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EFFECT DIETARY PROTEIN AND ENERGY LEVEL AND VITAMIN SUPPLEMENTATION ON RABBIT PERFORMANCE, UNDER EGYPTIAN CONDITIONS.

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ABSTRACT: **One hundred and eight male Bouscat rabbits, 35 day old, with nearly equal live body weight at the beginning of the experiment were randomly allotted to 12 experimental groups, of 9 rabbits each. The six rabbit groups were fed on the normal protein diet (16.0%), while the other six groups were fed on the high protein diet (18.0%). Within each dietary level, the first three groups were fed on the normal energy diet (2500 kcal/kg), while the other three groups were fed on the high energy diet (diet supplemented with 5% oil; 2850 kcal/kg). Within each dietary energy level, the first group was fed on the diet without supplementation, the second group was fed on the diet supplemented with 3000 IU vitamin A/kg diet, while the third group was fed on the diet supplemented with 25 mg vitamin E/kg diet. Final live body weight (at 8 weeks of the experimental period) and daily weight gain increased significantly (P<0.01 or 0.001) in rabbit group fed high-protein or high-energy diets. Rabbits were fed diet supplemented with vitamin A or E recorded higher daily body gain weight with 4.76 and 15.48%, respectively, at 0-8 weeks than those fed diet without supplementation. Rabbits fed high-protein high-energy diet and supplemented with vitamin E recorded the lower feed cost and the higher return from body gain weight and final margin than the other groups. Serum total protein, albumin, urea-N, creatinine, thyroxin and cortisone affected significantly with**

protein level in rabbit diets, while the concentrations of serum transaminase enzymes (AST and ALT) insignificantly affected. Serum total protein, albumin and thyroxin increased with increasing dietary protein level, while cortisone concentration decreased. Serum total protein, albumin, creatinine, thyroxin and cortisone affected significantly with energy level in rabbit diets, while the concentrations of urea-N, AST and ALT insignificantly affected. Serum total protein, urea-N, creatinine, ALT, thyroxin and cortisone affected significantly with vitamin supplemenation in rabbit diets, while the concentrations of albumin and AST insignificantly affected. Serum total protein, albumin and thyroxin increased with vitamin supplementation, while cortisone concentration decreased. Analysis of variance indicated that the dietary protein level, energy level or vitamin supplementation insignificantly affected pre-slaughter live body weight and carcass and non-carcass components.

INTRODUCTION

Contradictory reports exist in the literature regarding protein requirement for growing rabbits. Smith *et al.* (1960) suggested that diets containing 13-14% crude protein could meet the needs of growing rabbits. Also, Rico and Menclaca (1973) reported that 14% crude protein would meet the need of growing rabbits in tropical conditions. However, Lebas (1973) reported that the optimal crude protein level for growing rabbits was about 17-18%. NRC (1977) recommended that rations for growing rabbits should contain 16% crude protein. Contrarily, Martina (1977) suggested that the range of 17 to 20% crude protein in rabbit diets for growing rabbits was recommended. Spreadbury (1978) reported that about 16% crude protein was the optimal level in a temperate climate.

Energy is not a nutrient but a property of energy-yielding nutrients when they are oxidized during metabolism. Rabbits voluntarily adjusted their feed intake to meet their energy requirements, unless the intake is limited by gut capacity. Lebas (1975) found that approximately 9.5 kcal of digestible energy (DE) was required per g body weight gain. The data suggest that a level of 2500 kcal of DE per kg diet will satisfy the energy needs for rapid growth, but at energy levels lower than this, the rabbit may not be able to consume sufficient feed to meet its energy requirements for maximum growth. An increase in dietary fat level of rabbits has been shown to increase (Thacker, 1956, Arrington *et al.*, 1974 and Richard *et al.*, 1982), as well as decrease (Parigi *et al.*, 1974 and Raimoinidi *et al.*, 1974) body gain, or not to effect growth (Lebas, 1975). Partridge *et al.* (1986) found that rabbits given fat-supplemented diets showed slight non-significant improvements in daily live weight gain when compared to controls, although the type of fat and inclusion level had no marked effect. On the other hand, Ayyat *et al.* (1994) reported that dietary energy level (2707, 2436 and 2276 kcal DE/kg) had no effect on live body weight and body gain. It was concluded that the best economic returns were achieved by feeding a low energy diet.

Vitamin E, a fat-soluble vitamin, protects vitamin A and essential fatty acids from oxidation in the body cells and prevents breakdown of body tissues (USDA, 1995 and FASEB, 1995). Castellini and Bosco (2000) reported that a high vitamin E content of the diet of rabbits controls lipid peroxidation in both the live animal and during processing, preservation by refrigeration and freezing, and also cooking of their meat and meat products. Vitamins E have a synergistic antioxidant effect. Vitamin E appears to have several different, but related, functions. One of the most important is its role as an inter- and intra-cellular antioxidant. In this capacity it prevents the oxidation of unsaturated lipid materials within cells. If lipid hydroperoxides are allowed to form in the absence of adequate tocopherols, direct cell tissue damage can result. The more active the cell; such as those of skeletal and involuntary muscles; the greater the in-flow of lipids for energy supply and the greater the risk of tissue damage if vitamin E is limiting. This antioxidant property also ensures erythrocyte stability and maintenance of the integrity of capillary blood vessels. Recent studies have shown that vitamin E has a regulatory action on the pituitary-midbrain system, promoting the production of hormones that stimulate the output of the thyroid and the adrenal cortex (Weiser and Salkeld, 1977).

The present work was conducted to study the growth performance, feed efficiency, blood components and slaughter traits of Bouscat male broiler rabbits as affected by feeding varying levels of dietary protein and energy and supplemented with vitamin A and E, under the Egyptian conditions.

MATERIALS AND METHODS

The study was conducted at the Department of Animal Production, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. The practical work was carried out at Gemaza Animal Research Farm belonging to Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Cairo, Egypt. One hundred and eight male Bouscat rabbits, 35 day old, with nearly equal live body weight at the beginning of the experiment were randomly allotted to 12 experimental groups, of 9 rabbits each. The six rabbit groups were fed on the normal protein diet (16.0%), while the other six groups were fed on the high protein diet (18.0%). Within each dietary level, the first three groups were fed on the normal energy diet (2500 kcal/kg), while the other three groups were fed on the high energy diet (diet supplemented with 5% oil; 2850 kcal/kg). Within each dietary energy level, the first group was fed on the diet without supplementation, the second group was fed on the diet supplemented with 3000 IU vitamin A/kg diet, while the third group was fed on the diet supplemented with 25 mg vitamin E/kg diet during the experimental period (8 weeks). The feedstuff ingredients and chemical composition of the experimental diets were shown in Table 1.

Rabbits in all groups were kept under the same managerial and hygienic conditions. The rabbits were housed in wire cages provided with feeders and automatic drinkers. The batteries were located in a conventional confined and windowed building naturally ventilated, side electric fans were used. The rabbits were fed on pelleted ration *ad libitum*. The provided fed were weighed daily. The refused molasses blocks in the basins were collected daily in the morning and weighed to calculate intake levels. At the end of experimental period (at 8 weeks) three rabbits from each group were randomly selected to collecting the blood samples. The blood samples were centrifuged at 3000 RBM for 20 minutes to separate the serum. The collected serum were stored at 20 °C until assay. Total protein, albumin, urea-N, creatinine, choloesterol and serum transaminase enzymes (SGPT and SGOT) were estimated in blood serum by colormetric methods using commercial kits. At the end of the experimental period three rabbits from each group were randomly taken for slaughter after being fasted for 12 hours. After complete bleeding, the carcass and some non-carcass components were weighed. The carcass was separated into three cuts (fore-limbs, trunk and hind-limbs). Each of the three cuts was weighed. trunk and hind-limbs were weighed as the prime cuts.

The data of live body weight and gain and blood components were statistically analyzed by 2X2X3 factorial experiment (Snedecor and Cochran, 1994) according the following model:

$Y_{ijkll} = \mu + P_i + E_j + V_k + PE_{ij} + PV_{ik} + EV_{jk} + PEV_{ijk} + E_{ijkl}$,where μ = The overall mean, P_i = The fixed effect of i^{th} dietary protein level (P_i = 1 ... 2), E_j = The fixed effect of j^{th} dietary energy level (E_j = 1 ... 2), V_k = The fixed effect of k^{th} vitamin supplementation (V_j = 1 .. 3), PE_{ij} = Interaction between the i^{th} protein level and j^{th} energy level, PV_{jk} = Interaction between the i^{th} protein level and k^{th} vitamin supp., EV_{jk} = Interaction between the j^{th} energy level and k^{th} vitamin supp., PEV_{ijk} = Interaction between the i^{th} protein, j^{th} energy and k^{th} vitamin, E_{ijkl} = Random error.

The deference between experimental groups were separated by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Effect of dietary protein level:

Live body weight and daily weight gain increased significantly (P<0.01 or 0.001) in rabbit group fed high-protein diet when compared with those fed normal-protein diet, during the whole experimental periods. The increasing values in body weight at 8 weeks and daily gain at 0-8 weeks were 7.61% and 11.01%, respectively (Table 2). The results obtained are in agreement with those obtained by Omole (1977 and 1982), Ayyat (1994) and Ayyat *et al.* (1995). Omole (1982) found that the daily gain of New Zealand White rabbits fed 18% protein diet was significantly higher than those fed lower levels (10 and 14% crude protein). Also, Ayyat (1994) found that the body gain weight increased significantly (P<0.001) with increasing the level of dietary protein in rabbit diets. On the other hand, Zaragoza and Vallelo (1982) found no significant differences in body gain as affected with dietary protein level.

Increasing dietary protein level decreased feed intake and improved the feed conversion (Table 3). The improving values in feed conversion was 19.95% at 0-8 weeks than those fed normal protein diet. Ayyat (1991) and Omole (1977) have obtained similar results.

Feed cost was decreased by 6.04%, while return from body weight gain and final margin increased with 10.82 and 37.81%, respectively, in rabbits fed high protein diet than those fed normal protein diet (Table 3). Ayyat (1994) reported that feed cost, return from body gain and final margin increased by 7.52, 22.58 and 29.67%, respectively, in rabbits fed normal protein diet (16.8%) than those fed low protein diet (13.2%).

Serum total protein, albumin, Serum urea-N, creatinine and thyroxin significantly (P<0.05, 0.01 and 0.001) increased, while cortisone concentration decreased (P<0.01) with increasing protein level in rabbit diets (Tables 4 and 5). Similar results were obtained by Omole (1982) and Ayyat (1994). The concentrations of AST and ALT insignificantly affected with the protein level in rabbit diets (Table 5). However, Ayyat (1994) reported that the concentrations of AST and ALT significantly increased with the increasing dietary protein level.

The obtained results may be indicated that the increasing dietary protein level slightly improved the liver activity and increase the protein synthesis in the liver. On the other point of view increasing the concentration of thyroxin hormone and decreased of cortisone hormone in the blood of rabbit fed high protein diet may be also related with the increasing of protein synthesis and increased the anabolism processors.

Analysis of variance indicated that the dietary protein level insignificantly affected pre-slaughter live body weight and carcass and non-carcass components. However, kidney fat weight significantly (P<0.05) affected (Tables6 and 7). Kidney fat weight increased with increasing protein level in rabbit diets. The obtained resukts are in agreement with Omole (1977), Carregal (1993) and Ayyat.(1994).

Effect of dietary energy level:

The present work revealed the live body weight and daily weight gain increased significantly (P<0.01 or 0.001) in rabbit group fed high-energy diet when compared with those fed normal-energy diet The increasing values in daily gain were 7.62 and 10.24%, respectively, at 0-8 weeks of the experimental period (Table 2). These findings are in agreement with those obtained by Bassuny *et al.* (1997), Butcher *et al.* (1983) and El-Hindawy *et al.* (1994). Bassuny *et al.* (1997) reported that final body weight was significantly higher by 16.2% in rabbits fed high energy diet (2700 kcal DE/kg diet) than the normal energy diet (2500 kcal DE/kg diet). On the other hand, Castellini and Battaglini (1992) reported that body weight or body gain did not affected by dietary energy level.

Increasing dietary energy level in rabbits diet (with addition oil) decreased feed intake and improved the feed conversion (Table 3). Maertens *et al.* (1986) reported that daily energy intake decreased with 8% for rabbits fed low energy diet than the high energy diet, while feed intake was greater in low energy diet. Ayyat and Marai (1997). Indicated that rabbits fed high energy diet showed lower feed intake than those fed normal energy diet.

Feed cost was not affected with the increasing in dietary energy level, while return from body gain and final margin increased in rabbits fed high-energy diet with 10.01 and 25.38%, respectively, than those fed normal-energy diet (Table 3).

Serum total protein, albumin, creatinine and thyroxin concentrations increased significantly (P<0.01 and 0.001) with increasing energy level in rabbit diets, while serum urea-N, AST, ALT and cortisone insignificantly affected (Tables 4 and 5). Similar results were obtained by Bassuny *et al.* (1997) and Ayyat *et al.* (1994).

Serum urea-N and createinine increased with increasing energy level in rabbit diet, this may indicate slight over-function in kidney due to the increase in dietary energy level. On the other hand, Increasing the concentration of thyroxin hormone in the blood of rabbit fed high energy diet may be related with the increasing of protein synthesis in the body tissues.

Analysis of variance indicated that the dietary energy level insignificantly affected pre-slaughter live body weight and carcass and non-carcass components. However, kidney fat weight significantly (P<0.001) affected (Tables 6 and 7). Kidney fat weight increased with increasing energy level in rabbit diets. Similar results were obtained by Ayyat *et al.* (1994). Castello and Gurri (1992) reported that the increasing of energy level in rabbit diets improved significantly carcass yield. Also, El-Hindawy *et al.*, (1994) reported that the carcass components was significantly higher when dietary energy level was high.

Effect of vitamin supplementation:

The vitamin supplementation was significantly (P<0.001) affected live body weigh and daily body gain weight at 8 weeks of the experimental period (Table 2). Rabbits were fed diet supplemented with vitamin A or E recorded higher daily body gain weight at 0-8 weeks with 4.76 and 15.48%, respectively, than those fed diet without supplementation. Kormann and Schlater (1985) reported that growth rat increased with ß–carotene supplemented in rabbit diets. Also, Zeidan *et al.* (2001) reported that body gain was higher in rabbit bucks treated with vitamin E.

Supplemented rabbit diets with vitamins did not affected feed intake, while feed conversion improved. The improving values in feed conversion ratio were 5.32 and 14.15%, respectively, on rabbit fed diet supplemented with vitamin A and E. Rabbits fed diet supplemented with vitamin E recorded the best feed conversion. Similar results were obtained with El-Husseiny *et al.* (1997) and Kormann and Schlater (1984).

Feed cost was not affected with the vitamins supplementation in rabbit diets, while return from body gain and final margin increased. Return from body gain increased with 4.56 and 14.87%, respectively, in rabbit fed diets supplemented with vitamin A and E than those fed diet without vitamin supplementation. Also the final margin increased with 12.42 and 38.37%, respectively (Table 3). Rabbits fed diet supplemented with vitamin E recorded the higher margin.

Serum total protein, ALT and Thyroxin concentrations increased significantly ($P<0.01$ and 0.05), while serum urea-N, creatinine and cortisone significantly ($P<0.01$ and 0.001) decreased due to vitamin A and E supplementation in rabbit diets. On the other hand, albumin, AST concentration insignificantly affected (Tables 4 and 5).

Lee *et al.* (1976) reported that the improvement in metabolic processes may be involved in such increased growth rate and tissue anabolic occurred when animals fed diets supplemented with vitamin E. This finding may be indicated that the supplementation of vitamin E slightly improved the liver activity and increase the protein synthesis in the liver. Oriani *et al.* (2001) suggest that vitamin E supplemented at 375 mg/kg diet can effectively control reactive oxygen metabolites production and improve muscle lipostability. The studies have shown that vitamin E has a regulatory action on the pituitary-midbrain system, promoting the production of hormones that stimulate the output of the thyroid and the adrenal cortex (Weiser and Salkeld, 1977). Animals under stress need more vitamin E than those in less stressful conditions. Overcrowding, poor ventilation, transport, disease, vaccination and irregular noise patterns all increase the requirement for vitamin E (Barber et al., 1977).

Analysis of variance indicated that the dietary vitamin A and E supplementation insignificantly affected pre-slaughter live body weight and carcass and non-carcass components (Tables 6 and 7).

Interaction between dietary protein level, dietary energy level and vitamin supplementation:

The interaction between dietary protein and energy level was insignificantly affected daily body gain weight at 0-8 weeks of the experimental period, while live body weight at 8 weeks significantly (P<0.01) affected (Table 2). Increasing each of dietary protein and energy levels increased average daily weight gain. Similarly, Ayyat and Marai (1996) found that rabbits fed HP-NE diet (18.2% CP and 2588 kcal DE/kg diet) recorded higher daily gain than other rabbits fed NP-NE, NP-HE and HP-HE diets, under summer Egyptian conditions.

Increasing the protein and energy levels in rabbit diets reduced the daily feed intake, while the vitamin supplementation in rabbit diets did not affected daily feed intake. On the other hand, increasing dietary protein and energy levels and vitamin supplementation in rabbit diets improved the feed conversion (Table 3). Rabbits fed high-protein high-energy and supplemented with vitamin E recorded the lower feed intake and the best feed conversion ratio than the other experimental groups.

Increasing dietary protein and energy level and vitamin supplementation in rabbit diets increased the return from body gain and the final margin. Rabbits fed high-protein high-energy diet and supplemented with vitamin E (HP-HE-E) recorded the lower feed cost and the higher return from body gain weight and final margin than the other groups (Table 3).

Interaction between dietary protein and energy levels and supplementation with vitamin insignificantly affected serum total protein, albumin, urea-N, creatinine, AST, ALT, thyroxin and cortisone concentrations (Tables 4 and 5). Rabbits fed high-protein high-energy diet supplemented with vitamin E recorded higher thyroxin level in blood than the other experimental groups.

Thyroxin concentration in blood significantly (P<0.05) affected with the interaction between protein and energy levels in rabbit diets, while cortisone concentration insignificantly affected (Tables 4 and 5).

Analysis of variance indicated that the dietary protein and energy levels and dietary vitamin supplementation insignificantly affected pre-slaughter live body weight and carcass and non-carcass components (Tables 6 and 7).

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Table 1. Composition and chemical analysis of the experimental diets.

Items	NP-NE	NP-HE	HP-NE	HP-HE
Ingredients:				
Alfalfa hay	23.00	21.91	21.00	20.00
Soybean meal	10.00	9.52	16.00	15.24
Wheat bran	48.00	45.71	48.00	45.71
Yellow corn	14.00	13.33	10.00	9.52
Cottonseed oil	—	4.76	—	4.76
Molasses	3.00	2.86	3.00	2.86
Limestone	1.40	1.33	1.40	1.33
Sodium chloride salt	0.30	0.29	0.30	0.29
Vitamin and mineral premix	0.30	0.29	0.30	0.29
Chemical composition[1]:				
Crude protein %	16.02	15.45	18.14	17.48
Crude fibre %	12.26	11.78	12.43	11.94
Digestible energy (kcal/kg)	2561.40	2850.90	2583.20	2879.60
Price (LE/Ton)	750.00	795.00	792.00	840.00

NP = Normal protein, HP = High protein, NE = Normal energy, HE = High energy.

1. Analyzed according to A.O.A.C. (1980)

able 2. Live body weight and daily gain weight (g) of rabbits as affected by dietary protein level, energy level and vitamins supplementation and their interactions, at the different experimental periods.

Items	W0	W4	W8	W0-8
Protein level:				
Normal (NP)	480.10±6.53	1127.12±16.20	1705.48±18.63	21.88±0.35
High (HP)	474.81±5.96	1189.81±15.23	1835.19±18.20	24.29±0.32
Significance	NS	**	***	***
Energy level:				
Normal (NE)	475.38±6.18	1126.89±15.91	1706.51±18.37	21.98±0.34
High (HE)	479.52±6.32	1191.25±15.45	1836.63±18.43	24.23±0.33
Significance	NS	**	***	***
Vitamin:				
Without (W)	476.71±8.29	1129.86±22.58	1688.29±19.41[c]	21.64±0.36[c]
Vit. A (A)	480.29±7.40	1152.00±19.10	1749.86±22.01[b]	22.67±0.39[b]
Vit. E (E)	475.29±7.34	1194.43±16.39	1874.71±22.80[a]	24.99±0.42[a]
Significance	NS	NS	***	***
Interaction between dietary protein and energy levels:				
NP-NE	478.27±9.00	1084.42±20.92	1617.12±18.88[c]	20.34±0.35[c]
NP-HE	481.92±9.62	1169.81±22.08	1793.85±20.37[b]	23.73±0.42[b]
HP-NE	472.59±8.61	1167.78±21.34	1792.59±20.33[b]	23.57±0.38[b]
HP-HE	477.11±8.37	1212.69±21.21	1879.42±28.35[a]	25.04±0.47[a]
Significance	NS	NS	**	NS
Interaction between dietary protein level and vitamin supplementation:				
NP-W	483.06±11.36	1081.39±30.94	1653.33±29.34	20.90±0.52
NP-A	481.76±11.71	1122.06±28.03	1668.82±29.30	21.20±0.53
NP-E	475.29±11.45	1180.59±19.44	1797.35±27.68	23.61±0.55
HP-W	470.00±12.25	1181.18±28.85	1725.29±22.66	22.42±0.44
HP-A	478.89±9.54	1180.28±25.14	1826.39±20.27	24.06±0.31
HP-E	475.28±9.65	1207.50±26.23	1947.78±26.34	26.30±0.45
Significance	NS	NS	NS	NS
Interaction between dietary energy level and vitamin supplementation:				
NE-W	475.28±11.45	1122.50±32.77	1625.00±19.84	20.53±0.42
NE-A	476.67±10.90	1123.33±26.96	1699.72±32.09	21.84±0.56
NE-E	474.12±10.21	1135.29±22.97	1800.00±28.76	23.68±0.56
HE-W	478.24±12.37	1137.65±31.84	1755.29±25.68	22.80±0.46
HE-A	484.12±10.21	1182.35±26.00	1802.94±24.85	23.55±0.46
HE-E	476.39±10.77	1250.28±14.07	1945.28±26.14	26.23±0.46
Significance	NS	NS	NS	NS
Interaction between dietary protein level, energy level and vitamin supplementation::				
NP-NE-W	481.11±16.02	1065.00±43.25	1565.56±18.88	19.37±0.34
NP-NE-A	476.11±16.95	1066.67±33.69	1585.56±22.84	19.81±0.30
NP-NE-E	477.50±15.47	1126.25±29.26	1710.63±34.21	22.02±0.75
NP-HE-W	485.00±17.06	1097.78±46.17	1741.11±37.10	22.43±0.67
NP-HE-A	488.13±16.90	1184.38±36.18	1762.50±33.63	22.76±0.76
NP-HE-E	473.33±17.56	1228.89±11.93	1874.44±20.15	25.02±0.44
HP-NE-W	469.44±17.09	1180.00±43.21	1684.44±20.82	21.70±0.52
HP-NE-A	477.22±14.75	1180.00±33.94	1813.89±24.43	23.87±0.46
HP-NE-E	471.11±14.48	1143.33±35.19	1879.74±23.22	25.15±0.41
HP-HE-W	470.63±18.81	1182.50±40.52	1771.25±36.96	23.23±0.62
HP-HE-A	480.56±12.10	1180.56±39.18	1838.84±33.31	24.25±0.45
HP-HE-E	479.44±13.50	1271.67±24.18	2016.11±35.25	27.44±0.60
Significance	NS	NS	NS	NS

Means in the same column within each classification, bearing the different litters are differ significantly ($P<0.05$), W = Week, NS =Not significant, ** $P<0.01$ and *** $P<0.001$.

Table 3. Daily feed intake (g/day) of rabbits as affected by dietary protein level, energy level and vitamins supplementation and their interactions, at the different experimental periods.

Items	Daily feed intake (g/day)	Feed conversion (g feed/g gain)	Feed cost (LE/rabbit)	Return from gain (LE)	Final margin (LE/rabbit)
Protein level:					
Normal (NP)	122.01	5.576	5.285	8.586	3.301
High (HP)	108.55	4.469	4.966	9.515	4.549
Energy level:					
Normal (NE)	118.88	5.409	5.136	8.619	3.483
High (HE)	111.68	4.609	5.115	9.482	4.367
Vitamin:					
Without (W)	115.92	5.357	5.143	8.500	3.357
Vit. A (A)	114.99	5.072	5.114	8.888	3.774
Vit. E (E)	114.94	4.599	5.119	9.764	4.645
Interaction between dietary protein and energy levels:					
NP-NE	128.67	6.178	5.290	7.997	2.707
NP-HE	118.35	4.987	5.280	9.174	3.894
HP-NE	112.08	4.755	4.981	9.241	4.260
HP-HE	105.02	4.194	4.950	9.789	4.839
Interaction between dietary protein level and vitamin supplementation:					
NP-W	122.58	5.865	5.298	8.193	2.895
NP-A	121.90	5.750	5.283	8.344	3.061
NP-E	121.55	5.148	5.274	9.220	3.946
HP-W	109.25	4.873	4.988	8.806	3.818
HP-A	108.08	4.492	4.946	9.432	4.486
HP-E	108.33	4.119	4.963	10.308	5.345
Interaction between dietary energy level and vitamin supplementation:					
NE-W	119.53	5.822	5.153	8.050	2.897
NE-A	118.53	5.427	5.123	8.562	3.439
NE-E	118.58	5.008	5.132	9.246	4.114
HE-W	112.30	4.925	5.133	8.950	3.817
HE-A	111.45	4.732	5.106	9.214	4.108
HE-E	111.30	4.243	5.106	10.282	5.176
Interaction between dietary protein and energy levels and vitamin supplementation:					
NP-NE-W	126.36	6.523	5.307	7.593	2.286
NP-NE-A	125.50	6.335	5.285	7.766	2.481
NP-NE-E	125.15	5.683	5.277	8.632	3.355
NP-HE-W	118.80	5.296	5.289	8.793	3.504
NP-HE-A	118.30	5.198	5.280	8.922	3.642
NP-HE-E	117.95	4.714	5.271	9.808	4.537
HP-NE-W	112.70	5.194	4.998	8.506	3.508
HP-NE-A	111.55	4.673	4.960	9.357	4.397
HP-NE-E	112.00	4.453	4.986	9.859	4.873
HP-HE-W	105.80	4.554	4.977	9.106	4.129
HP-HE-A	104.60	4.313	4.932	9.506	4.574
HP-HE-E	104.65	3.814	4.940	10.756	5.816

W = Week.

Table 4. Total protein, urea-N and creatinin of rabbits as affected by dietary protein level, energy level and vitamins supplementation and their interactions.

Items	Total protein (g/l)	Albumin (g/l)	Urea-N (mg/dl)	Creatinin (mg/dl)
Protein level:				
Normal (NP)	6.37±0.13	3.64±0.08	28.62±0.47	0.79±0.02
High (HP)	7.20±0.14	4.34±0.07	29.81±0.52	0.87±0.03
Significance	***	***	*	**
Energy level:				
Normal (NE)	6.52±0.13	3.76±0.11	28.73±0.48	0.79±0.02
High (HE)	7.05±0.18	4.22±0.09	29.71±0.53	0.86±0.03
Significance	**	***	NS	**
Vitamin:				
Without (W)	6.46±0.16	3.96±0.15	31.29±0.46^a	0.91±0.03^a
Vit. A (A)	6.74±0.23	3.99±0.15	28.13±0.55^b	0.78±0.03^b
Vit. E (E)	6.97±0.19	4.02±0.12	28.24±0.39^b	0.79±0.02^b
Significance	*	NS	***	***
Interaction between dietary protein and energy levels:				
NP-NE	6.18±0.17	3.38±0.07	28.48±0.67	0.79±0.03^b
NP-HE	6.56±0.18	3.90±0.06	28.77±0.71	0.78±0.02^b
HP-NE	6.86±0.12	4.14±0.09	28.97±0.72	0.79±0.03^b
HP-HE	7.54±0.21	4.53±0.06	30.65±0.69	0.94±0.03^a
Significance	NS	NS	NS	**
Interaction between dietary protein level and vitamin supplementation:				
NP-W	6.13±0.21	3.55±0.14	30.61±0.72	0.87±0.03
NP-A	6.45±0.27	3.66±0.16	27.11±0.50	0.75±0.01
NP-E	6.54±0.17	3.72±0.12	28.15±0.48	0.74±0.01
HP-W	6.74±0.18	4.38±0.08	31.97±0.49	0.96±0.04
HP-A	7.42±0.25	4.32±0.16	29.14±0.81	0.80±0.05
HP-E	7.40±0.24	4.31±0.13	28.32±0.66	0.84±0.04
Significance	NS	NS	NS	NS
Interaction between dietary energy level and vitamin supplementation:				
NE-W	6.21±0.22	3.80±0.26	30.72±0.75	0.89±0.03
NE-A	6.63±0.23	3.69±0.16	27.39±0.60	0.73±0.03
NE-E	6.73±0.19	3.80±0.15	28.07±0.42	0.76±0.01
HE-W	6.71±0.21	4.12±0.14	31.86±0.50	0.94±0.04
HE-A	7.24±0.37	4.29±0.17	28.87±0.86	0.82±0.03
HE-E	7.21±0.32	4.23±0.16	28.40±0.69	0.82±0.05
Significance	NS	NS	NS	NS
Interaction between dietary protein level, energy level and vitamin supplementation:				
NP-NE-W	5.89±0.37	3.26±0.09	29.92±1.32	0.89±0.05
NP-NE-A	6.17±0.28	3.35±0.04	27.06±1.06	0.73±0.02
NP-NE-E	6.49±0.21	3.54±0.17	28.47±0.67	0.76±0.02
NP-HE-W	6.37±0.15	3.83±0.04	31.30±0.59	0.85±0.01
NP-HE-A	6.73±0.47	3.96±0.17	27.17±0.35	0.77±0.01
NP-HE-E	6.59±0.30	3.91±0.09	27.83±0.77	0.73±0.01
HP-NE-W	6.53±0.06	4.35±0.16	31.52±0.65	0.89±0.05
HP-NE-A	7.09±0.06	4.02±0.13	27.72±0.77	0.73±0.07
HP-NE-E	6.98±0.27	4.05±0.12	27.67±0.52	0.76±0.02
HP-HE-W	7.05±0.30	4.42±0.09	32.41±0.76	1.02±0.03
HP-HE-A	7.76±0.45	4.62±0.13	30.56±0.82	0.87±0.05
HP-HE-E	7.82±0.16	4.56±0.09	28.98±1.21	0.92±0.04
Significance	NS	NS	NS	NS

Means in the same column within each classification, bearing the different litters are differ significantly ($P<0.05$), NS =Not significant,* $P<0.05$, ** $P<0.01$ and *** $P<0.001$.

Table 5. Serum transaminase enzymes (AST and ALT), thyroxin and cortisone of rabbits as affected by dietary protein level, energy level and vitamins supplementation and their interactions.

Items	AST (U/l)	ALT (U/l)	T_4 (μ/dl)	Cortisone (mg/dl)
Protein level:				
Normal (NP)	25.44±0.54	19.74±0.69	2.83±0.14	19.40±0.67
High (HP)	26.56±0.55	15.22±0.43	3.29±0.14	15.18±0.65
Significance	NS	NS	***	***
Energy level:				
Normal (NE)	25.37±0.64	14.50±0.53	2.84±0.17	17.60±0.92
High (HE)	26.61±0.43	15.67±0.59	3.28±0.11	16.98±0.73
Significance	NS	NS	***	NS
Vitamin:				
Without (W)	26.25±0.63	13.83±0.60	2.48±0.11^{c}	20.24±0.86^{c}
Vit. A (A)	26.25±0.54	15.25±0.74	3.20±0.17^{b}	15.76±0.96^{b}
Vit. E (E)	25.50±0.87	16.17±0.63	3.50±0.13^{a}	15.87±0.62^{a}
Significance	NS	*	***	***
Interaction between dietary protein and energy levels:				
NP-NE	24.89±0.96	14.11±0.98	2.50±0.19^{b}	19.74±1.15
NP-HE	26.00±0.50	15.78±0.95	3.16±0.14^{a}	19.05±0.76
HP-NE	25.89±0.86	14.89±0.45	3.19±0.23^{a}	15.46±1.06
HP-HE	27.22±0.66	15.56±0.75	3.40±0.17^{a}	14.90±0.79
Significance	NS	NS	*	NS
Interaction between dietary protein level and vitamin supplementation:				
NP-W	25.50±0.92	12.67±0.67	2.43±0.17	22.40±0.98^{a}
NP-A	25.83±0.70	14.50±1.12	2.82±0.25	18.88±0.23^{b}
NP-E	25.00±1.26	17.67±0.80	3.24±0.20	16.91±0.72^{b}
HP-W	27.00±0.82	15.00±0.77	2.54±0.15	18.08±0.62^{b}
HP-A	26.67±0.84	16.00±0.97	3.58±0.09	12.63±0.36^{d}
HP-E	26.00±1.26	14.67±0.42	3.76±0.06	14.84±0.86^{c}
Significance	NS	**	NS	NS
Interaction between dietary energy level and vitamin supplementation:				
NE-W	26.33±1.20	13.50±0.89	2.25±0.17	21.07±1.35
NE-A	26.17±0.79	14.00±0.82	2.92±0.29	15.88±1.48
NE-E	23.67±1.09	16.00±0.86	3.36±0.23	15.85±1.02
HE-W	26.17±0.54	14.17±0.87	2.72±0.06	19.41±1.06
HE-A	26.33±0.80	16.50±1.06	3.48±0.12	15.64±1.38
HE-E	27.33±0.88	16.33±0.99	3.64±0.10	15.90±0.81
Significance	NS	NS	NS	NS
Interaction between dietary protein level, energy level and vitamin supplementation:				
NP-NE-W	24.67±1.76	12.33±1.33	2.17±0.26	23.30±1.81
NP-NE-A	26.33±0.88	13.00±1.00	2.31±0.16	19.13±0.32
NP-NE-E	23.67±2.33	17.00±1.53	3.02±0.37	16.78±1.28
NP-HE-W	26.33±0.67	13.00±0.58	2.68±0.10	21.50±0.84
NP-HE-A	25.33±1.20	16.00±1.73	3.37±0.18	18.62±0.31
NP-HE-E	26.33±0.88	18.33±0.67	3.45±0.13	17.04±0.99
HP-NE-W	28.00±1.15	14.67±0.88	2.33±0.25	18.84±0.90
HP-NE-A	26.00±1.53	15.00±1.15	3.53±0.14	12.62±0.45
HP-NE-E	23.67±0.67	15.00±0.58	3.71±0.11	14.92±1.64
HP-HE-W	26.00±1.00	15.33±1.45	2.76±0.08	17.31±0.75
HP-HE-A	27.33±0.88	17.00±1.53	3.62±0.12	12.65±0.66
HP-HE-E	28.33±1.45	14.33±0.67	3.82±0.06	14.76±1.01
Significance	NS	NS	NS	NS

Means in the same column within each classification, bearing the different litters are differ significantly ($P<0.05$), NS =Not significant, * $P<0.05$, ** $P<0.01$ and *** $P<0.001$.

Table 6. Pre-slaughter live body weight and carcass and non carcass weights (g) of rabbits as affected by dietary protein level, energy level and vitamins supplementation and their interactions.

Items	Pre-slaughter weight	Carcass weight	Liver weight	Kidney weight	Kidney fat weight
Protein level:					
Normal (NP)	2094.4±44.9	1284.6±25.8	65.8±2.6	12.1±0.4	6.0±1.2
High (HP)	2068.9±33.0	1277.8±19.9	67.3±2.8	12.1±0.4	8.5±0.9
Significance	NS	NS	NS	NS	*
Energy level:					
Normal (NE)	2066.7±38.8	1269.7±22.4	67.2±2.8	12.0±0.4	5.3±0.7
High (HE)	2096.7±39.9	1292.7±23.4	65.9±2.6	12.1±0.4	9.2±1.2
Significance	NS	NS	NS	NS	***
Vitamin					
Without (W)	2086.7±54.7	1287.7±32.2	68.5±3.6	12.3±0.6	6.6±1.3
Vit. A (A)	2085.0±55.0	1277.8±31.6	68.5±2.8	12.2±0.3	8.7±1.5
Vit. E (E)	2073.3±34.8	1278.1±20.6	62.6±3.3	11.7±0.5	6.4±1.1
Significance	NS	NS	NS	NS	NS
Interaction between dietary protein and energy levels:					
NP-NE	2064.4±70.9	1261.2±41.2	64.6±3.6	11.9±0.6	4.2±0.9
NP-HE	2124.4±57.5	1307.9±31.4	66.9±3.9	12.2±0.6	7.8±2.1
HP-NE	2068.9±36.8	1278.2±20.4	69.8±4.3	12.1±0.5	6.4±0.9
HP-HE	2068.9±54.2	1277.4±35.7	64.8±3.5	12.1±0.6	10.6±1.1
Significance	NS	NS	NS	NS	NS
Interaction between dietary protein level and vitamin supplementation:					
NP-W	2065.0±104.5	1271.2±61.8	65.8±4.9	12.4±1.1	4.1±0.9 [b]
NP-A	2145.0±85.3	1304.2±48.3	69.7±4.4	12.5±0.3	10.5±2.7 [a]
NP-E	2073.3±39.6	1278.3±22.3	62.0±4.5	11.3±0.5	3.5±0.9 [b]
HP-W	2108.3±45.2	1304.2±25.3	71.3±5.4	12.3±0.5	9.1±2.0 [a]
HP-A	2025.0±67.7	1251.5±42.2	67.4±3.9	11.9±0.6	7.0±1.1 [ab]
HP-E	2073.3±61.5	1277.8±37.0	63.3±5.1	12.1±0.9	9.4±1.2 [a]
Significance	NS	NS	NS	NS	***
Interaction between dietary energy level and vitamin supplementation:					
NE-W	1976.7±77.5	1222.2±47.3	63.8±4.9	12.1±0.9	3.9±0.8
NE-A	2133.3±64.2	1298.8±36.2	72.3±2.8	12.5±0.3	5.8±0.7
NE-E	2090.0±50.8	1288.2±29.8	65.6±6.3	11.4±0.5	6.3±1.7
HE-W	2196.7±48.1	1353.2±24.8	73.3±4.8	12.5±0.8	9.3±2.0
HE-A	2036.7±90.8	1256.8±54.0	64.7±4.7	11.9±0.5	11.7±2.4
HE-E	2056.7±51.5	1268.0±30.6	59.6±1.9	12.0±0.9	6.5±1.7
Significance	NS	NS	NS	NS	NS
Interaction between dietary protein level, energy level and vitamin supplementation:					
NP-NE-W	1893.3±146.2	1172.3±90.8	59.2±4.6	12.1±1.7	2.7±0.9
NP-NE-A	2160.0±128.6	1298.3±76.6	70.6±4.0	11.9±0.3	5.9±1.4
NP-NE-E	2140.0±20.0	1313.0±16.8	64.1±9.2	11.7±1.0	4.1±2.0
NP-HE-W	2236.7±61.7	1370.0±32.6	72.4±7.6	12.6±1.7	5.5±1.2
NP-HE-A	2130.0±140.1	1310.0±75.9	68.7±8.9	12.9±0.1	14.9±3.6
NP-HE-E	2006.7±54.6	1243.7±31.5	59.8±3.2	11.0±0.5	2.9±0.4
HP-NE-W	2060.0±41.6	1272.0±21.0	68.4±9.0	12.1±1.1	5.1±1.0
HP-NE-A	2106.7±58.1	1299.3±25.7	74.0±4.4	12.9±0.4	5.6±0.5
HP-NE-E	2040.0±100.0	1263.3±59.6	67.1±10.4	11.2±0.6	8.5±0.5
HP-HE-W	2156.7±78.4	1336.3±41.5	74.3±7.5	12.4±0.4	13.2±1.7
HP-HE-A	1943.3±113.5	1203.7±77.2	60.8±3.6	10.8±0.5	8.4±2.0
HP-HE-E	2106.7±88.2	1292.3±55.5	59.5±2.9	12.9±1.6	10.2±1.1
Significance	NS	NS	NS	NS	NS

Means in the same column within each classification, bearing the different litters are differ significantly ($P<0.05$), NS =Not significant, * $P<0.05$, ** $P<0.01$ and *** $P<0.001$.

Table 7. Carcass cuts weight of rabbits as affected by dietary protein level, energy level and vitamins supplementation and their interactions.

Items	Head weight	Fore part weight	Intermediate part weight	Hind part weight	Prime cuts weight
Protein level:					
Normal (NP)	130.0±3.8	289.2±8.2	370.6±8.4	411.1±9.0	781.7±16.7
High (HP)	130.0±2.3	283.9±5.5	365.0±7.1	411.1±7.0	776.1±13.1
Significance	NS	NS	NS	NS	NS
Energy level:					
Normal (NE)	130.0±3.1	280.3±5.8	367.2±7.8	407.8±8.6	775.0±15.6
High (HE)	130.0±3.1	292.8±7.8	368.3±7.8	414.4±7.4	782.8±14.4
Significance	NS	NS	NS	NS	NS
Vitamin					
Without (W)	133.3±3.6	285.4±9.2	372.5±10.3	409.2±11.6	781.7±21.1
Vit. A (A)	122.5±4.1	285.8±11.0	369.2±7.2	410.8±9.7	780.0±18.5
Vit. E (E)	134.2±2.9	288.3±4.4	361.7±9.3	413.3±8.6	775.0±16.0
Significance	NS	NS	NS	NS	NS
Interaction between dietary protein and energy levels:					
NP-NE	131.1±5.9	279.4±11.3	365.6±13.0	404.4±15.6	770.0±27.7
NP-HE	128.9±5.1	298.9±11.5	375.6±11.2	417.8±9.4	793.3±19.6
HP-NE	128.9±2.6	291.1±3.5	368.9±9.4	411.1±8.1	780.0±16.2
HP-HE	131.1±3.9	286.7±10.7	361.1±11.0	411.1±11.9	772.2±21.7
Significance	NS	NS	NS	NS	NS
Interaction between dietary protein level and vitamin supplementation:					
NP-W	135.0±6.2	284.2±17.3	368.3±19.2	401.7±22.1	770.0±40.9
NP-A	118.3±7.5	295.0±18.2	378.3±14.0	420.0±14.4	798.3±27.9
NP-E	136.7±3.3	288.3±6.0	365.0±11.8	411.7±9.8	776.7±17.1
HP-W	131.7±4.0	286.7±8.4	376.7±9.5	416.7±8.8	793.3±14.8
HP-A	126.7±3.3	276.7±13.1	360.0±11.8	401.7±13.0	761.7±24.6
HP-E	131.7±4.8	288.3±7.0	358.3±15.4	415.0±15.0	773.3±28.9
Significance	NS	NS	NS	NS	NS
Interaction between dietary energy level and vitamin supplementation:					
NE-W	135.0±6.2	265.8±11.3	353.3±15.9	388.3±17.8	741.7±31.9
NE-A	123.3±5.6	286.7±11.2	376.7±11.2	421.7±13.0	798.3±23.9
NE-E	131.7±4.0	288.3±4.7	371.7±13.5	413.3±12.0	785.0±23.2
HE-W	131.7±4.0	305.0±9.6	391.7± 8.3	430.0±10.0	821.7±17.0
HE-A	121.7±6.5	285.0±2.3	361.7±14.9	400.0±13.9	761.7±28.6
HE-E	136.7±4.2	288.3±7.9	351.7±12.5	413.3±13.3	765.0±23.5
Significance	NS	NS	NS	NS	NS
Interaction between dietary protein level, energy level and vitamin supplementation:					
NP-NE-W	140.0±11.6	258.3±23.2	333.3±23.3	366.7±32.8	700.0±55.7
NP-NE-A	120.0±11.6	286.7±24.0	376.7±23.3	426.7±26.0	803.3±49.1
NP-NE-E	133.3±6.7	293.3±8.8	386.7±12.0	420.0±10.0	806.7±30.0
NP-HE-W	130.0±5.8	310.0±17.3	403.3±8.8	436.7±12.0	840.0±20.0
NP-HE-A	116.7±12.0	303.3±31.8	380.0±20.8	413.3±17.6	793.3±38.4
NP-HE-E	140.0±0.01	283.3±8.8	343.3±8.8	403.3±17.6	746.7±23.3
HP-NE-W	130.0±5.8	273.3±6.7	373.3±17.6	410.0± 5.8	783.3±16.7
HP-NE-A	126.7±3.3	286.7±6.7	376.7±8.8	416.7±12.0	793.3±20.3
HP-NE-E	130.0±5.8	283.3±3.3	356.7±23.3	406.7±24.0	763.3±47.0
HP-HE-W	133.3±6.7	300.0±11.6	380.0±11.6	423.3±17.6	803.3±26.7
HP-HE-A	126.7±6.7	266.7±26.7	343.3±18.6	386.7±21.9	730.0±40.0
HP-HE-E	133.3±8.8	293.3±14.5	360.0±25.2	423.3±21.9	783.3±43.3
Significance	NS	NS	NS	NS	NS

Means in the same column within each classification, bearing the different litters are differ significantly ($P<0.05$), NS =Not significant.

تأثير مستوى البروتين والطاقة فى الغذاء وإضافة الفيتامينات على معدل أداء الأرانب ، تحت الظروف المصرية.

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وقد استخدم فى هذه الدراسة ١٠٨ ذكر أرنب بوسكات عمر ٣٥ يوم وكانت متقاربة فى الوزن الحى فى بداية التجربة. قسمت إلى ١٢ مجموعة فى كل مجموعة ٩ حيوانات وتم تغذية حيوانات الستة مجموعات الأولى على عليقة معتدلة البروتين (١٦,٠%) بينما الستة مجاميع الأخرى تم تغذيتها على عليقة مرتفعة البروتين (١٨%) وتحت كل مستوى فإن الثلاث مجاميع الأولى يتم تغذيتها على عليقة معتدلة الطاقة (٢٥٠٠ كيلو كالورى / كجم) بينما تغذت الثلاث مجموعات الأخرى على عليقة مرتفعة الطاقة بإضافة ٥% زيت من وزن العليقة (٢٨٥٠ كيلو كالورى/ كجم) وتحت كل مستوى من مستويات الطاقة فإن المجموعة الأولى لم تحتوى على إضافات وكانت المجموعة الثانية مضاف إليه الفيتامين (أ) بمعدل (٣٠٠٠ وحدة دولية / كجم علف) بينما كانت المجموعة الثالثة تتناول عليقة مضافاً إليها فيتامين (هـ) بمعدل ٢٥ ملجرام / كجم علف). الوزن الحى عند ٨ أسابيع ومعدل النمو اليومى يزداد معنويا بزيادة مستوى البروتين أو الطاقة فى الغذاء. إضافة فيتامين أ او هـ أدى إلى زيادة معدل النمو للحيوان بمعدل ٤,٧٦ و ١٥,٤٨% على التوالى؛ عن تلك التى تغذت على غذاء غير مضاف إلية فيتامين. الأرانب التى غذيت على غذاء عالى البروتين – عالى الطاقة مضاف إلية فيتامين هـ سجلت أقل تكلفة للغذاء وأعلى عائد من النمو وكذلك أعلى هامش ربح عن باقى المجاميع. مستوى البروتين الكلى والألبيومين واليوريا والكرياتينين والثيروكسين والكورتيزون فى سيرم دم الأرانب تأثر معنويا بمستوى البروتين فى غذاء الأرانب، فى حين مستوى الإنزيمات الناقلة لمجموعة الأمين لم يتأثر معنويا. مستوى البروتين الكلى والألبيومين والثيروكسين يزداد بزيادة مستوى البروتين فى الغذاء بينما مستوى الكورتيزون ينخفض. مستوى البروتين الكلى والألبيومين والكرياتينين والثيروكسين والكورتيزون فى سيرم دم الأرانب تأثر معنويا بمستوى الطاقة فى الغذاء بينما مستوى اليوريا والإنزيمات الناقلة لمجموعة الأمين لم يتأثر معنويا. مستوى البروتين الكلى والألبيومين واليوريا والكرياتينين وALT والثيروكسين والكورتيزون فى سيرم دم الأرانب تأثر معنويا بإضافة الفيتامينات فى غذاء الأرانب. مستوى البروتين الكلى والألبيومين والثيروكسين فى سيرم دم الأرانب يزداد بإضافة فيتامين أ و هـ. صفات الذبحية التى تم دراستها لم تتأثر معنويا بمستوى البروتين والطاقة فى الغذاء وكذلك إضافة الفيتامينات. بينما أظهرت صفة وزن الدهن الكلى تأثر معنويا (عند مستوى ٥% و ١%) بمستوى البروتين والطاقة فى الغذاء.