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# Impact Of Feeding Programs and Oral Administration of Coenzyme Q10 During Fattening Period on The Productive and Physiological Responses of Growing Rabbits.

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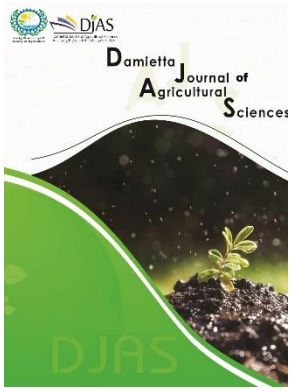


## ABSTRACT

This study was designed to evaluate the role of feeding program (FP) and exogenous coenzyme Q10 (CoQ10) and their interaction on productive performance and some physiological responses in growing rabbits during fattening period. In a 2×3 factorial experiment, 78 weaned NZW rabbits aged 35 days and weighed 663.14 g were randomly assigned to three FP. The first group was fed ad libitum to serve as a first FP1 whereas the second FP group (FP2) received 75% of diet at the morning and 25% of diet at the night; and the third feeding program (FP3) group received 25% of diet at the morning and 75 % of diet at night. Animals of the three previous major groups were split into two subgroups, the first group was kept untreated to serve as a control, while the second subgroup fed orally with 10 mgCoQ10/kg/rabbit. The obtained results illustrated that growing rabbits belong to FP3 group showed significantly ($P < 0.05$) the heaviest averages of all growth parameters compared to those belonging to FP2 and FP1. It was found that oral administration of CoQ10 at a dose of 10 mg/kg body weight significantly increased all productive performance. Rabbits received CoQ10 caused a significant decrease in lipid profile as well as MDA levels and caused a significant increase in total antioxidant capacity. It has been concluded that CoQ10 and either FP2 or FP3 could be suitable management strategy for rabbits during fattening period through improving productive performance and serum blood metabolites and antioxidant status.

*Keywords: Antioxidant, blood, CoQ10, Growing rabbits, productive.*

## INTRODUCTION

Management and nutritional strategies are crucial in rabbit breeding because they can prevent a number of diseases by: (i) using unbalanced diets or toxic compounds in feeds; and (ii) detecting pathogenic agents (bacteria, viruses, and parasites) in drinking water or feeds (Gidenne et al., 2020). So, feed is an important aspect of rabbit production, with the right diet and effective care, meat production can increase.

Besides that, weaning, a critical time for all young animals—are linked to a great deal of stress because of separation from the mother, the transition to a new environment with other partners, and the changes in diet. Young animals are unable to handle this stress, which leads to raised cortisol levels in the bloodstream, immunosuppression, and heightened vulnerability to numerous illnesses (Hoon et al., 2010; Serkan et al., 2012). According to Hoon et al. (2010), weaning is typically a difficult time for young animals, marked by a drop in body weight and growth as well as, in certain situations, an increase in fatality rate.

In the quest for sustainable rabbit's production practices, a growing interest has emerged in exploring the potential benefits of dietary supplements in boosting growth and health, as well as growing rabbits' general performance (El-Kholy et al., 2021; El-Ratel et al., 2023a; Khaleel et al., 2025).

To maintain normal cellular activity in the productive tissues, the energy-intensive manufacturing process also requires a constant supply of adenosine triphosphate (ATP) (Zhang et al., 2023). For biological activity to be at its best, CoQ10 is essential. It is a part of the mitochondrial oxidative phosphorylation process, which transforms the energy in carbs and fatty acids into ATP to power cellular synthesis (Kismali, 2009). Moreover, a large number of functional mitochondria (MIT) are required for the cell meiotic process to supply the energy it requires (May-Panloup et al., 2007). The body's energy level was diminished by inadequate or dysfunctional mitochondria (May-Panloup et al., 2005). Aerobic metabolism produces reactive oxygen species (ROS), a naturally occurring and important part of many physiological processes. MIT is particularly

susceptible to damage because of its closeness to the source of ROS production. Because inadequate respiration raises ROS, which in turn hinders the cell's energy-intensive processes, malfunctioning MIT can create a self-replicating loop (Pritchard et al., 2015). At every stage of life, MIT is necessary for eukaryotic cells to function, and their main purpose is to provide ATP to cells through oxidative phosphorylation (Smith et al., 2005). Abdelrazik et al. (2009) claim that MIT dysfunction may lead to inadequate free radical detoxification, which may result in oxidative damage to macromolecules such as proteins, DNA, and lipids.

Coenzyme Q10 (CoQ10) is a fat-soluble quinone ring molecule that is structurally similar to vitamin K. It is a powerful free radical scavenger and an antioxidant part of the mitochondrial respiratory chain in a range of body tissues (Hernandez-Camacho et al. 2018). As a result, numerous studies have demonstrated that dietary CoQ10 supplementation improves the physiological responses and performance of a variety of animals, such as quails (Bayril et al., 2020; Irani et al., 2023), broilers (Geng et al., 2007; Fathi, 2015), and rats (El-Laithy et al., 2018; Couto et al., 2021). To the best of our knowledge, there are conflicting and very few research on the addition of CoQ10 to rabbit diets throughout the fattening period in Egypt. Thus, the current study sets out to examine the effects of three feeding schedules and three weekly oral doses of coenzyme Q10 on the physiological responses and productive performance of growing NZW rabbits during fattening period.

## MATERIALS AND METHODS

In cooperation with the Faculty of Agriculture at Damietta University in Egypt, this experiment was conducted during the breeding season of January through March 2024 on a private farm close to Kafr Saad in the Damietta Governorate.

**Ethical approval**

Following the standards published by the National Institutes of Health for the Care and Use of Laboratory Animals and "Animal Research: Reporting of In Vivo Experiments" (ARRIVE) (https://arriveguidelines.org), this study was conducted. Without needless suffering, the experiment's rabbits received the right attention and care.

**Experimental design**

In a 2 × 3 factorial experiment, 78 weaned New Zealand White (NZW) rabbits aged 35 days and weighed 663.14 ± 4.19 g were randomly assigned to three feeding programs, each with 26 rabbits in each group. The first group was fed ad libitum to serve as a first FP (FP1) whereas the second FP group (FP2) received 75% of diet at the morning and 25% of diet at the night; and the third feeding program (FP3) group received 25% of diet at the morning and 75 % of diet at night. Animals of the three previous major groups were split into two subgroups, the first group received a commercial pelleted diet according to NRC (1977) recommendations (Table 1) and was kept untreated to serve as a control, while the second subgroup fed orally with 10 mg/ Kg LBW/dose thrice weekly CoQ10 (MEPACO Arab Company, Cairo, Egypt) /kg diet.

**Table 1: Ingredient and nutrient composition of basal diet.**

| **Ingredients** | **(%)** |
|---|---|
| Yellow corn | 9 |
| Barley | 15 |
| Wheat bran | 30 |
| Soybean meal (44%) | 8 |
| Alfalfa hay | 35 |
| Di-calcium phosphate | 1.2 |
| Limestone | 1.0 |
| Salt | 0.5 |
| Premix [1] | 0.3 |
| **Total** | **100** |
| **Calculated chemical analysis of diets** | |
| Digestible energy (kcal/kg) | 2732 |
| Crude protein % | 16.52 |
| Crude fiber % | 13.18 |
| Ether extract % | 2.96 |
| Calcium% | 1.23 |
| Phosphorus% | 0.81 |
| Available phosphorus% | 0.53 |
| Lysine% | 0.78 |
| Methionine% | 0.33 |

[1]One kilogram of mineral–vitamin premix provided: Vitamin A, 150,000 UI; Vitamin E, 100 mg; Vitamin K3, 21mg; Vitamin B1, 10 mg; VitaminB2, 40mg; Vitamin B6, 15mg; Pantothenic acid, 100 mg; Vitamin B12, 0.1mg; Niacin, 200 mg; Folic acid, 10mg; Biotin, 0.5mg; Choline chloride, 5000 mg; Fe, 0.3mg; Mn, 600 mg; Cu, 50 mg; Co, 2 mg; Se, 1mg; and Zn, 450mg. 2 Calculated according to NRC (1977).

**Management:**

All of the experimental rabbits were housed in the same sanitary and managemental circumstances and were clinically free of both internal and exterior parasites. The rabbits were kept in 45 x 36 × 36 cm wire floor cells that had automated nipple drinkers and feeders installed. Every animal was kept in a same sanitary environment. The rabbits were kept in a block building with good ventilation. Exhaust fans were used to circulate fresh air throughout the facility. The rabbits were kept in an 8-hour dark and 16-hour light cycle. The rabbits were never given any kind of systematic immunization or therapy, and the incidence of harmful diseases was mainly prevented.

**Productive traits :**

Weekly averages of each rabbit's daily feed intake (FI, g/d) and weight gain (ADG, g/d) were recorded throughout the growing season (from the weaning age up to the marketing age at 13 weeks). The ratio of g gain to g feed was used to compute the feed conversion ratio (FCR, g/g). Sex-growing rabbits from each experimental group were randomly selected for slaughter at the conclusion of the trial, following a 12-hour fast. The heart, liver, kidneys, spleen, and carcass were weighed following full bleeding. The ratio of carcass weight values to their corresponding pre-slaughter (live body) weight values is known as the carcass percentage.

**Blood sampling and analyses:**

Three rabbits per treatment were chosen at random at the conclusion of the experiment, fasted for the whole night, and used for blood analysis. Ethylene diamine tetra acetic acid (EDTA)-treated tubes for hematological analysis and EDTA-free tubes for serum biochemical evaluation were used to collect blood samples during slaughter. Pack cell volume (PCV), hemoglobin (Hb), red blood cell (RBC), white blood cell (WBC), and white differential counts—which comprise the percentages of neutrophils, lymphocytes, monocytes, eosinophils, and basophils—are among the hematological indices that were calculated. While the improved Neubauer haematocytometer and cyanomethemoglobin were used to assess WBC, RBC, and Hb, respectively, the micro hematocrit technique was used to determine PCV (Marjory et al., 2022).

Blood samples intended for serum chemistry were gathered and placed in anticoagulant-free vials. The serum was carefully separated after centrifugation (T32c; Janetzki, Wallhausen, Germany) at 3000 rpm for 20 minutes and then stored in 1.5 mL Eppendorf tubes, which were then frozen at -20 oC until hormonal and blood analysis tests were conducted. Serum triiodothyronine (T3) concentrations were measured using the radio-immuno-assay technique with coated-tube kits and hormones labeled with I125 (Diagnostic Products Corporation, Los Angles, USA). Using commercial kits from Bio-Merieux Laboratory Reagents and Products (France), colorimetric methods were used to quantify serum total protein (TP), albumin (Alb), aspartate aminotransferase (AST), and alanine aminotransferase (ALT). The globulin values (Glb) were calculated by subtracting the albumin values from the corresponding total protein values. The levels of total lipid, cholesterol, triglycerides (TG), low-density lipoproteins (LDL), and high-density lipoproteins (HDL) were measured using a calorimetric assay after the frozen blood had thawed using commercial kits manufactured by Biodiagnostic Co. in Cairo, Egypt. Commercial kits manufactured by Biodiagnostic Co. in Cairo, Egypt, were also used to measure the levels of creatinine and serum urea-N. According to the manufacturer's recommendations, tests for serum total antioxidant capacity (TAC) and malondialdehyde (MDA) were conducted (Biodiagnostic, Egypt).

**Statistical analysis:**

Data of productive performance and blood analysis were statistically analyzed according to SPSS for Windows (v.16.0., SPSS Inc., Chicago, IL, USA) computer program using the following fixed model :-

$$Y_{ijk}=\mu+FP_i + T_j + FP\times T_{ij} + e_{ijk}$$

Where: $Y_{ijk}$ = Observation of the $ij^{th}$ rabbit; $\mu$ = Overall mean, common element to all observations; $FP_i$ = Effect of the feeding programs (i = 1, 2 and 3); $T_j$ = Effect of CoQ10 treatment (j = 1 and 2); $FP\times T_{ij}$ = Interaction effect between $FP^{th}$ feeding program and $T^{th}$ CoQ10 treatment; $e_{ijk}$ = Random error component assumed to be normally distributed. Duncan's New Multiple Range Test (Duncan, 1955) was used to test mean differences.

## RESULTS:

**1. Growth performance:**

**1-1. Effect of feeding program (FP):**

Table 2 shows that FP significantly ($P<0.05$) affect FBW, BWG, FI and FCR. Growing rabbits belongs to FP3 group showed significantly ($P < 0.05$) the heaviest averages of FBW and BWG in compared to those belongs to FP2 and FP1. The improvement in FP3 and FP2 for FBW; BWG and FCR were 7.8 and 5.0%; 11.3 and 8.2%; 3.8 and 2.5; respectively in compared to FP1. It's interesting to see that growing rabbits in FP2 and FP3 had the highest values of FI compared to FP1. Also, Table 2 shows insignificant ($P>0.05$) differences in FI between FP2 and FP3. The lowest values of FCR were shown in PF2 and PF3 compared to FP1.

**1-2. Effect of CoQ10:**

Growing rabbit treated with CoQ10 showed significantly ($P<0.05$) higher value of FBW, BWG and FI than control group (Table 2). The improvement in FBW, BWG and FI due to dietary addition of CoQ10 were 2.3, 3.2 and 1.9% in compared to control group (Table 2). Dietary addition of CoQ10 shows insignificant and significant differences in FCR (Table, 2). Overall fattening period, the improvement of FCR was 1.6% because of CoQ10 in compared to control group. (Table 5).

**1-3. Effect of interaction:**

The interaction effect between FP and CoQ10 on FBW, BWG, FI and FCR was significant ($P<0.01$; Table 2). The growing NZW rabbits in FP3 either CoQ10 treated or non-treated had the highest values of FBW, BWG and FI compared to the other interaction groups. The growing NZW rabbits in FP3 and treated with CoQ10 had the best value of FCR.

2- Carcass characteristics:

2-1. Effect of feeding program:

Feeding program shows insignificant (P>0.05) differences for all carcass characteristics except for carcass and spleen percentages (Table 3). The highest values of carcass and spleen percentages were shown in PF3 in compared to other FP.

**2-2. Effect of CoQ10:**

Dietary addition of CoQ10 shows insignificant differences in all carcass characteristics except in giblet, total edible and liver % (Table, 3). The highest latest values were shown in CoQ10 treated group compared to control one (Table 3).

**2-3. Effect of interaction:**

Statistically, significant (P<0.05) differences were observed in the interaction between FP and dietary addition of CoQ10 on carcass, giblet, total edible and spleen percentages (Table, 3). In contrast, liver, kidney and heart % were insignificantly (P>0.05) affected by FP and CoQ10 interactions. The growing NZW rabbits in belongs to FP2×T; FP3×C and FP3 × T had the highest values of carcass and total edible% in compared to other interactions with insignificant (P>0.05) differences among them. The growing NZW rabbits in FP3 and treated with CoQ10 had the highest value of spleen% compared to other interactions.

**3- Blood hematology:**

***3-1. Effect of feeding program:***

According to the results obtained in Tables 4 and 5, all blood hematology were non-significant differences among different feeding programs except PCV% and mono.%. The rabbits belong to FP2 and FP3 recorded lower and higher values for PCV% and mono.% than those belongs to FP1, respectively.

***3-2. Effect of CoQ10:***

Rabbit does receive CoQ10 showed a significant increase in Hb, PCV%, RBCs and Lympho% compared to those untreated (control) (Tables 4&5). The results in a Table 8 demonstrate that growing rabbits receive CoQ10 caused a significant (P<0.05) decrease in neuto. Percentage in compared to the control group. Whereas the group that treated with CoQ10 showed insignificant (P>0.05) differences in WBCs, Mono., Eosino. and Basophil percentages in compared to control group.

***3-3. Effect of interaction:***

The effects of interaction between FP × CoQ10 on some blood hematology parameters are shown in Tables 4 & 5. The results indicated that RBCs, Neuto., Lympho., Eosion. and Basophil percentages of rabbits were insignificantly (P>0.05) different in all experimental groups of rabbits. While, significant (P<0.05) differences were observed in the interaction between FP and dietary addition of CoQ10 on Hb, PCV, WBCs and Mono. percentage (Tables, 4&5). Also, it was observed that either FP2 and FP2 × CoQ10 caused a significant (P≤0.05) increased in Hb levels and PCV% in compared to other interactions groups.

Table 7 demonstrate that rabbits received CoQ10 caused a significant (P<0.05) decrease in serum total lipids, cholesterol, triglyceride and LDL levels compared to the control group. Whereas the group that treated CoQ10 showed a significant (P<0.05) increase in serum HDL level in compared to control group.

***4-3. Effect of interaction:***

The effects of interaction between FP × CoQ10 on some blood biochemical parameters and liver enzymes are given in Tables 6, 7 & 8. The results indicated that globulin LDL, creatinine, Urea-N, AST and ALT of rabbits were insignificantly (P>0.05) different in all experimental groups of rabbits. Also, it was observed that FP × CoQ10 caused a significant (P≤0.05) difference in serum total lipids, cholesterol, triglyceride and HDL levels. It is so clear that dietary CoQ10 addition in FP1, FP2 and FP3 recorded the best values for TP and Alb compared to FP1 × C group. Also, both FP2 and FP3 × CoQ10 recorded the best values (lowest) lipids profile in compared to other interactions groups.

**5- Antioxidant status and triiodothyronine hormone:**

***5-1. Effect of feeding program:***

Antioxidant status as affected by feeding programs is shown in Table 9. The FP for rabbit does did not significantly affect TAC and MDA (Table 9)

***5-2. Effect of CoQ10:***

The blood antioxidants profile of does was significantly influenced by oral CoQ10 administration (Table 9). Investigations showed that the TAC and MDA levels significantly (P<0.05) increased and decreased, respectively in compared to that of the control group. The improvement values due to oral CoQ10 administration were 27 and 37% for TAC and MDA, respectively.

***5-3. Effect of interaction:***

The interaction between FP and CoQ10 was highly significant (P<0.01) affected all studied serum levels of antioxidant markers (Table 9). It was noticed that Coenzyme Q10 supplementation and its interactions with the three-feeding program had significant (P<0.05) highest TAC and lowest MDA values compared to other interaction groups (Table 9).

**Table 2. Growth performance of NZW growing rabbits as affected by different feeding programs and CoQ10 administration.**

| Items | Growth performance | | | | |
|---|---|---|---|---|---|
| | Initial body weight (g) | Final body weight (g) | Body weight gain (g) | Feed intake (g) | FCR (g/g) |
| Effect of feeding program (FP): | | | | | |
| FP 1 | 664.23±8.24 | 2134.00 $^{c}$±11.19 | 26.21$^{c}$±0.22 | 83.29$^{b}$±0.70 | 3.18$^{a}$±0.03 |
| FP 2 | 657.50±6.32 | 2241.46 $^{b}$±12.62 | 28.36$^{b}$±0.21 | 87.95$^{a}$±0.29 | 3.10$^{b}$±0.02 |
| FP 3 | 667.69±5.23 | 2300.96 $^{a}$±7.03 | 29.17$^{a}$±0.11 | 89.14$^{a}$±0.23 | 3.06$^{b}$±0.01 |
| *P*-value | 0.554 | 0.001 | 0.001 | 0.001 | 0.001 |
| Effect of CoQ10 : | | | | | |
| Control (C) | 664.49±5.63 | 2200.41±15.65 | 27.47±0.29 | 85.99±0.69 | 3.14±0.02 |
| Treatment (T) | 661.79±5.33 | 2251.45±11.43 | 28.36±0.19 | 87.60±0.34 | 3.09±0.01 |
| *P*-value | 0.729 | 0.010 | 0.012 | 0.040 | 0.092 |
| Effect of interaction (FB × CoQ10) : | | | | | |
| FP1 × C | 667.69±12.65 | 2100.38 $^{a}$±10.90 | 25.58$^{d}$±0.29 | 81.89$^{d}$±1.21 | 3.20$^{a}$±0.05 |
| FP1 × T | 660.77±10.98 | 2170.42 $^{b}$±14.04 | 26.88$^{c}$±0.30 | 84.81$^{c}$±0.26 | 3.16$^{ab}$±0.03 |
| FP2 × C | 659.23±9.74 | 2212.73 $^{c}$±21.50 | 27.90$^{b}$±0.36 | 87.17$^{b}$±0.52 | 3.13$^{abc}$±0.03 |
| FP2 × T | 655.77±8.43 | 2265.77 $^{d}$±11.42 | 28.75$^{a}$±0.17 | 88.61$^{ab}$±0.17 | 3.08$^{bc}$±0.02 |
| FP3 × C | 666.54±6.56 | 2290.00$^{de}$±11.53 | 28.99$^{a}$±0.19 | 89.11$^{a}$±0.39 | 3.07$^{bc}$±0.02 |
| FP3× T | 668.85±8.42 | 2311.92 $^{e}$±7.28 | 29.34$^{a}$±0.12 | 89.18$^{a}$±0.27 | 3.04$^{c}$±0.01 |
| *P*-value | 0.911 | 0.001 | 0.001 | 0.001 | 0.002 |

$^{a, b, c, d, e}$ Means in the same column with different superscripts are significantly different (P<0.05).

**Table 3. Carcass characteristics of growing NZW rabbits as affected by different feeding programs and CoQ10 administration.**

| Items | Carcass characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Live body weight | Carcass % | Giblet% | Total edible% | Liver% | Kidney% | Heart% | Spleen% |
| Effect of feeding program (FP): | | | | | | | | |
| FP 1 | 2075.83±72.63 | 45.05 $^{b}$ ±0.49 | 5.37±0.28 | 50.42$^{b}$±0.74 | 3.81±0.22 | 0.62±0.05 | 0.39±0.02 | 0.56$^{b}$±0.02 |
| FP 2 | 2153.33±38.72 | 47.13 $^{ab}$ ±0.98 | 5.38±0.30 | 52.51$^{ab}$±1.05 | 3.80±0.22 | 0.62±0.10 | 0.35±0.01 | 0.61$^{b}$±0.04 |
| FP 3 | 2235.00±38.82 | 48.25 $^{a}$ ±0.59 | 6.10±0.27 | 54.35$^{a}$±0.39 | 4.17±0.22 | 0.69±0.04 | 0.37±0.02 | 0.87$^{a}$±0.11 |
| *P*-value | 0.135 | 0.020 | 0.148 | 0.010 | 0.410 | 0.700 | 0.267 | 0.015 |
| Effect of CoQ10 : | | | | | | | | |
| Control (C) | 2123.33±40.93 | 46.17±0.80 | 5.14±0.18 | 51.31±0.89 | 3.62±0.13 | 0.58±0.06 | 0.36±0.02 | 0.59±0.03 |
| Treatment (T) | 2186.11±50.85 | 47.45±0.58 | 6.10±0.20 | 53.54±0.54 | 4.24±0.16 | 0.70±0.02 | 0.38±0.01 | 0.78±0.09 |
| *P*-value | 0.350 | 0.214 | 0.003 | 0.048 | 0.009 | 0.079 | 0.412 | 0.056 |
| Effect of interaction (FB × CoQ10) : | | | | | | | | |
| FP1 × C | 2013.33±84.77 | 44.22 $^{c}$ ±0.23 | 4.76$^{d}$±0.10 | 48.99$^{c}$±0.33 | 3.34$^{b}$±0.06 | 0.52±0.03 | 0.39±0.04 | 0.52$^{b}$±0.03 |
| FP1 × T | 2138.33±123.64 | 45.87 $^{bc}$ ±0.68 | 5.99$^{ab}$±0.12 | 51.86$^{b}$±0.76 | 4.27$^{a}$±0.11 | 0.71±0.02 | 0.39±0.01 | 0.60$^{b}$±0.01 |
| FP2 × C | 2188.33±51.83 | 45.17 $^{c}$ ±0.90 | 5.05$^{cd}$±0.41 | 50.22$^{c}$±0.54 | 3.65$^{ab}$±0.29 | 0.50±0.17 | 0.35±0.03 | 0.54$^{b}$±0.04 |
| FP2 × T | 2118.33±59.88 | 49.08 $^{a}$ ±0.35 | 5.71$^{abc}$±0.42 | 54.79$^{a}$±0.24 | 3.95$^{ab}$±0.38 | 0.73±0.06 | 0.35±0.02 | 0.68$^{b}$±0.02 |
| FP3 × C | 2168.33±32.45 | 49.11 $^{a}$ ±0.26 | 5.60$^{bcd}$±0.19 | 54.72$^{a}$±0.28 | 3.86$^{ab}$±0.21 | 0.710±.07 | 0.34±0.03 | 0.70$^{b}$±0.05 |
| FP3× T | 2301.66±45.12 | 47.39 $^{ab}$ ±0.97 | 6.59$^{a}$±0.28 | 53.98$^{a}$±0.74 | 4.49$^{a}$±0.30 | 0.66±0.04 | 0.39±0.04 | 1.05$^{a}$±0.18 |
| *P*-value | 0.214 | 0.001 | 0.008 | 0.001 | 0.072 | 0.254 | 0.564 | 0.005 |

$^{a, b, c, d}$ Means in the same column with different superscripts are significantly different (P<0.05).

**Table 4. Blood hematological values of growing NZW rabbits as affected by different feeding programs and CoQ10 administration.**

| Items | Hb (g/ dl) | PCV (%) | RBCs ($\times10^6$/µl) | WBCs ($\times10^3$/µl) |
|---|---|---|---|---|
| Effect of feeding program (FP): | | | | |
| FP 1 | 10.96±0.28 | 39.18$^{b}$±0.55 | 5.23±0.12 | 4.95±0.28 |
| FP 2 | 11.54±0.41 | 42.30$^{a}$±0.60 | 5.58±0.27 | 4.28±0.15 |
| FP 3 | 11.60±0.33 | 42.30$^{a}$±0.60 | 5.59±0.27 | 4.28±0.17 |
| *P*-value | 0.374 | 0.002 | 0.476 | 0.062 |
| Effect of CoQ10 : | | | | |
| Control(C) | 10.69±0.18 | 40.21±0.59 | 5.17±0.07 | 4.76±0.24 |
| Treated(T) | 12.04±0.15 | 42.31±0.58 | 5.77±0.22 | 4.26±0.09 |
| *P*-value | 0.001 | 0.022 | 0.019 | 0.066 |
| Effect of interaction (FB × C0Q10) : | | | | |
| FP1× C | 10.39$^{c}$±0.23 | 38.10$^{c}$±0.52 | 5.07±0.04 | 5.40$^{a}$±0.40 |
| FP1×T | 11.53$^{ab}$±0.09 | 40.27$^{b}$±0.27 | 5.39±0.22 | 4.50$^{b}$±0.17 |
| FP2×C | 10.78$^{bc}$±0.50 | 41.27$^{b}$±0.54 | 5.21±0.15 | 4.43$^{b}$±0.30 |
| FP2×T | 12.30$^{a}$±0.17 | 43.33$^{a}$±0.65 | 5.95±0.46 | 4.13$^{b}$±0.09 |
| FP3×C | 10.90$^{bc}$±0.12 | 41.27$^{b}$±0.54 | 5.22±0.14 | 4.43$^{b}$±0.33 |
| FP3×T | 12.30$^{a}$±0.17 | 43.33$^{a}$±0.65 | 5.96±0.46 | 4.13$^{b}$±0.08 |
| *P*-value | 0.001 | 0.001 | 0.190 | 0.047 |

[a, b, c] Means in the same column with different superscripts are significantly different (P<0.05).

[1]Hb= hemoglobin; PCV= The packed cell volume; RBCs= red blood cells; WBCs= while blood cells.

**Table 5. White blood cells differential values of growing NZW rabbits as affected by different feeding programs and CoQ10 administration.**

| Items | White Blood Cells Differential[1] | | | | |
|---|---|---|---|---|---|
| | Neutro. (%) | Lympho. (%) | Mono. (%) | Eosino. (%) | Basophil (%) |
| Feeding program (FP) | | | | | |
| FP 1 | 49.33±1.94 | 40.33±2.40 | 5.67$^{a}$±0.56 | 3.67±0.21 | 1.00±0.00 |
| FP 2 | 53.67±1.28 | 38.67±1.45 | 4.16$^{b}$±0.31 | 2.83±0.31 | 0.67±0.21 |
| FP 3 | 52.17±1.80 | 40.00±2.08 | 4.33$^{b}$±0.33 | 2.83±0.31 | 0.67±0.21 |
| *P*-value | 0.220 | 0.828 | 0.043 | 0.082 | 0.315 |
| Effect of CoQ10 : | | | | | |
| Control (C) | 53.67±1.35 | 37.00±1.44 | 5.22±0.43 | 3.33±0.29 | 0.78±0.15 |
| Treated (T) | 49.78±1.28 | 42.33±1.17 | 4.22±0.28 | 2.89±0.20 | 0.78±0.15 |
| *P*-value | 0.053 | 0.011 | 0.070 | 0.224 | 1.000 |
| Effect of interaction (FB × CoQ10) : | | | | | |
| FP1 × C | 51.00±3.61 | 37.33±4.10 | 6.67$^{a}$±0.67 | 4.00±0.00 | 1.00±0.00 |
| FP1 × T | 47.67±1.76 | 43.33±1.76 | 4.67$^{b}$±0.33 | 3.33±3.33 | 1.00±0.00 |
| FP2 × C | 54.00±1.15 | 38.00±2.31 | 4.33$^{b}$±0.33 | 3.00±0.58 | 0.66±0.33 |
| FP2 × T | 53.33±2.60 | 39.33±2.19 | 4.00$^{b}$±0.58 | 2.67±0.33 | 0.66±0.33 |
| FP3 × C | 56.00±1.15 | 35.67±1.20 | 4.67$^{b}$±0.33 | 3.00±0.58 | 0.66±0.33 |
| FP3× T | 48.33±0.33 | 44.33±1.20 | 4.00$^{b}$±0.58 | 2.66±0.33 | 0.66±0.33 |
| *P*-value | 0.085 | 0.126 | 0.020 | 0.258 | 0.840 |

[a, b] Means in the same column with different superscripts are significantly different (P<0.05).

[1]Neutro.=Neutrophils; Lympho.= Lymphocytes; Mono.= Monocytes; Eosino.= Eosinophils; Baso.= Basophil.

**Table 6. Plasma total protein and its fractions in growing NZW rabbits as affected by different feeding program and CoQ10 administration.**

| Items | Total protein and its fractions : | | |
|---|---|---|---|
| | Total protein (TP, g/dl) | Albumin (Alb, g/dl) | Globulin (Glb, g/dl) |
| Effect of feeding program (FP): | | | |
| FP 1 | 5.95$^{b}$±0.13 | 3.02$^{b}$±0.07 | 2.93±0.07 |
| FP 2 | 6.43$^{a}$±0.10 | 3.22$^{a}$±0.05 | 3.08±0.04 |
| FP 3 | 6.39$^{a}$±0.10 | 3.34$^{a}$±0.05 | 3.14±0.08 |
| *P*-value | 0.014 | 0.005 | 0.082 |
| Effect of CoQ10 : | | | |
| Control (C) | 6.10±0.11 | 3.17±0.08 | 2.99±0.06 |
| Treatment (T) | 6.41±0.09 | 3.21±0.04 | 3.11±0.05 |
| *P*-value | 0.046 | 0.648 | 0.144 |
| Effect of interaction (FB × CoQ10) : | | | |
| FP1 × C | 5.72$^{b}$±0.08 | 2.89$^{b}$±0.07 | 2.82$^{b}$±0.03 |
| FP1 × T | 6.19$^{a}$±0.14 | 3.15$^{a}$±0.05 | 3.03$^{ab}$±0.10 |
| FP2 × C | 6.37$^{a}$±0.13 | 3.26$^{a}$±0.07 | 3.11$^{a}$±0.05 |
| FP2 × T | 6.49$^{a}$±0.17 | 3.18$^{a}$±0.08 | 3.06$^{ab}$±0.07 |
| FP3 × C | 6.22$^{a}$±0.13 | 3.36$^{a}$±0.07 | 3.04$^{ab}$±0.13 |
| FP3× T | 6.56$^{a}$±0.09 | 3.31$^{a}$±0.08 | 3.24$^{a}$±0.06 |
| *P*-value | 0.006 | 0.007 | 0.066 |

$^{a, b}$ Means in the same column with different superscripts are significantly different (P<0.05).

**Table 7. Serum lipids profile of growing NZW rabbits as affected by different feeding programs and CoQ10 administration.**

| Items | Lipids profile[1] | | | | |
|---|---|---|---|---|---|
| | Total lipids (g/dl) | Cholesterol (mg/dl) | Triglyceride (mg/dl) | HDL (mg/dl)[1] | LDL (mg/dl)[2] |
| Effect of feeding program (FP): | | | | | |
| FP 1 | 306.17$^{a}$±3.48 | 73.16$^{a}$ ±0.68 | 86.83$^{a}$ ±0.85 | 51.94$^{a}$ ±2.31 | 30.10±2.15 |
| FP 2 | 289.85$^{b}$±4.06 | 71.29 $^{ab}$±0.78 | 83.68$^{b}$±0.74 | 42.95$^{b}$±2.48 | 26.33±2.14 |
| FP 3 | 285.33$^{b}$±2.35 | 70.16$^{b}$±0.39 | 83.40$^{b}$±0.71 | 42.24$^{b}$±2.14 | 26.25±2.33 |
| *P*-value | 0.001 | 0.016 | 0.011 | 0.017 | 0.394 |
| Effect of CoQ10 : | | | | | |
| Control (C) | 299.57±3.81 | 72.51±.67 | 85.78±0.65 | 41.06±1.78 | 30.06±0.82 |
| Treatment (T) | 288.00±3.36 | 70.56±.47 | 83.49±0.77 | 50.36±1.73 | 25.06±2.16 |
| *P*-value | 0.037 | 0.030 | 0.037 | 0.002 | 0.046 |
| Effect of interaction (FB × C0A10) : | | | | | |
| FP1 × C | 313.00$^{a}$ ±2.31 | 74.37$^{a}$ ±0.67 | 88.11$^{a}$±0.49 | 56.55$^{a}$±1.80 | 31.05±1.18 |
| FP1 × T | 299.33$^{b}$±2.91 | 71.95$^{bc}$±0.65 | 85.55$^{ab}$±1.33 | 47.34$^{b}$±1.48 | 29.15±4.57 |
| FP2 × C | 297.37$^{bc}$±3.20 | 72.39$^{ab}$±1.21 | 84.90$^{bc}$±.42 | 47.97$^{b}$±1.54 | 29.65±0.76 |
| FP2 × T | 282.33$^{d}$±3.93 | 70.18$^{bc}$±0.67 | 82.45$^{c}$±1.04 | 37.93$^{c}$±1.80 | 23.02±3.36 |
| FP3 × C | 288.33$^{cd}$±1.76 | 70.76$^{bc}$±0.39 | 84.34$^{bc}$±.72 | 46.56$^{b}$±1.05 | 29.49±2.32 |
| FP3× T | 282.33$^{d}$±3.93 | 69.55$^{c}$±0.49 | 82.45$^{c}$±1.04 | 37.93$^{c}$±1.80 | 23.02±3.36 |
| *P*-value | 0.001 | 0.006 | 0.007 | 0.001 | 0.257 |

$^{a, b}$ Means in the same column with different superscripts are significantly different (P<0.05).

[1]HDL= high density lipoprotein; LDL= Low density lipoprotein.

**Table 8. Liver and kidney functions of growing NZW rabbits as affected by different feeding programs and CoQ10 administration.**

| Items | Kidney function | | Liver function[1] | |
|---|---|---|---|---|
| | Creatinine (mg/dl) | Urea-N (mg/dl) | AST (U/l) | ALT (U/l) |
| Effect of feeding program (FP): | | | | |
| FP 1 | 1.03±0.02 | 13.31±0.12 | 22.15±0.32 | 15.51±0.21 |
| FP 2 | 1.07±0.04 | 13.47±0.13 | 21.87±0.19 | 15.32±0.27 |
| FP 3 | 1.08±0.03 | 13.46±0.13 | 21.79±0.23 | 15.49±0.18 |
| *P*-value | 0.532 | 0.632 | 0.588 | 0.810 |
| Effect of CoQ10 : | | | | |
| Control (C) | 1.05±0.02 | 13.38±0.11 | 21.91±0.21 | 15.54±0.21 |
| Treatment (T) | 1.06±0.03 | 13.45±0.09 | 21.96±0.21 | 15.34±0.12 |
| *P*-value | 0.721 | 0.652 | 0.872 | 0.443 |
| Effect of interaction (FB × CoQ10) : | | | | |
| FP1 × C | 1.00±0.02 | 13.25±0.18 | 22.24±0.52 | 15.59±0.38 |
| FP1 × T | 1.05±0.03 | 13.38±0.20 | 22.05±0.48 | 15.42±0.25 |
| FP2 × C | 1.07±0.05 | 13.45±0.23 | 21.82±0.19 | 15.34±0.56 |
| FP2 × T | 1.07±0.07 | 13.48±0.18 | 21.91±0.38 | 15.30±0.25 |
| FP3 × C | 1.08±0.04 | 13.44±0.24 | 21.67±0.33 | 15.68±0.26 |
| FP3× T | 1.07±0.06 | 13.48±0.18 | 21.91±0.38 | 15.30±0.25 |
| *P*-value | 0.886 | 0.955 | 0.933 | 0.947 |

[a, b] Means in the same column with different superscripts are significantly different (P<0.05).

[2]AST= aspartate aminotransferase; ALT = alanine transaminase.

**Table 9. Total antioxidant capacity and malondialdehyde as a markers of oxidative stress and concentration of triiodothyronine in growing NZW rabbit as affected by different feeding program and CoQ10 administration.**

| Items | Oxidative stress markers | | Triiodothyronine ($T_3$, ng/dl) |
|---|---|---|---|
| | MDA[1] (U/l) | TAC[2] (ng/ml) | |
| Effect of feeding program (FP): | | | |
| FP 1 | 1.43±0.13 | 34.07[b]±1.39 | 1.53±0.18 |
| FP 2 | 1.05±0.14 | 37.43[a]±1.11 | 1.82±0.15 |
| FP 3 | 1.01±0.18 | 39.67[a]±0.31 | 1.91±0.16 |
| *P*-value | 0.126 | 0.006 | 0.246 |
| Effect of CoQ10 : | | | |
| Control (C) | 1.40±0.14 | 35.40±1.30 | 1.51±0.08 |
| Treatment(T) | 0.93±0.06 | 38.71±.56 | 1.99±0.14 |
| *P*-value | 0.006 | 0.032 | 0.009 |
| Effect of interaction (FP × C0Q10) : | | | |
| FP1 × C | 1.70±0.11 | 31.33±1.27 | 1.33±.011 |
| FP1 × T | 1.17±0.05 | 36.80±0.78 | 1.72±0.33 |
| FP2 × C | 1.30±0.19 | 35.53±1.52 | 1.57±0.10 |
| FP2 × T | 0.81±0.02 | 39.33±0.50 | 2.08±0.21 |
| FP3 × C | 1.21±0.34 | 39.33±0.52 | 1.64±0.16 |
| FP3× T | 0.80±0.02 | 40.00±0.26 | 2.18±0.15 |
| *P*-value | 0.022 | 0.000 | 0.069 |

[a, b] Means in the same column with different superscripts are significantly different (P<0.05).

[2] MDA = malonaldehyde; TAC = total antioxidant capacity.

## DISCUSSION:

In order to increase productivity in rabbit farms and give breeders some guidance to promote the breeding and spread of this species into various regions of our country, the goal of this work was to study the interaction between feeding programs and dietary additions of CoQ10 on health and some physiological traits and their reflection on the production performance under Egyptian conditions. This was because nutrition and feeding strategies are important in rabbit breeding, not only to optimize production as mentioned by Gidenne et al. (2020). The current results showed that second and third feeding programs (FP2 and FP3) detected higher FBW, BWG, FI, FCR, carcass% and total edible% compared to FP1. The current results are in agreement with those reported by Ojebiyi *et al*. (2015) and Farghly *et al*. (2017) who observed that BW of rabbits on night feeding exceeded those of the day feeding. However, Uhlířoval *et al*. (2015) observed non-significant changes in FBW of growing rabbits due to feeding times.

In the current study, administrating CoQ10 showed pronounced effect on productive response of growing NZW rabbits by increasing FBW and BWG, leading to marked improvement in FCR of treated rabbits in compared to control group (Tables 2-5). Similar findings were found in other studies, such as Ayyat et al. (2024) who added that endogenously generated CoQ10 is presently gaining a lot of interest as a supplement for fast-growing rabbits.

Differences in production performance traits in relation to FP and treatment with CoQ10 were observed in this study and might be as a result of physiological changes that come with improving of hematology and as well as the serum biochemical indices for growing rabbits. The results of present study showed that the divide of rabbit meal into two period (FP2 or FP3) and treated rabbits by CoQ10 administration achieved the best production performance traits compared to other interaction groups. Interestingly, the improvement of litter traits in FP2×T and FP3×T groups was associated with improved antioxidant capacity and lower MDA levels in the same groups, a marker of oxidative stress. Consequently, it is evident that mitochondria play a crucial role in providing energy for embryogenesis. The results of several recent clinical studies suggest that exogenous CoQ10 supplements have antioxidant qualities and may be a potential treatment to reduce oxidative stress (Lee et al., 2022). The protective effect of antioxidants against lipid oxidation in the cell membrane may be the cause of the increase in productive performance in CoQ10 administration (Cao et al., 2023). Furthermore, as young animals are more susceptible to oxidative damage than adults, it is essential for the development of their immune systems (Debier et al., 2005). These results showed that dietary CoQ10 could reverse the negative effects of rabbits during weaning-dependent increases in oxidative stress.

Ayyat et al. (2024) showed that supplemented rabbit diets by 30 mg CoQ10/kg diet increased FBW by 10.43%, DWG by 14.62%, serum total protein by 18.40%, serum ALB by 17.41%, serum globulin with 19.67%, T3 concentration with 5.17, and also FCR improved with 20.19%, Furthermore, ALT concentration in serum decreased with 11.18%, AST decreased with 1.04%, blood urea decreased with 23.72 and serum CREAT decreased with 19.68%. According to Demirci (2014), CoQ10 is a necessary part of the electron transport chain in the mitochondria, which is necessary for the production of ATP.

Generally speaking, the addition of CoQ10 raises total red blood cells, which raises Hb levels. This is because RBCs and Hb have a positive association (Scanes, 2017). The administration of CoQ10 raised hemoglobin levels (within a normal range). This suggests that the addition has a good impact on hematological parameters, the liver, spleen, and other organs such as bone marrow, which is where red blood cells are formed (Marjory et al., 2022). The last phenomena was demonstrated by the markedly higher relative weight of the spleen (Table 4) for treated groups when compared to control groups.

We may also assess the body condition and productivity of rabbits by looking at some of the blood metabolic indicators during the fattening period. Blood measures are also crucial for determining health and metabolism (El-Kholy et al., 2021; El-Ratel et al., 2023a). The current blood parameter concentrations fell within the physiological levels, according to Özkan et al. (2012). The current findings suggest that eating schedules affected blood protein synthesis, transport, and catabolism. According to previous findings, rabbits fed at night had higher amounts of total proteins than those given during the day (Daader et al., 2002). When compared to the control group, where all of the results were within the normal range of blood values in growing rabbits, it is clear from the current data that oral CoQ10 supplementation significantly improved the blood metabolite features. Similar findings were found by Ayyat et al. (2024) who found that feeding growing rabbits a diet supplemented with 30 mg CoQ10 raised their TP, Alb, and Glb levels. Contrary to the present findings, Hamad et al. (2016) shown that oral administration of 10 mg CoQ10/kg LBW of developing rabbits had no discernible influence on TP and its fractions. The results of this study showed that CoQ10 increased HDL while decreasing lipids, TC, and LDL. Interestingly, lower blood triglyceride was associated with lower urea-N, indicating that the energy properties of the blood synchronized the use of N recycling (Abou-Elkhair et al., 2020). Furthermore, Bakhshayeshkaram et al. (2018) showed that patients who received CoQ10 supplements experienced a significant reduction in total cholesterol, LDL, and malondialdehyde (MDA). Sarrible et al. (2025) demonstrated that CoQ10 had no effect on the lipid profile of rats, which is in contrast to the current findings.

According to Abdulhasan et al. (2015), CoQ10 is a vital coenzyme in the production of ATP and is involved in the electron transport chain in the mitochondria. This hypothesis suggests that the current study's dietary supplementation of CoQ10 may improve mitochondrial activity in the growing weaned rabbits, which in turn accounts for a significant ($P<0.05$) rise in FBW and BWG. Additionally, CoQ10 is a potent antioxidant that combats free radicals; according to Silva et al. (2022), its tissue concentration is five to ten times greater than that of the other main lipid-soluble antioxidant. Additionally, it protects DNA and cell membrane stability from oxidative damage brought on by free radicals, aids in the recycling of vitamin E, and maintains healthy energy levels (El-Tohamy et al., 2012). This could account for the significantly ($P<0.05$) higher and lower levels of TAC and MDA in the treated group relative to the control group.

Albumin levels are thought to be a good indicator of an animal's capacity for protein synthesis and storage (El-Ratel et al., 2023b & El-Kholy et al., 2023). Thus, elevated blood total proteins and albumin levels in NZW-treated rabbits relative to control rabbits (Table 7) would indicate improved hepatic function. These findings from the current investigation may help to explain the negligible variations in the AST and ALT activity of the liver function enzymes between treated and control rabbits. Ayyat et al. (2024) found that growing rabbits fed a diet supplemented with 30 mg CoQ10 had lower serum levels of ALT, AST, creatinine, and urea-N, which is in contradiction to the current findings. These findings suggest that rabbits given CoQ10 may have a faster metabolic rate than the control group. Additionally, as seen in Table 12, the increase in protein synthesis seen in those treated with CoQ10 may be the result of increased release of anabolic hormones like triiodothyronine.

The normal activity of liver serum AST and ALT in growing NZW rabbits in the treated group may be due to lower serum levels of MDA in this study, where increased lipid peroxidation led to depression in antioxidant and normal range of liver enzyme activities in compared to control group, according to Al-Rekabi et al. (2019), who showed a negative correlation between serum levels of MDA and serum levels of liver function enzymes. According to earlier research in developing rabbits, the normal range of the liver enzymes (ALT, AST) in the CoQ10 group indicated a potential protective impact of hepatocytes (Ayyat et al., 2024). This could be explained by CoQ10, which stabilizes the plasma membrane of hepatocytes and stops AST and ALT from being delivered to extracellular fluid (Okuyama et al., 1991). Similarly, Al-Rekabi et al. (2019) showed that the endogenous antioxidant enzymes glutathione peroxidase (GPX), catalase (CAT), and superoxide dismutase (SOD) are significantly increased by CoQ10 supplementation. Its direct capacity to scavenge free radicals and lower lipid peroxidation may be the reason for this. Additionally, mice's cellular metabolism, antioxidant capacity, and ability to stop lipid peroxidation were all improved by CoQ10 (Hosseinzadeh et al., 2015). It is a coenzyme for several significant enzymatic steps in the cellular energy production process (Kapoor and Kapoor, 2013) and plays a critical role in the mitochondrial electron transport chain and ATP creation (Abdulhasan et al., 2015). It protects DNA and cell membrane stability from oxidative damage brought on by free radicals, aids in the recycling of vitamin E, and keeps energy levels in check (El-Tohamy et al., 2012). Supplementing CoQ10 may improve mitochondrial function in cells (Bentov et al., 2010). It is well known that taking CoQ10 as a supplement is safe.

On the other hand, the study found that CoQ10 had a negligible influence on the blood creatinine and urea-N levels of growing rabbits, which indicated an improvement in renal function. This conclusion is supported by Hamad et al. (2016), who showed that oral administration of 10 mg CoQ10/kg improved kidney function in developing rabbits. Accordingly, the balance between the production and neutralization of ROS in the biological body system is maintained by the presence of natural antioxidants such TAC and SOD (Lubrano & Balzan, 2015). As a result, CoQ10 is an essential component of the mitochondria's electron transport chain, which is required for ATP synthesis (Demirci, 2014).

According to the current study, the reduction in MDA concentration following coenzyme Q10 treatment suggests a reduction in the hydrolysis of unsaturated fatty acids in biological membranes. The increased concentration of TAC in the rabbit group treated with coenzyme Q10 may be because TAC is an antioxidant and plays a crucial role in scavenging free radicals. Additionally, coenzyme Q10 plays a role in the respiratory chain as one of the compounds necessary for energy production during the electron transfer and oxidative phosphorylation processes. Since 80–90% of coenzyme Q10 in blood serum is in the form of Ubiquinol, which is dissolved in lipoprotein molecules (Bhagavan & Chopra, 2007), it may provide the necessary protection for DNA from the harmful effects of free radicals, including preventing mutations or damage to DNA and cell death (Liu et al., 2016). Coenzyme Q10 also has antioxidant properties due to its composition and content of phenols, its close proximity to unsaturated fatty acids in the cell membrane, and its fat-soluble nature, which inhibits the lipid oxidation process in the cell membrane and keeps the LDL-c proteins present in the blood circulation from oxidation (Awad et al., 2019). These results showed that dietary CoQ10 could reverse the negative effects of rabbit's weaning shock-dependent increases in oxidative stress. Therefore, we recommend that dietary CoQ10 supplementation should be trialed in an actual rabbit production system to test its impact on the productive performance of fattening rabbits.

**Conclusively,** according to the current study's results, rabbits fed either 75% of their diet in the morning and 25% at night, or the third feeding program (FP3), or 25% of their diet at night and 75% at night, had better blood components and comparatively more productive performance than rabbits fed 100% of their diet once a day. Additionally, giving growing rabbits oral coenzyme Q10 three times a week can enhance their antioxidant status and lipid

profiles. This therefore suggests that this nutritional management strategy, in addition to being favourable for the farm economy, will improve rabbit production better than he traditional system currently applied on rabbitries.

## CONFLICTS OF INTEREST:

The authors of this work declare that they have no known conflicts of interest.

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## DATA AVAILABILITY STATEMENT:

Upon reasonable request, the data supporting the study's conclusions can be provided by the corresponding author.

## AUTHORS CONTRIBUTIONS.

M.R., T.E.H.T., K.H.E. developed the concept of the manuscript. All authors checked and confirmed the final revised manuscript.

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## الملخص العربى

### تأثير برامج التغذية وإضافة الإنزيم المساعد Q10 أثناء فترة التسمين على استجابات الأداء الإنتاجي وبعض الخصائص الفسيولوجية للأرانب النامية

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صُممت هذه الدراسة لتقييم دور برنامج التغذية (FP) والإنزيم المساعد الخارجي (CoQ10) Q10 وتداخلهما على الأداء الإنتاجي وبعض الاستجابات الفسيولوجية في الأرانب النامية خلال فترة التسمين. في تجربة فكتورية التصميم 2 × 3، تم توزيع 78 أرنباً أبيض نيوزيلندياً مفطوماً (NZW) يبلغ عمرهم 35 يوماً ويزن 663.14 جم بشكل عشوائي على ثلاثة برامج تغذية. تم تغذية المجموعة الأولى حسب الرغبة "تغذية حرة" لتكون بمثابة برنامج تغذية أولي بينما تلقت المجموعة الثانية من برنامج التغذية 75 (FP2)٪ من النظام الغذائي في الصباح و25٪ من النظام الغذائي في الليل؛ وتلقت المجموعة الثالثة من برنامج التغذية 25 (FP3)٪ من النظام الغذائي في الصباح و75٪ من النظام الغذائي في الليل. تم تقسيم حيوانات المجموعات الرئيسية الثلاث السابقة إلى مجموعتين فرعيتين، تم الاحتفاظ بالمجموعة الأولى دون علاج لتكون بمثابة مجموعة ضابطة، بينما تم تغذية المجموعة الفرعية الثانية عن طريق الفم بـ 10 مللجم من CoQ10 / كجم / جرعة. أظهرت النتائج أن الأرانب النامية التي تنتمي إلى مجموعة FP3 أظهرت أعلى متوسطات لجميع معايير النمو بشكل ملحوظ ($P < 0.05$) مقارنةً بتلك التي تنتمي إلى FP2 و FP1. وُجد أن تناول CoQ10 عن طريق الفم بجرعة 10 ملغم/كغم من وزن الجسم زاد بشكل ملحوظ من الأداء الإنتاجي. تسبب تناول CoQ10 للأرانب في انخفاض ملحوظ في مستوى الدهون ومستويات MDA، كما أدى إلى زيادة ملحوظة في إجمالي قدرة مضادات الأكسدة. وقد خلصت هذه الدراسة إلى أن CoQ10، بالإضافة إلى FP2 أو FP3، يمكن أن تكون استراتيجية مناسبة لإدارة الأرانب خلال فترة التسمين من خلال تحسين الأداء الإنتاجي ومستقلبات الدم وحالة مضادات الأكسدة.