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Economic Assessment of Various Levels of Protein and Energy in Pigeon Squabs Diet

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Abstract

This study was conducted to evaluate the effect of nine diets through the application of 3×3 randomized design which included three levels of energy (2600, 2800 and 3000 Kcal/kg) with 3 supplemental protein levels (14, 16 and 18%) on growth performance, blood parameters, carcass yields and economic efficiency of Baladi pigeon squabs from 28 days old until 6 months of age (age of sexual maturity). A total of 135 pairs of squabs were randomly and independently allocated to the nine dietary treatments, each containing 15 pairs (3 replicate of 5 pairs). The diets were formulated in mash form fortified with vitamin and mineral premix. Moreover, feed and water were provided for *ad-libitum* consumption. The results showed that, squabs fed higher energy and crude protein diets (3000 ME+16% CP) had higher live body weight with a coincident significant decrease of the feed intake ($P<0.0001$). In addition, dressing (%), breast and thigh meat yield (%) increased significantly with increasing levels of both energy and protein, where they hit the peak values in squabs fed on 3000 ME+16% CP diet. Furthermore, increasing energy levels did not affect serum proteins (albumin and globulin), urea and uric acid. However, it had a significant positive effect on serum lipids (cholesterol, triglyceride, high density lipoprotein and low density lipoprotein). In terms of economic analysis, 3000 ME+16% CP diet revealed the lowest cost per Kg live weight of birds 81.87 L.E per pair, along with the highest economic return 110.3 L.E per pair and net profit 10.43 L.E per pair. In conclusion, squabs can efficiently utilize diet containing high energy (3000 Kcal/kg) and crude protein (16%) diets, consequently, it can be used to optimize their growth performance and maintain the maximum economic return.

Key words: Pigeons growth performance, Crude Protein, Metabolic Energy, Economics of squabs.

Introduction

Domestic pigeons (*Columba livia*) are multi-purpose birds, as they can be used for meat production (because of their powerful breast muscles and high growth rate), sports (racing) and as experimental animals [1]. However, in Egypt, especially in the rural areas, pigeons are kept mainly for meat production which plays an important role in the profitability of both small-scale and commercial farms. Compared with the other poultry, pigeons are deemed economic meat producers because of the lower costs of their feed, caring, housing and capital investment. Moreover, it has a relatively long productive life and short reproductive cycle besides its high immunity against diseases. Meat of the baby pigeon (squabs at the age of 28-30 days) has a high nutritive value as it is rich in protein, minerals and vitamins. In addition, it is very delicate, lean (low cholesterol), easily digested and considered as fancy meat because of its taste and delicacy [2, 3]. Until now, there is insufficient information about nutrient requirements or growth curves of pigeons, as the National Research Council (NRC) has not provided any standards or guidelines [4, 5].

Squabs are fed by their parents (both male and female) with “crop milk” in the first 5-7 days of life; therefore, the feeding system of pigeons differs markedly from of different poultry species [6]. Pigeon's diet consists mainly of whole grain which could supply enough protein, carbohydrates and fat, however it is scanty of necessary vitamins, macro and micro nutrients. Metabolizable energy (ME) and crude protein (CP) are the costliest components of the pigeon's diet as they constituted about 85% of the gross feed costs. Moreover, they are significantly implemented in their growing and laying performance. Therefore, their levels in the diets should be optimized cautiously during ration formulation, in order to get the least cost with maximum production as well [7]. Some

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studies were conducted to evaluate the impact of different dietary CP 12 to 18 % and ME content (2600, 2800 and 3000 Kcal ME/kg) separately on the productivity of pigeons [1,8]. Whereas, the present study aimed to evaluate the diets formulated by combing three levels of CP (14, 16 and 18%) and three levels of ME (2600, 2800 and 3000 Kcal/kg diet) on the growth performance, carcass traits serum parameters and economic efficiency of Baladi growing squabs during 1st six month and before laying under Egyptian conditions.

Material and Methods

This study was conducted at especially constructed farm, Elkenayat, Zagazig, Sharkia Governorate, Egypt. All the experimental methods were done according to the Committee of Community Service and Environment Development, Zagazig University, Egypt. Squabs were cared for using husbandry guidelines and standard operating procedures derived from Department of Avian and Rabbit Medicine, Faculty of Veterinary Medicine, Zagazig University, Zagazig, Egypt. During the period from 1st February until the end of June 2017 with a view to study the efficiency of feeding different metabolic energy and protein levels in diets on productive, physiological and economic performance of growing squabs.

Birds, design, housing and experimental diets

A total number of 135 pairs of Baladi pigeon squabs (aged 28-30 days), obtained from three small scale pigeon hatcheries were allocated to nine dietary treatments, each containing 3 replicates with 5 pairs per each. A 3×3 factorial experiment using 3 dietary ME levels (2600, 2800 and 3000 Kcal /kg) and 3 supplemental CP levels (14, 16 and 18 %) was conducted to study the effects of dietary energy levels and CP levels. Squabs in all treatments were fed *ad-libitum*. The squabs were housed in an environmentally controlled home with each pair was kept in individual pigeon breeding cage (width 100 x length 70 x height 40 cm), prepared to keep pigeon pair separately. The fronts of the cage batteries were modified to suspend feed and water. All squabs were treated with piprazin drugs during the quarantine period to ensure eliminating of any parasites that can affect the performance. The lighting schedule program used through the experimental period was natural daylight and artificial light (60-watt electric bulb intensity), provide 14 light vs 10 dark and the mean daily temperature was 25±4 Cº [9]. Diets were formulated as mash form consists of 3 protein levels (14-16 and 18%) and 3 energy levels were used (2600, 2800, and 3000 ME Kcal /kg of diet). The components of the diets were showed in Table (1).

Experimental parameters

Growth performance measurements

Through the experiment, the following measurements were recorded: initial weight at 28 day of age, average final weight at 180 day of age, daily feed intake per pair, total feed intake per pair (during 5 months).

Carcass traits measurements

At 6 months of age, 6 birds (two birds per replicate) group were taken randomly for carcass analysis. The squabs were weighed, sacrificed and left to bleed for 3 minutes and then scalded at 60ºC for 1 minute. After that they were de-feathered and manually eviscerated to study carcass characteristics. Each carcass was weighed to record the dressing carcass weights and all values were calculated as percentages of live body weights.

Blood Parameters

On a random basis, blood samples were collected from 6 squabs per group (2 birds per replicate) at slaughtering. Triglycerides (TG), total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), total plasma proteins (TP), albumin (ALB), globulin (GLB), urea and uric acid (UA) were determined calorimetrically by using the commercial kits (ELITech SEEPPIM S.A.S. Zone industrielle - 61500 France).

Economic analysis

At the end of experiment, the following indices were calculated per pair: feed cost (FC), total costs (TC), total return (NR), net profit (NP) and economic efficiency (EE).

Statistical Analysis

Data were analyzed as a 3×3 factorial arrangement in a randomized complete block design to find the main effects of 3 levels of CP and 3 levels of ME and their corresponding interaction effects using the GLM procedure and means were separated using Bonferroni's adjusted multiple comparison. Analysis was done using Statistical Package for Social Sciences version 22.0 (IBM Corp., Armonk, NY, USA) and Graphpad PRISM 7.0 (San Diego, CA) software. Results were reported in means ± SEM (Standard Error of Mean). The value of $P < 0.05$ was used to indicate statistical significance. Cage (pair) served as assessment unit for all measurements for the statistical analysis of live performance. Differences were considered significant at $P < 0.05$. The effect of replicate and hatchery location was incorporated in the initial model to determine if significant differences exist.

Results

Growth performance

The effects of different levels of dietary ME and CP on both BW and FI were showed in Table 2. From 2 to 5 months of the experiment, BW and FI of squabs were significantly improved by increasing dietary levels of both ME and CP with significant ($P < 0.0001$) ME ×CP interaction effect. In particular, when 3000 Kcal/Kg ME + 16% CP diets were fed to the squabs, higher BW was observed with a coincident decrease in FI. However, further increasing of CP level in 3000 Kcal/Kg ME diets did not lead to a significant change in growth parameters. The mortality rate was low 13.3% with no signs of either bacterial or viral infection, however higher losses were reported in squabs fed 18% CP diets.

Table 1: Ingredients and calculated composition (%) of the experimental diets

Items									
CP (%)[1]		14%			16%			18%	
ME (Kcal)[2]	2600	2800	3000	2600	2800	3000	2600	2800	3000
Ingredients									
yellow corn (kg)	11	23	24.7	-	8	3.8	-	-	-
Wheat (kg)	18	26	30	29	32	35.5	30.7	21	10
Millet (kg)	35.7	12	-	22.2	5	-	-	-	-
Horse beans (kg)	31	33.7	37	44	48.2	50.4	64	69.5	76
Soybean oil (kg)	-	1	4	0.5	2.5	6	1	5.2	9.7
Calcium carbonate (kg)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Calcium dibasic phosphate (kg)	2	2	2	2	2	2	2	2	2
Common salt (kg)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Premix[3] (kg)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Antimycotoxin (kg)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Anticoccidial (kg)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Calculated composition									
ME, Kcal/Kg	2645.58	2820.01	3026.55	2623.45	2804.21	3001.82	2613.32	2810.05	3016.4
CP %	14.32	14.07	14.02	16.11	16	16.01	18.07	18.02	18.02
EE %[4]	2.6	2.19	1.86	1.98	1.65	1.37	1.36	1.29	1.21
CF %[5]	4.02	4.01	4.03	4.62	4.66	4.68	5.4	5.5	5.62
Ca %[6]	1.16	1.16	1.16	1.16	1.17	1.17	1.18	1.18	1.18
Available phosphorus %	0.43	0.42	0.41	0.42	0.4	0.4	0.39	0.38	0.37
Lysine %	0.72	0.72	0.74	0.87	0.89	0.9	1.08	1.12	1.18
Methionine %	0.21	0.2	0.19	0.21	0.2	0.19	0.2	0.18	0.16

[1]CP: crude protein; [2]ME: metabolizable energy; [3]Muvco premix: Each 2.5kg contain vit. A (10, 000000 IU),vit. D3 (2, 000000 IU), vit. E (10 g),vit.k3 (1000 mg), vit. B1 (1000 mg), vit. B2(5 g) ,vit.B6 (1.5 g) , pantothenic acid(10 g) ,vit. B12 (10 mg),niacin(30 g) ,folic acid (1000 mg), biotin(50 g) , fe (30 g) ,Mn (60 g) ,Cu (4 g), I (300 mg), Co(100 mg) , Se (100 mg) and Zn(50 g), [4]EE: ether extract; [5]CF: crude fiber; [6]Ca: calcium.

Table 2: Body weight (g) and daily feed intake[*] of squabs fed diets with different ME and CP levels

ME[1]	CP[2]	Initial (28 days)	2 Month		3 Month		4 Month		5 Month		6 Month		TFI[4]
			Body weight	DFI[3]	Body weight	DFI	Body weight	DFI	Body weight	DFI	Body weight	DFI	
2600	14	270.01 ±13.17	286.55 ±11.92	26.8 ±0.72	290.63 ±12.08^{e}	38.01 ±0.55^{a}	295.83 ±7.37^{d}	48.41 ±2.08^{ab}	300.62 ±9.53^{d}	54.8 ±1.82^{a}	311.4 ±2.51^{e}	61.99 ±1.43^{a}	6900.3 ±12.01^{a}
	16	267.97 ±11.97	283.29 ±8.94	25.93 ±0.49	294.14 ±9.31^{d}	38.98 ±0.75^{a}	303.13 ±6.83^{c}	48.64 ±2.55^{ab}	313.42 ±7.27^{c}	53.09 ±1.52^{ab}	322.8 ±9.93^{d}	65.32 ±1.3^{a}	6958.8 ±25.16^{a}
	18	263.80 ±13.8	279.96 ±14.36	26.32 ±0.88	293.01 ±10.98^{d}	33.92 ±1.22^{ab}	307.36 ±12.33^{c}	51.07 ±2.27^{a}	316.64 ±11.85^{c}	54.62 ±1.53^{a}	323.71 ±11.88^{d}	64.29 ±0.9^{a}	6906.6 ±18.39^{a}
2800	14	260.21 ±5.37	288.96 ±10.67	25.81 ±0.7	304.39 ±8.68^{c}	32.53 ±0.83^{ab}	313.2 ±9.77^{c}	46.19 ±2.22^{ab}	321.8 ±8.07^{c}	49.45 ±1.19^{ab}	336.1 ±11.67^{c}	54.12 ±1.08^{b}	6243 ±11.91^{ab}
	16	279.66 ±4.67	296.26 ±5.81	24.83 ±1.19	311.04 ±12.21^{b}	36.68 ±1.38^{ab}	325.87 ±8.28^{b}	38.45 ±1.1^{b}	339.05 ±8.13^{b}	47.24 ±1.56^{b}	349.28 ±7.99^{b}	52.94 ±1.59^{b}	6004.2 ±22.4^{b}
	18	273.57 ±9.56	293.45 ±4.81	25.21 ±0.59	314.21 ±6.52^{b}	36.99 ±1.44^{ab}	327.62 ±11.08^{b}	40.46 ±1.02^{b}	338.1 ±12.24^{b}	47.72 ±1.49^{b}	348.72 ±6.9^{b}	53.77 ±1.81^{b}	6124.5 ±14.11^{b}
3000	14	275.09 ±6.4	305.21 ±6.14	25.19 ±0.87	318.86 ±8.35^{ab}	28.24 ±2.07^{c}	323.49 ±7.7^{b}	41.1 ±0.93^{b}	341.9 ±8.50^{b}	41.08 ±1.01^{c}	358.18 ±7.69^{b}	48.66 ±0.67^{bc}	5528.1 ±10.91^{c}
	16	280.61 ±4.79	309.63 ±7.91	25.36 ±0.98	321.08 ±11.99^{ab}	26.27 ±0.97^{c}	341.8 ±9.19^{a}	32.44 ±1.38^{c}	379.33 ±10.26^{a}	39.08 ±0.94^{c}	407.27 ±12.7^{a}	41.4 ±1.31^{d}	4936.5 ±16.71^{d}
	18	271.54 ±5.8	301.01 ±7.17	25.02 ±1.02	325.85 ±12.1^{a}	29.66 ±1.02^{c}	351.09 ±6.06^{a}	39.61 ±1^{b}	372.24 ±8.11^{a}	39.86 ±0.74^{c}	411.6 ±9.65^{a}	44.31 ±1.35^{c}	5353.8 ±19.51^{c}
P-values													
ME		0.661	0.329	0.283	0.009	0.003	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.253
CP		0.848	0.961	0.137	<0.0001	<0.0001	<0.0001	0.619	<0.0001	0.323	<0.0001	0.455	<0.0001
ME × CP		0.629	0.414	0.544	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[*]Daily feed intake per pair of squabs; [1]ME: metabolizable energy; [2]CP: crude protein; [3]DFI: daily feed intake; [4]TFI: total feed intake.
Means within the same column carrying different superscripts were significantly different at $P < 0.05$ based on Bonferroni multiple comparison test.

Table 3. Carcass traits and relative organ weights of squabs fed diets with different ME and protein levels

ME[1]	CP[2]	Dressing (%)	Breast meat (%)	Thigh meat (%)	Liver %	Heart %	Gizzard %	Small intestine %
2600	14	55.2±7.31^{d}	13.2±3.84^{c}	4.47±2.11^{c}	2.31±0.29	1.33±0.27	1.92±0.27	0.19±0.01
	16	60.5±5.51^{c}	12.94±4.52^{c}	4.68±2.06^{c}	2.35±0.4	1.39±0.32	1.97±0.25	0.41±0.05
	18	61±8.39^{c}	13.7±3.89^{c}	5.16±2.4^{b}	2.41±0.46	1.4±0.29	1.98±0.3	0.46±0.1
2800	14	57.5±7.89^{d}	15.20±2.29^{b}	5.34±5.72^{b}	2.24±0.54	1.37±0.23	1.93±0.29	0.23±0.09
	16	64.6±6.89^{b}	14.91±2.8^{b}	5.58±5.54^{b}	2.50±0.33	1.41±0.37	1.99±0.34	0.45±0.1
	18	66.8±5.85^{b}	16.1±4.64^{b}	5.64±2.48^{b}	2.41±0.41	1.49±0.39	2.01±0.45	0.39±0.06
3000	14	56.8±5.97^{d}	16.5±3.34^{b}	5.11±3.47^{b}	2.33±0.37	1.47±0.28	1.96±0.36	0.48±0.04
	16	70.1±7.02^{a}	18.2±3.56^{a}	6.96±3.52^{a}	2.52±0.52	1.50±0.34	2.1±0.47	0.3±0.08
	18	69.3±6.1^{a}	18.9±4.31^{a}	6.51±2.69^{a}	2.66±0.33	1.53±0.3	2.34±0.39	0.53±0.05
P-values								
ME		<0.0001	<0.0001	<0.0001	0.936	0.663	0.317	0.645
CP		<0.0001	<0.0001	<0.0001	0.857	0.248	0.486	0.629
ME ×CP		<0.0001	<0.0001	<0.0001	0.409	0.352	0.494	0.535

[1]ME: metabolizable energy; [2]CP: crude protein.
Means within the same column carrying different superscripts were significantly different at $P < 0.05$ based on Bonferroni multiple comparison test.

Carcass traits and relative organ weights

The effects of different levels of dietary ME and CP on carcass traits and relative organ weights were showed in Table 3. Highest dressing %, breast and thigh meat % were obtained from squabs fed on 3000 Kcal/Kg ME + 16% CP diets. On the other hand, there were no ME, CP and ME × CP interaction effects on the relative weights of the other body organs (Liver %, Heart %, Gizzard% and Small intestine %).

Biochemical analysis

The effects of different levels of dietary ME and CP on blood parameters of squabs at 6th month of age were presented in Table 4. High protein diets resulted in higher serum proteins (TP, ALB and GLB) along with significant increase in the concentrations of urea and uric acid regardless of the dietary ME content. In contrast, higher TC, TG, HDL and LDL were observed in serum samples obtained from squabs fed on high ME diets.

Economic analysis

The effects of different levels of dietary CP and ME on the economic indices were showed in Table 5. Feed cost and total cost decreased with increasing of dietary energy and protein levels. The higher values of TC were recorded in squabs fed 3000 Kcal ME +16% CP diet. Furthermore, TR, NP and EE the highest values for squabs fed diets containing 3000 Kcal ME +16% CP combinations compared with other groups.

Table 4: Serum biochemical parameters of squabs fed diets with different ME and CP levels

ME[1]	CP[2]	ALB[3] (g/dL)	GLB[4] (g/dL)	TP[5] (g/dL)	Urea (mg/dL)	UA[6] (mg/dL)	TC[7] (mg/dL)	TG[8] (mg/dL)	HDL[9] (mg/dL)	LDL[10] (mg/dL)
2600	14	1.09 ±0.11 ^{c}	1.98 ±0.4 ^{c}	3.08 ±0.33 ^{c}	2.71 ±0.25 ^{c}	4.11 ±0.14 ^{b}	136.83 ±7.43 ^{c}	113.93 ±3.25 ^{c}	40.9 ±2.82 ^{c}	71.57 ±2.22 ^{c}
	16	2.24 ±0.13 ^{b}	2.83 ±0.12 ^{b}	5.07 ±0.18 ^{b}	4.12 ±0.09 ^{b}	5.16 ±0.17 ^{a}	140.13 ±4.89 ^{c}	115.47 ±8.66 ^{c}	37.07 ±1.99 ^{c}	72.67 ±3.58 ^{c}
	18	2.91 ±0.09 ^{b}	4.13 ±0.25 ^{a}	7.04 ±0.35 ^{a}	5.1 ±0.1 ^{a}	6.45 ±0.32 ^{a}	150.2 ±2.83 ^{c}	107.1 ±7.05 ^{c}	40.73 ±2.07 ^{c}	69.07 ±4.84 ^{c}
2800	14	1.06 ±0.13 ^{c}	1.9 ±0.24 ^{c}	2.96 ±0.13 ^{c}	2.73 ±0.12 ^{c}	3.9 ±0.11 ^{b}	164.3 ±3.02 ^{b}	141.4 ±2.75 ^{b}	49.33 ±4.66 ^{b}	78.5 ±2.12 ^{b}
	16	2.26 ±0.22 ^{b}	2.88 ±0.16 ^{b}	5.14 ±0.13 ^{b}	3.81 ±0.15 ^{b}	5.26 ±0.27 ^{a}	166.4 ±5.92	155.57 ±6.58 ^{b}	52.17 ±2.83 ^{b}	86.77 ±2.19 ^{b}
	18	3.38 ±0.22 ^{a}	3.95 ±0.27 ^{a}	7.34 ±0.43 ^{a}	5.66 ±0.41 ^{a}	6.88 ±0.11 ^{a}	169.77 ±2.31 ^{b}	153.87 ±8.55 ^{b}	53.33 ±2.39 ^{b}	81.73 ±2.87 ^{b}
3000	14	1.32 ±0.17 ^{c}	1.76 ±0.29 ^{c}	3.08 ±0.44 ^{c}	2.45 ±0.07 ^{c}	3.79 ±0.28 ^{b}	181.93 ±1.53 ^{a}	174.43 ±5.72 ^{a}	73.8 ±2.4 ^{a}	93.93 ±2.5 ^{a}
	16	2.21 ±0.18 ^{b}	2.94 ±0.17 ^{b}	5.15 ±0.31 ^{b}	3.93 ±0.14 ^{b}	4.96 ±0.22 ^{ab}	179.93 ±2.03 ^{a}	175.2 ±4.82 ^{a}	70.53 ±2.94 ^{a}	101.33 ±3.8 ^{a}
	18	3.43 ±0.27 ^{a}	4.35 ±0.27 ^{a}	7.78 ±0.2 ^{a}	5.88 ±0.45 ^{a}	6.61 ±0.37 ^{a}	184.03 ±5.45 ^{a}	170.17 ±2.66 ^{a}	77.53 ±0.54 ^{a}	98.47 ±2.71 ^{a}
P-values										
ME		0.550	0.495	0.261	0.344	0.566	<0.0001	<0.0001	<0.0001	<0.0001
CP		<0.0001	0.005	<0.0001	0.003	<0.0001	0.341	0.557	0.469	0.753
ME × CP		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]ME: metabolizable energy; [2]CP: crude protein; [3]ALB: albumin; [4]GLB: globulin; [5]TP: total proteins; [6]UA: uric acid; [7]TC: total cholesterol; [8]TG: Triglycerides; [9]HDL: high density lipoprotein; [10]LDL: low density lipoprotein; Means within the same column carrying different superscripts were significantly different at P < 0.05 based on Bonferroni multiple comparison test

Table 5: The effects of different levels of dietary ME and CP on the economic indices

ME[1]	CP[2]	Total Cost of Feed	Total Cost	Total Return	Net Profit	Economic Efficiency[1]
2600	14	40.02±1.8[a]	100.02±10.16[a]	92.4±3.12[b]	-7.62±0.64[f]	-19±2.1[f]
	16	41.4±2.41[a]	101.4±6.45[a]	95.6±5.35[b]	-5.8±0.56[e]	-14±2.4[f]
	18	42.48±2.98[a]	102.48±8.64[a]	91.9±8.81[bc]	-10.58±0.92[g]	-24.9±2.1[g]
2800	14	36.52±3.16[b]	93.52±6.41[b]	92.5±4.14[b]	-4.02±0.86[e]	-11±1.8[e]
	16	36.03±3.23[b]	91.03±3.05[b]	98.2±3.68[b]	2.57±0.61[c]	6±1.46[c]
	18	38.09±5.2[ab]	92.09±4.24[b]	98.4±3.27[b]	0.71±0.17[d]	0.8±3.1[d]
3000	14	32.62±4.13[c]	88.62±3.99[b]	95.7±6.54[b]	7.08±0.42[b]	21.7±3.8[b]
	16	29.87±2.37[d]	81.87±6.51[c]	110.3±8.14[a]	10.43±0.69[a]	34.9±1.4[a]
	18	33.62±2.79[c]	93.62±5.48[b]	90.8±5.14[c]	-2.82±0.84[e]	-8.4±1.2[e]
P-values						
ME		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
CP		0.096	0.041	0.036	<0.0001	<0.0001
ME × CP		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]ME: metabolizable energy; [2]CP: crude protein. Means within the same column carrying different superscripts were significantly different at $P < 0.05$ based on Bonferroni multiple comparison test

[1] Economic efficiency= Net return / Price of feed cost.

Discussion

Considering our main interest was to establish a bio-economic optimum for feed formulation that meet the nutritional requirements of pigeons and maintain maximum performance with least cost as well.

Growth Performance

Body weights in different ages were a significantly improved, squabs fed the highest ME and CP level (16-18% with 3000 Kcal ME/kg) of diet recorded significantly highest body weight and average daily gain contrast with other treatments. These results are in the line with others who pointed out that 15.5% protein and 16% CP had a significant positive influence on average BW in growing squabs from 28 days to 6th month of age [5,10]. While, these results disagreed with Abdel-Azeem [11], who recommended that the best protein level of Baladi pigeons diets was 14% CP with 3100 ME kcal/kg that produced the better performance (fertility, livability, squab production, the return of squabs and body measurements of squabs). Also, the body weight and weight gain were not significantly affected when dietary metabolic levels increased up to 3200 ME Kcal/kg of pigeon diet [8].

In terms of the FI, increasing energy and CP level results in decreased feed intake. This indicated that birds fed more feed on the low-energy diet to fulfill their energy requirements and normal growth when compared with those of high-energy diet. This result is in accordance with previous studies that reported the FI decreased significantly as ME increased from 2,650 to 3,150 Kcal/kg [8, 12, 13]. Abdel-Azeem [11], showed that increase the level of protein diet (14, 17 and 20%) of pigeons caused a decreased in the amount of feed consumed at different periods. However, the daily feed intake of pigeon increased when the protein in diet increased from 12 to 20% [6].

Carcass traits

The current results revealed significant increase in dressing, breast and thigh muscles percentage with increase energy and protein level. While, there was no significant difference in liver, heart, gizzard percentage among the treated groups. These are in agreement with those who reported that the muscle (breast and drumstick) yields were significantly higher in broiler fed high protein diet when compared with those of medium and low protein diets [20]. Aggoor *et al.* [21] found that increasing ME content of the control diet of quail with adding fat, produced carcasses of higher dressing percentage, whilst had no effect on gizzard, liver, giblets, heart and testis percentage. On the contrary, the carcass weight and yield of breast muscle remained unaffected by changes in dietary energy or lysine content in quail's diet [22].

Biochemical analysis

The knowledge of hematological parameters is deficient and there are only few reports on the parameters of blood analysis in pigeons. The current results indicated that the plasma protein and lipids fractions were affected by the nutritional status of birds. In our study, increased both dietary energy and protein level, elevated the plasma protein and lipid parameters. The previous findings are in agreement with those found by others, who reported that energy and protein levels in diet influenced the chicken plasma metabolites [14,15]. These results were in line with those of other researchers who recorded that the plasma total protein, globulin, urea, uric acid cholesterol and triglyceride [8,16,17]. High density lipoprotein and LDL were increased by increasing the dietary CP (14, 17 and 20%) and metabolic energy level (2600, 2800, 3000 and 3200 ME Kcal). While, these results disagree with Abdel-Azeem *et al*. [18] and Abou-Zeid *et al*. [19] who found that the total plasma protein, albumin and total cholesterol levels were not significantly affected by feeding Japanese quail on diet containing 20, 22 and 24% CP.

Economic analysis

The cost of feeding represents the largest item in the variable costs. Cost of feeding and total costs were significantly higher in groups fed on 2600 ME Kcal/kg with different levels of protein, while the lower were in group fed on 3000 ME Kcal/kg with 16% protein. Fixed costs are cost depreciation, labor, electricity, equipment and building. The fixed costs represented a minor proportion of the total costs while the total variable costs represented the major portion of the total costs. The revenues of pigeon squab's pair included sales of squabs as layers. Net profit and economic efficiency were significantly higher in group fed on 3000 ME Kcal/kg with 16% protein followed by group fed on 3000 ME Kcal/kg with 14% protein. These findings are strongly confirmed the findings of Khashaba *et al*. [10], who detected that the highest economic efficiency was in group fed on dietary protein level 16% CP with 2900 ME Kcal/kg. Quails diet contained high energy (3100 Kcal/Kg) was enhanced the production efficiency with least cost [22].

Conclusion

The metabolizable energy and crude protein content of pigeon's diets play important roles on performance of pigeon. Feeding high crude protein (16%) and metabolizable energy (3000 ME Kcal/kg) diets improved pigeon squab's body weight, carcass characteristics, serum biochemical analysis and economic efficiency. It is recommended to formulate the pigeon diet containing high energy (3000 Kcal/Kg) with 16% crude protein to maximize the production with least cost.

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Conflict of interest

The authors declare that they have no conflict of interest.

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الملخص العربى

التقييم الإقتصادى لبعض الممارسات الغذائية فى زغاليل الحمام

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أجريت هذه التجربة بهدف دراسة تأثير مستويات مختلفة من الطاقة والبروتين على بعض الصفات الغذائية والفسيولوجية فى زغاليل الحمام البلدى (عمر ٢٨ يوم) تحت الظروف المصرية. إستخدم عدد ١٣٥ زوج من زغاليل الحمام قسمت إلى تسع معاملات غذائية بواقع ١٥ زوج لكل معاملة. قسمت المعاملات وفقا لمستويات الطاقة (٢٦٠٠-٢٨٠٠-٣٠٠٠) كيلو كالوري و(١٤-١٦-١٨)% بروتين خام كما تحتوى العلائق على الفيتامينات والأملاح المعدنية اللازمة وتتعرض الطيور الى ١٤ ساعة ضوء خلال اليوم ويتم تقديم الماء والعلائق بصورة حرة حتى الشبع. فى هذه التجربة وجد أن بزيادة مستوى الطاقة والبروتين يزداد كلا من وزن الجسم الحى ونسبة التصافى مع إنخفاض ملحوظ فى كمية العلف المستهلكه خاصة فى المجموعة التى تتغذى على ١٦% بروتين و٣٠٠٠ كيلو كالورى طاقة. وأيضا وجد أن زبادة مستوى الطاقة ليس لها تاثير معنوى على كمية البروتين فى الدم (الألبيومين- الجلوبيولين- اليوريا و حمض اليوريك) بينما تزداد كمية الدهون الموجوده به (الكوليسترول – الدهون الثلاثية- البروتين عالى ومنخفض الكثافة). من الناحية الأقتصادية أعطت المجموعة التى تحتوى على ١٦% من البروتين و٣٠٠٠ كيلو كالورى أقل تكلفة لكل كيلو جرام وزن حى للطبور وبالتالى أعلى عائد إقتصادى وصافى ربح. نستخلص من هذة الدراسة ان مستوى طاقة ٣٠٠٠ كبلو كالورى وبروتين ١٦% فى علائق زغاليل الحمام كان الأفضل للحصول على أعلى أداء إنتاجى بتكاليف أقل وبالتالى زيادة الكفاءة الاقتصادية.