feed more efficiently than those kept at high stocking density which may be attributed to the loss of the energy which used for growth as the group at high density were more disturbed and had less opportunity to rest (**Hall (2001**) , these results in agreement with **Biligili and Hess (1995)** who concluded that feed conversion was significantly improved when birds were given more space. however, but in variance with **Thaxton et al., (2006)** who reported a higher feed conversion ratio due to a higher stocking density used.

On the other hand supplementation of garlic (600 gm /ton feed) improve the FCR in ($HS+G_{600}$) group and this may be due to the enhancing effect of garlic on villi length, villi width and cryptal depth and goblet cell numbers in the duodenum, jejunum and ileum of birds which activates the entire absorptive process of nutrients and results in better feed efficiency (**Masoud,2006 ., Incharoen et al., 2010 .,Oladele et al .,2012),** these results agreed with **(Ibrahim et al., 2004)** who found that FCR of muscovy ducks was significantly better by supplementation of 35 of garlic at 10 weeks than that at the end of the 12th week (3 versus 3.67) but disagreed with **Ismoyowati et al., (2015)** which found that FCR of ducklings were not affected by inclusion of 1 % of garlic .

Dressing yield and visceral organs weight and percentage

Table (5) showed that dressing yield % was significance ($p < 0.05$) decreased in ($HS+G_{300}$) group and (HS) group compared with other groups and these may related to the lower final live weight of these

groups. These agreed with **Ahaotu and Agbasu (2015)** who showed that increasing of stocking density above 4 birds /m^2 decrease dressing % of pekin ducks,. However this wasn't occurred in ($HS+G_{600}$) group and this may be due to the effect of garlic supplementation which increased it final body weight and dressing %. Of it These agreed with (**Demir et al., (2003)** who showed that using garlic powder in broiler's diet influenced carcass yield positively. While disagreed with **Onibi et al., (2009)** who stated that garlic supplementation had no significant effects on carcass characteristics

Visceral organ weight in table (5) showed no significance ($p < 0.05$) difference among groups in gizzard ,liver and heart weight , our results agreed with (**Sekerglu et al., 2011)** who showed no significant difference of different stocking density of broiler(9,13,17 birds/m^2 on organ weigh) and also with (**Onibi et al., 2009, Raeesi et al., 2010 and Fayed et al., 2011)** who showed that garlic supplementation had no significant effects on giblet weight among different treatments however disagreed with **Jayalakshmi et al., (2009)** who studied different stocking density 900 cm, 750 cm, 600 cm and 450 cm per bird and found higher organ weight at 450 cm/ bird .

Meat quality (fat %)

Meat quality (fat %) in table (6) showed that ($HS+G_{600}$) group and ($SS+G_{600}$) group showed the lower breast and thigh fat % compared with other groups and this indicate that garlic supplementation of (600 gm/ton) of ducks decrease the fat % in breast and thigh muscle than the other concentration, these may be due to the greater effect of garlic in reducing fatty acid synthetase enzyme. These results in agreement with Kim et al., (2009) who found that dietary supplementation of different level of garlic 2% and 4% for 5 weeks for broiler lower fat content in chicken thigh muscle, Choi et al., (2010) who found that higher concentration of dietary garlic powder supplementation in broiler lower fat contents of thigh muscle significantly ($P < 0.05$) than the control group. However these results in disagreement with **Amouzmehr et al (2012)** who showed that there were no significant differences of broiler breast and thigh fat in groups fed with different levels (0.3% and 0.6%) of garlic extracts .

CONCLUSION

Garlic supplementation of 600 g. / ton feed in Muscovy ducks improve body weight and weight gain and showed better FCR and lower

fat % in carcass in standard stocking density and even in high stocking density which may be useful for economical and efficient production of ducks

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