Research Article

Effect of Different Dietary Protein Levels on Some Behavioral Patterns and Productive Performance of Muscovy Duck

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Abstract | The aim of the present study was to investigate the effect of reduced dietary protein levels on some behavioral patterns, and productive traits of the Muscovy duck. Ninety ducks of six weeks of age were divided equally into three treatments of 30 birds. Treatments were designed according to the protein level in the ration into 22%, 18% and 14% crude protein (CP). All groups received a starter diet of 22% protein from one day old until 6 weeks old. Two treatment groups received reduced protein levels, 18 % and 14%, while the third (control) group continued with 22% protein till the end of the experiment at 12 weeks old (control). Behaviors (ingestive, standing, walking, resting, and feather pecking) were measured during the whole study. In addition, body weight, average daily gain (ADG), feed intake, and relative growth rate (RGR) were measured throughout the experiment on a weekly basis. Birds fed on 14 % crude protein recorded the highest significant values for feeding, standing, walking, vent pecking and litter eating times in comparison to other treatments. Our results showed that severely decreasing dietary CP had significant ($P < 0.05$) negative effects on BW, ADG and feed intake of Muscovy ducks during finishing period. However, birds fed on 18 % crude protein had better feed conversion ratios during the last 3 weeks of experiment and recorded the highest significant values for ADG. Feeding Muscovy ducks on 18 % CP during the finishing period (6-12 weeks) could be utilized advantageously to improve body weight, ADG and RGR with low feed intake and cost.

Keywords | Behavior, Duck, Diet, Protein level, Performance traits

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INTRODUCTION

Duck farming is a very popular and lucrative business. Ducks are highly available around the world and the demand for duck meat, and eggs is increasing each year. There are numerous meat and egg productive duck breeds available throughout the world. All the present domestic ducks around the glove come from the wild mallard ducks. This type of birds can adapt to a wide range of environmental and natural conditions, which may be the reason for the increasing importance, and popularity of the duck industry in many countries on the world. The duck industry is considered the second largest poultry production in Africa after chicken (Cumberbatch et al., 2006). There is an increasing demand for animal protein, and duck production may be able to help meet this demand (Solomon et al., 2006). In Egypt, duck is one of the major sources of animal protein either meat or egg production (FAO, 2009). Duck have a high protein requirement during the first two weeks of life; about 20% of diet should be protein (Jacob, 2015). Based on the growth performance, Xie et al. (2014) recommended that the diet of growing ducks should contains from 18% to 21 crude protein (CP) during the first 3 weeks (wk) of age at energy levels from 2,450 to 3,050 kcal of AME/kg.

However, the main environmental problem caused by poultry production is ammonia emission, which is responsible for water pollution and soil acidification (Méda et al., 2011). Ammonia is emitted from the manure by the breakdown of undigested protein and uric acid in poultry fecal matter. A possible way to decrease ammonia emission is to decrease nitrogen excretion by lowering the dietary CP content. Several studies have shown a reduction in nitrogen excretion by about 10% with 1% decrease in the dietary CP content in broilers (Aletor et al., 2000; Gomide et al., 2011). As feed represents 70% of the total cost in poultry production (Willems et al., 2013), it is crucial to look for ways to reducing feed cost. El-Kholya and El-Tahawy (2017) showed that rearing mule ducks under early feed restriction was associated with increased wall exploration and increased aggressive behavior, and higher body weight from the 3rd to 7th weeks of age and weight gain from 4th to 6th weeks of age compared to white pekin ducks. Therefore, the aim of this experiment was to investigate the effects of reducing the dietary CP content in finishing Muscovy ducks on some behavioral patterns and productive performance as a strategy to reduce the feed cost in developing counties.

MATERIALS AND METHODS

Ethical approval

This study was reviewed and approved by the Animal Care and Welfare Committee of Zagazig University, Egypt. The study was conducted at experimental Unit related to the Veterinary Public Health Department, Faculty of Veterinary Medicine, Zagazig University, Egypt. This experimental unit was provided with all the equipment necessary for the care of experimental animals.

Experimental birds and management

From one day old till the age of 6 weeks, a total of 120 Muscovy ducks were brooded together in one brooding unit using a deep litter system under the same environmental conditions. During the first 6 weeks all ducks were fed a starter commercial basal mash diet with 22% crude protein level (Table 1) according to NRC (1994). At age of six weeks old (Mean BW ± SE; 2105 ± 68.04 g), ninety ducks were randomly selected and used in the current experiment. The birds were randomly divided into three groups of 30 each, and each group was further randomly divided into 10 replicates of 3 birds each with a one male: two females mating ratio. Ducks were reared in a deep litter system of about 8-10 cm wood shavings with stocking density 10 duck per 2 m^2. Each group was provided with a manual feeder and drinker, water and feed were provided ad libitum. The lighting schedule was 16h light: 8h dark for the whole experimental period. Each pen provided with one incandescent white fluorescent lamp of 100 watt at 2m above the level of birds. The environmental temperature was recorded with digital thermometer at the level of bird's back and was maintained at about 32–34 °C in the first week, and was decreased by 3–5 °C per week until it reached 19–20 °C at 4 weeks with R.H 65-70% as the ducklings were fully feathered. (Sari et al., 2013). Ducklings were vaccinated with cholera vaccine at 28th day of age at (0.5cm s/c). While, at 28th day of age ducklings were vaccinated by Reassortant Avian influenza vaccine with a dose (0.5ml / bird) intramuscular in the muscles of breast.

Table 1: Chemical analysis of dietary treatments used in the study.

Ingredients (%)	Diet 1 (22% CP)	Diet 2 (18% CP)	Diet 3 (14% CP)
Yellow Corn (8.5%)	59.80	63.14	63.98
Soybean meal (44-46%)	34.90	24.81	13.59
Wheat bran	0.30	6.71	18
Corn gluten meal (60)	1.30	1.30	0.10
Mono phosphate Calcium	1.03	1.40	1.93
Limestone[a]	1.35	1.63	1.46
Sodium chloride	0.34	0.31	0.33
Mineral-vitamin premix [b]	0.30	0.30	0.30
DL-Methionine	0.29	0.01	0.12
L-lysine	0.18	0.18	0.00
Sodium bicarbonate	0.10	0.10	0.10
Choline chloride	0.10	0.10	0.10
Nutrient composition			
Metabolizable energy, (Kcal/ Kg)[c]	2949.11	2844.00	2720.00
CP, %	22.08	18.50	14.20
Lysine, %	1.20	1.10	0.65
Methionine, %	0.66	0.33	0.37
Methionine + cysteine	0.98	0.62	0.61
Calcium	0.94	1.96	0.96
Available phosphorus	0.45	0.45	0.60
Chloride	0.24	0.22	0.23

[a]Limestone contains 36% calcium and locally produced.
[b]Mineral and vitamin premix: each 3 kg contains Vit A (12000000IU); Vit D (2000000IU); Vit E (10000 mg); Vit K3 (2000 mg); Vit B1(1000 mg); Vit B2 (5000 mg); VitB6 (1500 mg); Vit B12 (10000 mg); Nicotinic acid (30000 mg); Pantothinic acid (10000 mg); Folic acid (1000 mg); Biotin (50mg); Choline chloride 50% (250mg); Iron (30000 mg); Copper (10000 mg); Zinc (50000 mg); Manganese (60000 mg), Iodine (1000 mg), Selenium (100 mg), Cobalt (100 mg) and carrier lime stone up to 3 kg. 5Lysine 87% produced by Archar Daniels Midland company, LL., USA. 6DL-methionine produced by Evoink Co. guranted analysis 99.5% DL- methionine.
[c]Calculated according to (NRC, 1994).

Ducks in the three treatments were identified by using colored wing band (red, green and yellow) that enabled easier observation and estimation of different parameters. To establish our treatment groups, we formulated three commercial granules formulated rations with different included CP levels (22%, 18%, and 14%, Table 1) according to NRC (1994). The treatment groups were as follows 1) control group; the ducks were given a ration of 22% CP from one day old until the end of the experiment at 12 weeks of age. 2) medium protein diet group; the ducks were given a ration of 22 % from one day old until 6 weeks, then protein level reduced to 18% during the finishing period (6 -12 weeks). 3) low protein diet group; the ducks were given ration of 22 % from one day old until 6 weeks, then protein level reduced to 14% during the finishing period (6 -12 weeks).

Behavioral observations

The behavioral patterns were measured according to Gustafson et al. (2007) which included ingestive behaviors (feeding and drinking), postures (standing and sitting), walking, resting, huddling, and comfort behaviors (feather preening, flapping, head and body shaking), feather and vent pecking behaviors (definitions provided in Table 2). For each treatment group, different behavioral traits were recorded in seconds (S) for 3 hours weekly with 6-minute intervals from 6 A.M to 6 P.M by using focal sampling technique (Shimmura et al., 2007). All the recorded traits were recorded by one observer.

Table 2: Ethogram of behavioral patterns used during observation.

Behavior	Definition
Ingestive behaviors	birds were fed directly from feeders either feeding or drinking (mean duration in seconds per 3h)
Standing	Ducks were standing idle and not engaged in any activity (duration & frequency)
Walking	(time and frequency)
Resting	birds were lying on ground (time or frequency)
Huddling	when two birds or more engaged in crouching behavior (duration & frequency)
Feather preening	bird clean their feather with their beak
Wing flapping	bird stretch its full height and flap its wings repeatedly
Head and body shaking	Bird shakes the feather at regions of head and body
Feather pecking	One bird uses beak to peck at the feathers of a conspecific
Vent pecking	One bird pecks or pulls at the vent of another.
Litter eating	Duck eat some of the bedding (litter)

Production parameters

Live body weight (BW) was weekly recorded for three birds from each treatment group. Average daily gain (ADG) was calculated as the difference body gain between two weeks weight gain (w2 -w1). Relative growth rate (RGR) was calculated according to Maruyama et al. (2001) using this formula % = (w2-w1)/(o.5×(w2+w1). While, Feed intake (kg) and feed conversion ratio (FCR) were measured for all treatment groups.

Statistical analysis

Data were analyzed as a completely randomized design by the One-way ANOVA procedure of SAS software (SAS, 2003). When dietary treatment was significant ($P < 0.05$), means were compared using Duncan's multiple comparison procedure of SAS software. In our study, broken-line regression analysis (Robbins et al., 2006) was used to estimate the Apparent metabolizable energy requirement of growing ducks using the NLIN procedure of SAS software, and the broken line model was as follows:

$$y = l + u\,(r - x)\; y = l + u\,(r - x)$$

Where; y = weight gain or feed gain; x = dietary energy level (kcal/kg); r = requirement of dietary energy; l = the response at x = r; and u = the steepness of the curve. In this model, y = l when x > r.

Table 3: Effect of different crude protein dietary levels on behavior of meat type Muscovy ducks from 6 to 12 weeks old.

	Crude protein, %		
Behaviors	**22**	**18**	**14**
Duration, second /3hr			
Feeding	116.87 ± 21.43[b]	155.00 ± 20.64[ab]	408.75 ± 47.38[a]
Drinking	78.75 ± 2.42[a]	50.00 ± 2.10[a]	40.00 ± 2.39[a]
Standing	155.00 ± 8.42[b]	188.75 ± 7.78[b]	298.75 ± 12.42[a]
Walking	77.38 ± 2.69[b]	92.63 ± 3.49[b]	183.75 ± 3.79[a]
Resting	1708.88 ± 23.39[a]	2019.00 ± 34.60[a]	1613.75 ± 28.05[a]
Sleeping	1328.75 ± 34.64[a]	468.25 ±15.09[b]	869.38 ± 28.66[ab]
Huddling	33.75 ± 2.54[a]	17.50 ± 1.26[ab]	15.00 ± 1.00[b]
Frequency/3hr			
Feeding	2.75 ± 0.40[a]	3.75 ± 0.13[a]	8.00 ± 0.85[a]
Drinking	3.50 ± 0.93[a]	4.13 ± 1.14[a]	1.75 ± 0.56[a]
Standing	4.63 ± 0.63[b]	9.25 ± 0.84[a]	6.50 ± 0.46[ab]
Walking	4.13 ± 0.55[b]	6.63 ± 0.68[a]	4.38 ± 0.80[b]
Resting	10.38 ± 0.75[a]	14.50 ± 0.32[a]	8.88 ± 0.35[a]
Sleeping	6.88 ± 0.55[a]	5.88 ± 0.61[a]	3.75 ± 0.23[a]
Huddling	1.63 ± 0.07[a]	1.50 ± 0.02[a]	1.13 ± 0.09[a]
Preening	1.00 ± 0.07[a]	1.00 ± 0.09[a]	0.88 ± 0.05[a]
Leg stretch	1.13 ± 0.03[a]	0.75 ± 0.05[a]	0.63 ± 0.08[a]
Feather pecking	0.25 ± 0.06[a]	1.50 ± 0.08[a]	1.63 ± 0.08[a]
Head shaking	1.25 ± 0.31[a]	1.63 ± 0.41[a]	1.00 ± 0.33[a]
Vent pecking	0.50 ± 0.09[b]	1.25 ± 0.05[b]	2.63 ± 0.09[a]
Litter eating	0.38 ± 0.08[b]	0.75 ± 0.01[b]	2.38 ± 0.06[a]

Means of different ages within the same row having different superscripts are significantly different ($P \leq 0.05$).

RESULTS

Behavioral observations

In our study, decreasing dietary CP had significant negative effects on the behavioral patterns of Muscovy ducks during finishing period (Table 3). Birds fed on 14 % CP recorded the highest significant values for feeding, standing, walking, vent pecking and litter eating times (408.75, 298.75, 183.75, 2.63 and 2.38 S; respectively). While, birds fed on 18 % CP showed a significant greater frequency of standing and walking. Vent peck and litter eating were increased in the group with 14 % CP in their diet while feather peck and head shake were not affected by dietary CP levels. Leg stretch, huddling and sleeping time were highly increased with 22 % CP in duck diet in comparison to other treatment groups (Table 3).

Production parameters

Our results showed that decreasing dietary CP had significant ($P < 0.05$) negative effects on BW, ADG and RGR of meat type Muscovy ducks during finishing period from 6 to 12 weeks old (Table 4). Ducks received 14 % CP diet showed significant ($P < 0.05$) decrease in BW and ADG in comparison to those received 18 and 22% CP. However, birds fed on 14 % CP recorded the highest significant values for feed intake during the 8th, 9th, 10th, 11th and 12th weeks (2.03, 1.66, 1.92, 2.08 and 2.54 kg; respectively) in comparison to other treatment groups. When dietary CP decreased from 22% to 14 %, the BW of finishing ducks was significantly ($P < 0.05$) decreased during the 10th, 11th, and 12th weeks of the study in comparison to other treatment groups. While the BW of birds fed on 18 % CP were not affected during the whole study, however, the birds in this group showed higher numerical values for BW during the 11th and 12th weeks (3256.67 and 3720.66 g; respectively) in comparison to control group (22% CP). Moreover, decreasing dietary CP to 18 % had no significant negative effects on ADG and recorded the highest significant values for ADG at 10-11 and 11-12 (58.38 and 66.29; respectively, Table 4) in comparison of groups of ducks received 22% CP. Additionally, ducks fed on 18 % CP showed significant RGR during the week 10 to week 12 in comparison to birds who received 22, and 14% CP and showed significant RGR during the week 6-7 and week 9-10 in comparison to birds fed 14% CP only. During the whole experiment birds who received 14% CP showed significant feed intake in comparison to other groups. However, ducks fed 18% CP had similar feed intake to ducks who received CP of 22% (Table 4). During the whole experiment, there was a significantly higher feed conversion ratio observed with the ducks under dietary 14% CP in comparison to 18 and 22% CP (Table 4). The lower feed conversion ratio was obtained when ducks were fed a high dietary CP of 18 %.

Table 4: Effect of different crude protein dietary levels on production parameters of meat type Muscovy ducks from 6 to 12 weeks old.

	Crude protein, %		
Traits	22	18	14
Body weight (g)			
6 weeks	2093.67 ±13.68^{a}	2254.67 ± 24.48^{a}	1966.66 ± 27.57^{a}
7 weeks	2372.67 ± 60.24^{a}	2482.0 ± 50.65^{a}	2120.0 ± 77.53^{a}
8 weeks	2546.66 ± 75.38^{a}	2686.0 ± 80.53^{a}	2324.67 ± 83.47^{a}
9 weeks	2948.00 ± 20.00^{a}	2505.33 ± 21.73^{a}	2328.67 ± 26.28^{a}
10 weeks	3013.33 ± 43.21^{a}	2650.67 ± 29.17^{a}	1684.0 ± 46.00^{b}
11 weeks	3155.33 ± 36.69^{a}	3256.67 ± 16.75^{a}	1954.0 ± 62.43^{b}
12 weeks	3320.67 ± 22.04^{a}	3720.66 ± 24.73^{a}	2090.0 ± 29.25^{b}
Average daily gain (ADG, g)			
6-7 week	66.66 ± 6.11a	32.48 ± 6.11b	21.91 ± 6.11b
7-8 week	24.86 ± 1.98^{a}	29.14 ± 1.07^{a}	29.24 ± 1.68^{a}
8-9 week	35.58 ± 6.12a	32.00 ± 6.11a	0.57 ± 6.11b
9-10 week	17.01 ± 1.53a	18.57 ± 3.52a	3.24 ± 1.79b
10-11 week	26.57 ± 1.57b	58.38 ± 1.78^{a}	4.76 ± 1.28c
11-12 week	27.96 ± 1.58b	66.29 ± 3.12^{a}	1.10 ± 2.84c
6-12 week	29.21 ± 1.80a	34.90 ± 2.46a	9.85 ± 0.22b
Relative growth rate (RGR)			
6-7 week	19.41 ± 1.04^{a}	13.31 ± 1.04^{b}	7.50 ± 1.04^{c}
7-8 week	7.31 ± 1.04^{a}	7.38 ± 1.04^{a}	9.21 ± 1.04^{a}
8-9 week	14.61 ± 1.04^{a}	1.89 ± 1.04^{b}	0.17 ± 1.04^{b}
9-10 week	3.86 ± 1.04^{a}	5.86 ± 1.04^{a}	0.96 ± 1.04^{b}
10-11 week	5.81 ± 1.04^{b}	12.95 ± 1.04^{a}	1.41 ± 1.04c
11-12 week	6.45± 1.04^{b}	13.30 ± 1.04^{a}	1.44 ± 1.04^{c}
6-12 week	45.54 ± 1.04^{b}	52.74 ± 1.04^{a}	20.46 ± 1.04^{c}
Feed intake (Kg/bird/day)			
7 weeks	1.59 ± 0.05^{a}	1.21 ± 0.06^{a}	1.33 ± 0.05^{a}
8 weeks	1.39 ± 0.08^{b}	1.43 ± 0.06^{b}	2.03 ± 0.04^{a}
9 weeks	1.25 ± 0.05^{b}	1.33 ± 0.06^{b}	1.66 ± 0.06^{a}
10 weeks	1.51 ± 0.07^{b}	1.46 ± 0.05^{b}	1.92 ± 0.03^{a}
11 weeks	1.64 ± 0.07^{b}	1.65 ± 0.02^{b}	2.08 ± 0.07^{a}
12 weeks	1.32 ± 0.06^{c}	2.19 ± 0.08^{b}	2.54 ± 0.06^{a}
Feed conversion ratio (FCR)			
6-7 week	1.67 ± 0.12c	3.70 ± 0.12b	6.03 ± 0.12a
7-8 week	5.48 ± 0.12b	4.88 ± 0.12c	6.89 ± 0.12a
8-9 week	3.30 ± 0.12c	4.10 ± 0.12b	292.52 ± 0.12a
9-10 week	8.57 ± 0.12b	7.90 ± 0.12c	59.43 ± 0.12a
10-11 week	6.10 ± 0.12b	2.84 ± 0.12c	42.56 ± 0.12a
11-12 week	4.78 ± 0.12b	3.30 ± 0.12c	227.52 ± 0.12a

Means of different ages within the same row having different superscripts are significantly different ($P \leq 0.05$).

DISCUSSION

It is well known that low-protein diets are beneficial to the environment and are associated with low ammonia emission and nitrogen excretion which has been shown in broilers (Rojas et al., 2014). However, in our study we showed that feeding Muscovy ducks a diet containing 14% CP had adverse effect on the behavior of ducks. The feeding behavior was greatly affected with the CP level in the duck ration and the significances were different as it was increased with 14 % CP in comparison with the groups that received 18 % and 22 % CP. Similarly, Baeza et al. (1998) stated that the feeding behavior of duck increased when dietary CP decreased from 17.22 to 13.54 %. Feed restriction may increase appetite by modulating both central and peripheral mechanisms of hunger regulation. These results agrees with those of Morrissey et al. (2014) and Dixon et al. (2014). Ducks fed 14 % CP exhibited much walking and standing than which might be attributed to a shift of feeding activities toward resting, walking and foraging during feed restriction, these results similar to Aydn et al. (2009) and Morrissey et al. (2014).

In our study, ducks fed 14 % CP showed higher frequency of vent pecking and eating of bedding material ($P < 0.05$) from 6 to 12 wk compared with ducks fed 18% and 22% CP. Feather pecking is abnormal behavior which consist of pecking the feathers of other birds which can range from gentle pecks to severe forms of vent pecking and cannibalism (Van Hierden et al., 2002). Cannibalism has been linked to deficiencies in protein, sodium, and phosphorus. Feed lacking protein and other nutrients, particularly the amino acid methionine, will also cause birds to pick feathers. Hughes et al. (1972) mentioned that birds consuming diets deficient in protein are often poorly feathered and usually end with feather pecking and/or cannibalism. The higher frequency of aggression in ducks fed 14 % CP could be attributed to hunger and boredom which is associated with stress of nutritional deficiency.

The BW was significantly decreased during finishing period when CP was 14 %. Our results agreed with the results observed with Zeng et al. (2015a) who found that reducing dietary CP from 17 to 15% not only increased feed/gain markedly but also reduced the 35-d body weight and 14 to 35 d weight gain of birds significantly. However, our results differed with those obtained by Xie et al. (2017) who found that decreasing dietary CP from 17.22 to 13.54% had no significant negative effects on weight gain and feed intake of ducks. This incongruence could be attributed to the fact that they added supplementary amino acids to the low protein diet to match the amino acid profile of control diet of 18% CP. Xia et al. (2016) mentioned that it is possible to formulate the low-protein diets containing about 15% CP for Pekin ducks without adverse effects on their growth performance and carcass yield through addition of essential amino acids to the diet. Our results showed that there was a significantly higher feed consumption observed with the ducks under 14% CP in comparison to other treatment groups. The findings are in line with those obtained by Mohanty et al. (2016) who found the feed intake of Khaki Campbell ducks at 14 % protein level from 9th to 14th weeks of age was higher in comparison to ducks fed 16 and 18% CP.

Practical finishing diets for growing Muscovy ducklings are often formulated with a crude protein content of around 160 g/kg to cover the protein and the essential amino acid requirements. The best body weight gain and feed conversion ratio was obtained when ducks were fed a high dietary CP of 18 %. The information on the optimal protein level for growing ducks is still limited. Undoubtedly, the protein recommendation (16%) of for 2 to 7-week growing Pekin duck is not enough for modern ducks. Recently, 18% CP had also been used in trial diets to estimate amino acid requirements of modern growing Pekin ducks (Zhang et al., 2014; Zeng et al., 2015b) and thus this value was supposed to be the optimal CP level of standard diets for growing ducks. Therefore, more researches are needed to identify the optimum CP level for finishing ducks. The limitation of our study is that we had a small sample size to determine the effect of dietary protein on growth performance. In addition, study wasn't adjusted for the energy level so the obtained significant differences could be also attributed to the difference in energy levels among the treatment groups, however, the energy levels among the different diets was formulated to meet the requirements of NRC.

CONCLUSION

In conclusion, feeding finishing Muscovy ducks with diet contains 14 % CP had a significant adverse effect on behavior and growth performance of Muscovy ducks during finishing period from 6 to 12 weeks of age. Therefore, we suggest formulating diets containing 18 % CP for finishing Muscovy ducks for marketing without adverse effects.

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AUTHORS' CONTRIBUTIONS

All authors contributed equally.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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