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EFFECT OF DIETARY ENERGY LEVELS WITH OR WITHOUT SELENIUM AND CHOLINE SUPPLEMENTATION ON PERFORMANCE OF BROILER CHICKENS

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SUMMARY

This research was conducted to study the impact of using two levels of ME (recommended (R) and R-150 Kcal/Kg diet) and each with four type of addition (without Se or choline supplementation, 0.1 mg Se/Kg diet in the form of organic Se as Sel-Plex (Se yeast), 0.10% of choline and 0.05 mg Se/Kg diet + 0.05% choline in 2 x 4 factorial arrangement (giving eight dietary treatments) on growth performance of Cobb broiler chickens. Accordingly, a total numbers of 192 one-day old unsexed Cobb broiler chickens were firstly fed a control diet for five days. At six day of age, chicks were randomly allotted to the dietary treatments, birds were divided into eight treatments (24 birds each) and each treatment contained three replicates (eight birds each).

Results obtained could be summarized in the following:

Performance: Chicks fed diet containing recommended level of ME (R)-150 Kcal/Kg diet had significantly higher values of LBW at 41 days and LBWG, FI, GR, PI during the period from 6 to 41 days, while, chicks fed diet containing R had significantly lower values during the same previous periods. Chicks fed R-150 Kcal/Kg had the best FC, CPC and CCR during the period from 25 to 41 days, and those fed R-150 Kcal/Kg had the best CCR during the period from 6 to 41 days. Type of addition and interaction due to level of ME effect X type of addition (experimental treatments) had insignificant effect on LBW, LBWG, FC, CPC, CCR, GR and PI during the periods from 25 to 41 and 6 to 41 days (finisher and over all experimental period). Chicks fed diet containing R with 0.05 mg Se/Kg diet and 0.05% choline had higher value of FI during the period from 6 to 41 days.

Slaughter parameters% and blood constituents: neither level of ME, type of addition nor interaction due to level of ME effect X type of addition had any significant effect on slaughter parameters% and blood constituents except, type of addition with dressing% and bursa, which was significantly affected. Chicks fed diet containing 0.1 mg Se/Kg diet as Sel-Plex had higher value of dressing percentage. Also, interaction due to level of ME effect X type of addition, which was significantly affected of total leucocytes. Chicks fed diet containing R-150 Kcal/Kg diet with 0.1% choline had higher value of total leucocytes at the end of the experiment. GSH-PX activity were significantly ($P \leq 0.01$) affected by level of ME and type of addition, chicks fed 0.1 mg Se/Kg diet as Sel-Plex had higher value of GSH-PX at 41 days.

Chemical composition of broiler meat: Level of ME, type of addition and interaction due to level of ME effect X type of addition had insignificant effect on chemical composition of broiler meat, except, moisture %, which was significantly affected.

Economic efficiency (EEf): EEf values during the period from 6 to 41 days of age improved in chicks fed all experimental diets, except, chicks fed diet containing recommended level of ME with 0.05 mg Se/Kg diet as Sel-Plex plus 0.05% choline (the lowest corresponding values, being 0.126 and 95.74%, respectively), as compared with those fed the control diet. Chicks fed diet 7 (R-150 Kcal/Kg diet plus 0.1% choline) had the best Economic and relative efficiency values being 0.251 and 191.34%, respectively.

It would be concluded that: It can be concluded that, dietary ME can be reduced from the recommended level up to 150 Kcal/Kg diet and supplement these diets with 0.1 mg Se/Kg diet as Sel-Plex or/and 0.1% choline without affecting Cobb broiler performance.

Keywords: energy-selenium-choline-broiler-performance.

Introduction: In Egypt, poultry production has become one of the biggest agriculture industries, and its development is a major goal of broiler producers. Furthermore, feeding cost represents the major parts of total cost in poultry production, especially dietary energy sources and optimal energy level is important for decreasing feed cost per unit of poultry product. Efforts to reduce dietary energy and improving

utilization of common feeds by using some additives have been the subject of much research. Adequate energy intake is very imperative for broiler since any excess of energy consumption is deposited mainly as fat in the body which indicating the wastage of dietary energy. Broiler obesity is normally coupled with lower production and feed efficiency (**Ghaffari et al., 2007**). Moreover, obesity in poultry increases the incidence of reproductive failure, death due to heart diseases and impaired thermoregulation (**Garlich, 1979**). So, we need to provide adequate energy intake to get best performance and economic. The metabolizable energy (ME) content of rations has been decreased over time, a fact that well associate with improved efficiency. Feed additives are essential materials that can improve the efficiency of feed utilization, performance of poultry and immune response to diseases. Vitamins and minerals addition of commercial compound feed as a single or in combination are mostly oriented towards recommendations for addition of choline and selenium.

Selenium (Se) is a dietary essential trace element for broiler nutrition. The broiler chickens requirement for Se have been given as 0.15 ppm (**NRC, 1994**). Se requirement is quite low, while, this level is not related to commercial conditions and physiological functions of poultry production and it seems likely Se requirement for optimal broiler health is much higher (**Li and Sunde, 2016**). The maximum allowed level of Se in the United States is 0.3 ppm, while, the maximum allowed Se inclusion level is 0.5 ppm (**European Commission, 2014**).

Generally, the chemical dietary form of Se is a major determinant of its bioavailability. Selenium has been added to broiler diets namely inorganic sources (sodium selenite, Na_2SeO_3) or (selenate, Na_2SeO_4), or as organic Se derived from yeast (*Saccharomyces cerevisiae*), mainly selenomethionine and analogues (**Burk and Hill, 2015**). Organic Se is a highly available form of Se for chickens than inorganic Se in sodium selenite (**Mahmoud and Edens, 2003**). Organic Se compounds generally have higher efficacy and biological activities, less toxicity compared with inorganic Se (**Briens et al., 2013**), thus varieties of Se-enriched biological products have been commercialized.

Microorganism fermentation with Se technique provides a feasible and economic approach for production of organic Se compounds (**Zhang et al., 2008**). So,

organic sources of Se such as Sel-Plex, a Se yeast have been explored as an alternative to inorganic form in animal diets (**Payne *et al.*, 2005** and **Payne and Southern, 2005**). A number of studies reported that Se supplementation at 0.2-0.3 ppm in the organic form as Sel-Plex provides optimum Se status for broiler growth and development. Organic Se is proven to be an effective diet supplement to meet broiler requirement from this element in various commercial conditions and physiological functions **Papazyan *et al.* (2006)**. In addition, the use of organic Se results in less Se being transferred to the environment through feces and more Se is deposited into body tissues and eggs (**Payne *et al.*, 2005**, **Payne and Southern 2005** and **Utterback *et al.*, 2005**). Advantages of organic Se in the form of Se-yeast for broilers include improvement of growth rate, FCR, lower mortality and drip loss during meat storage **Papazyan *et al.* (2006)**. Se from Se yeast (0.2 mg/ kg) was used more efficiently for performance in high yielding or fast growing broiler chickens (**Upton *et al.*, 2008**).

There are many demonstrations of potential positive impacts of Se supplementation to increase broiler resistance against major pathogens and/or alleviate consequences of environmental stresses (**Dalgaard *et al.*, 2018**). Selenium is a cofactor of large numbers of Se dependent antioxidant enzymes such as glutathione peroxidase (GSH-Px) activities, which protects the cell and membranes from severe oxidation caused by free radicals (**Rotruck *et al.*, 1973** and **Singh *et al.*, 2006**). Furthermore, **Klasing (1998)** reported that chronically severe deficiencies of micronutrients are more debilitating to the development of the immune system than deficiencies of dietary energy and protein.

Choline is an absolutely charged quaternary amine, water soluble nutrient that has been grouped inside the B-complex (no resemblance to the B vitamins) vitamins (**Zeisel *et al.*, 1991**). While, other author has theorized that adequate nutrition requires dietary choline but this nutrient is not a vitamin, its metabolism are more akin to the amino acids than any other class of nutrients (**Garrow, 2007**). **Wu and Davis (2005)** demonstrated that choline chloride (metabolized into choline in the body) is an effective source of choline in the poultry diets (100% bio-available). According to **McDowell (2000)**, poultry requirements for choline are in the range of 300–2000 mg/kg diet. Choline cannot be stored in the body so choline in excess of essential

needs is oxidized to betaine (**Wang *et al.*, 2004**). Betaine has a more pronounced effect when dietary energy and FI are limiting (**Dunsha *et al.*, 2009**). According to **Garrow (2007)**, the oxidation of choline is an energy yielding process.

Choline is an essential nutrient for the poultry and for prevention of perosis in chicken. One of choline functions is to give methyl groups that can also be furnished by methionine, betaine and folate, that act as S-adenosine methionine metabolism, methylation of DNA, RNA, protein and histone as illustrated by **Pillai *et al.* (2006)** and **Dunlevy *et al.* (2006)**. Therefore, the level of choline in the poultry diet can affect the methionine requirement (**Harms *et al.*, 1990**), but choline cannot reduce the need for methionine if the diet does not contain enough choline (**McDevitt *et al.*, 2000**). Choline is important as a constituent of phospholipids in cell membranes, methyl metabolism and hepatic lipid metabolism to prevent fatty liver, cholinergic neurotransmission and precursor acetylcholine (**Workel *et al.*, 1999**). **Finkelstein (2000)** reported that choline interacts with methionine and folate to achieve this one carbon methylation and decrease the amount of homocysteine which be toxic in high levels. In the case of choline deficiency, **Niculescu *et al.* (2006)** reported that modifying the intake of choline nutrients could alter lipid metabolism and methylation.

Information are lacking on the use of choline and/or Se at low level of ME. The present study therefore evaluated effects of Se (Sel-Plex (SP, Alltech Inc., Nicholasville, KY), a Se yeast) and/ or choline as feed additives in broiler diets at low level of ME on performance and some physiological response of broiler chickens.

MATERIALS AND METHODS

This study was carried out at the Poult. Res. Station, Ministry Of Agric. and Land Recl., Regional Councils for Agric. Res. and Extension, Fayoum, Egypt, during the period from Jan. to Feb., 2016. Chemical analyses were performed in the laboratories of Poult. Prod. Dep., Faculty of Agric., Fayoum University according to the methods outlined by **A.O.A.C (1990)**.

This research was conducted to study the impact of using two levels of ME (recommended (R) and R-150 Kcal/Kg diet) and each with four type of addition (without Se or choline supplementation, 0.1 mg Se/Kg diet in the form of organic Se as

Sel-Plex (Se yeast), 0.10% of choline (dry choline chloride (0.167%) product (60% choline) were added to the diets) and 0.05 mg Se/Kg diet + 0.05% choline in 2 x 4 factorial arrangement (giving eight dietary treatments) on growth, feed utilization and Economic efficiency of Cobb broiler chicks. Se yeast as Sel-Plex (Alltech Inc.) contains 1000 mg Se/Kg Sel-Plex and created by the fermentation of yeast (*Saccharomyces cerevisiae*) in a high Se medium.

Accordingly, a total numbers of 192 one-day old unsexed Cobb broiler chickens were originally fed a control diet for five days. Chicks were weighed (individually) to the nearest gram at six days of age (start of experiment), wing banded and randomly allotted to the dietary treatments, birds were divided into eight treatments (24 birds each) and each treatment contained three replicates (eight birds each). Chicks were raised in electrically heated batteries with raised wire mesh floors, and had a free access of mach feed and fresh water from nipple drinkers {2 nipples/cage} throughout the experiment. **The experimental treatments were as follows:**

1. Chicks were fed the control diet (D_1).
2. $D_1 + 0.1$ mg Se /Kg diet (D_2).
3. $D_1 + 0.1\%$ choline (D_3).
4. $D_1 + 0.05$ mg Se /Kg diet+ 0.05% choline (D_4).
5. $D_1 - 150$ Kcal/Kg diet (D_5).
6. $D_1 - 150$ Kcal/Kg diet+ 0.1 mg Se/Kg diet (D_6).
7. $D_1 - 150$ Kcal/Kg diet+ 0.1% choline (D_7).
8. $D_1 - 150$ Kcal/Kg diet+ 0.05 mg Se /Kg diet + 0.05% choline (D_8).

The composition and calculated analysis of the experimental diets (without Se or choline supplementation) are presented in Table (1). The experimental diets were supplemented with vitamins and minerals mixture, to cover the recommended requirements according to the strain catalog recommendations and were formulated to be iso-nitrogenous.

Batteries were placed into a room provided with a continuous (23 hour/day up to 41 days of age) light and fans for ventilation. The experimental birds were reared under similar (open system) environmental conditions, and were fed with broiler starter diet from 6 to 12 days of age, broiler grower diet from 13 to 24 days and broiler finisher diet from 25 to 41 day (the end of the experiment). Room temperature on day 0 was 35°C and 33°C at the end of first week and decreased approximately 2°C per week until 23°C was reached, according to standard poultry rearing practices. The vaccination program, adopted by recommended requirements according to standard

commercial guidelines. Birds were weighed (individually) to the nearest gram at 6, 12, 24 and 41 days intervals during the experimental period.

Table 1: Composition and calculated analyses of the experimental diets.

Item, %	Starter (6-12 days)		Grower (13-24 days)		Finisher (25-41 days)	
	Control	Control -150 Kcal. ¹	Control	Control -150 Kcal.	Control	Control -150 Kcal.
Yellow corn, ground	55.90	58.90	60.40	64.54	62.90	66.42
Soybean meal (44%CP)	36.85	36.58	31.66	30.50	28.61	27.89
Calcium carbonate	1.00	1.00	1.00	1.00	0.90	0.90
Sodium chloride	0.40	0.40	0.40	0.40	0.40	0.40
Vit. and trace Min. premix ²	0.30	0.30	0.30	0.30	0.30	0.30
Dicalcium phosphate	2.20	2.20	2.10	2.02	2.00	2.00
Vegetable oil ³	3.20	0.50	4.00	1.08	4.70	1.90
DL-Methionine	0.15	0.12	0.13	0.13	0.13	0.13
L-Lysine Hcl	0.00	0.00	0.01	0.03	0.06	0.06
Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis ⁴ :						
Crude protein	21.06	21.18	19.16	19.02	18.07	18.06
Ether extract	5.62	3.04	6.55	3.78	7.32	4.65
Crude fiber	3.81	3.86	3.55	3.56	3.39	3.42
Calcium	0.98	0.98	0.95	0.93	0.88	0.88
Available phosphorus	0.54	0.54	0.51	0.50	0.49	0.49
Methionine	0.48	0.45	0.43	0.43	0.42	0.42
Methionine+Cystine	0.82	0.80	0.75	0.75	0.72	0.72
Lysine	1.14	1.14	1.02	1.01	0.98	0.97
Sodium	0.17	0.17	0.17	0.17	0.17	0.17
Chloride	0.28	0.28	0.28	0.28	0.28	0.28
Selenium, mg Se /Kg diet	0.154	0.154	0.150	0.150	0.148	0.148
ME, Kcal/Kg	2991	2842	3098	2949	3179	3029
C/P ratio	142.0	134.2	161.7	155.1	175.9	167.7
Cost (£.E./ton) ⁶	5918	5674	5759	5480	5704	5451
Relative cost ⁷	100.0	95.88	100.0	95.16	100.0	95.56

¹ ME, Kcal/Kg diet.

² Each 3.0 Kg of the Vit. and trace Min. premix manufactured by Vetgreen Company and contains: Vit. A 10000000 IU; Vit. D₃ 2000000 IU; Vit. E 1000 mg; Vit. K₃ 1000 mg; Vit. B₁ 1000 mg; Vit. B₂ 500 mg; Vit. B₆ 1500 mg; Vit. B₁₂ 10 mg; biotin 50 mg; folic acid 1 g; niacin 3000 mg; Ca pantothenate 1000 mg; Zn 50 g; Cu 4 g; Fe 30 g; Co 0.1 g; Se 0.1 g; I 0.3 g; Mn 60 g and anti-oxidant 10 g, and complete to 3.0 Kg by calcium carbonate.

³ Mixture from 75% soybean oil and 25% sunflower oil.

⁴ According to NRC, 1994.

⁵ According to the local market price at the experimental time.

⁶ Assuming the price of the control group equal 100.

At the same time, feed consumption was recorded and feed conversion (FC, g feed/g gain) and live body weight gain (LBWG) were calculated. Crude protein conversion (CPC), caloric conversion ratio (CCR), growth rate (GR) and performance index (PI) was calculated according to the equation described by North (1981) as follows: $PI = (LBW, Kg / FC) \times 100$.

Accumulative mortality rate was obtained by adding the number of dead birds during the experiment divided by the total number of chicks at the starting of the experimental period (mortality % was within normal range and not related to treatments studied). At 41 days of age (end of the finishing period), slaughter tests

were performed using three chicks around the average LBW of each treatment. The birds were on feed withdrawal (approximately 16 hour) overnight, then weighed (individually) to the nearest gram, and slaughtered by severing the jugular vein. After five minutes bleeding time, each bird was dipped in a water bath (79°) for 30s, and feathers were removed mechanically. After the removal of head, carcasses were manually eviscerated, by the same person to ensure uniformity of cuts, to determine some carcass traits, dressing % {eviscerated carcass without legs, head and neck} and total giblets% {liver, heart, gizzard empty and spleen}. The eviscerated weight included the front part with wing and rear part. The abdominal fat was removed by hand from the parts around the gizzard and viscera, and was weighed to the nearest gram. The bone of front and rear were separated and weighed to calculate meat%. The meat (without the skin) from each part was weighed, and blended using a kitchen blender.

At the time of slaughter test, individual blood samples were taken from three birds of each treatment to determine hematological and biochemical characteristics of blood. Glutathione peroxidase (GSH-Px) activity was determined in plasma via enzymatic methods; adjusted for poultry blood, using available commercial kits SCLAVO INC.; 5 Mansard Count.; Wayne NJ 07470, USA.

Chemical analyses of representative samples of the carcass meat without the skin were carried out to determine DM, CP= (N x 6.25), EE and ash contents according to the methods of **A.O.A.C. (1990)**. Nitrogen free extract (NFE) was calculated by difference. To obtain bone ash values, the right tibia bone was collected according to the method of **Martinez *et al.* (2006)**. Tibias were pooled by replicate groups and autoclaved and adhering tissue was removed. Then bones were dried for 24 hour at 100°C and weighed, tibia relative weight as a percentage of LBW was calculated, and then dry-ashed for 24 hour in a 600°C muffle furnace. Ash weight was expressed as a percentage of dried tibia weight. The economic efficiency was calculated as the price of LBW–total costs of raising a broiler chicks as relative to total raising costs which was estimated based upon local current prices at the experimental time. Statistical analysis of results was performed using the General Linear Models procedure of the SPSS software (**SPSS, 2007**), according to the follow general model:

$$Y_{ijk} = \mu + M_i + T_j + MT_{ij} + e_{ijk}$$

Where:

- Y_{ijk} : observed value. μ : overall mean.
 M_i : level of ME effect (i : recommended (R), R-150 Kcal/Kg diet)
 T_j : type of addition (j : without, Se, choline and mixture)
 MT_{ij} : interaction effect of level of ME by type of addition.
 e_{ijk} : random error.

Treatment means indicating significant differences ($P \leq 0.01$ and $P \leq 0.05$) were tested using Duncan's multiple range test (**Duncan, 1955**).

RESULTS AND DISCUSSION:

Performance: Effects of Se and/or choline as feed additives in broiler diets at low level of ME on LBW, LBWG and feed intake (FI) are shown in Table 2. The main effects of level of ME had insignificantly ($P > 0.05$) affected LBW and LBWG at all periods studied except, LBW at 41 days and LBWG during the periods from 25 to 41 and 6 to 41 days, which was significantly ($P \leq 0.01$) affected (Table 2). It is clear that, chicks fed diet containing recommended level of ME (R)-150 Kcal/Kg diet had significantly higher values of LBW at 41 days and LBWG during the periods from 25 to 41 and 6 to 41 days (this may be due to the birds fed on low-ME diets consumed the same amount of energy due to increased FI), while, chicks fed diet containing R had significantly lower LBW and LBWG values during the same previous periods. Similar to the present findings **Ragab (2013)** found that chicks fed diet containing R-100 Kcal/Kg diet had higher LBW at 42 days and LBWG during the period from 5 to 42 days. While, no significant difference in final LBW (**Giachetto et al., 2003** and **Emam et al., 2014**) and LBWG (**Emam et al., 2014**) was found by different energy levels in the birds diet over the range 2900 or 3200 Kcal ME/kg.

Type of addition had insignificant effect on LBW and LBWG at all periods studied, except, LBWG during the period from 6 to 12 days which was significantly ($P \leq 0.01$) affected (Table 2). As shown in Table 2, chicks fed 0.1 mg Se/Kg diet as Sel-Plex had higher value of LBWG during the period from 6 to 12 days and those fed diet containing 0.1% choline had the lower value of LBWG during the same period, the differences between values of LBWG for chicks fed control diet and those fed diet containing 0.1% choline were not significant (Table 2).

Table 2: Effect of dietary energy levels with or without selenium and choline supplementation on live body weight (LBW, g), live body weight gain (LBWG, g) and feed intake (FI, g) of broiler chickens.

Items	LBW, g (age, days)				LBWG, g (age period, days)				FI, g (age period, days)				
	6	12	24	41	6-12	13-24	25-41	6-41	6-12	13-24	25-41	6-41	
Level of metabolizable energy (ME, Kcal./Kg diet (L))													
Recommended (R)	144.03	276.47	865.27	1933.50 ^b	134.65	587.05	1037.62 ^b	1786.48 ^b	203.43 ^b	1038.52 ^b	2680.60 ^b	3925.19 ^b	
R-150	144.56	276.14	852.01	2052.56 ^a	131.33	575.23	1164.44 ^a	1904.46 ^a	208.70 ^a	1063.18 ^a	2741.38 ^a	4015.12 ^a	
SEM ¹	1.67	3.17	10.00	27.09	2.10	8.35	22.93	26.67	0.10	4.87	13.51	16.07	
P-value	0.829	0.944	0.374	0.005	0.289	0.342	<0.001	0.004	<0.001	0.001	0.003	<0.001	
Type of addition (T)													
Without ²	144.40	275.20	844.15	1952.13	130.30 ^b	568.95	1071.43	1804.63	193.79 ^d	1040.28	2660.85 ^c	3898.63 ^c	
Selenium (Se) ³	143.73	282.98	872.03	1988.40	141.33 ^a	586.08	1087.23	1840.93	204.50 ^c	1064.39	2787.44 ^a	4063.04 ^a	
Choline ⁴	145.06	274.00	858.74	2016.17	128.94 ^b	584.54	1124.27	1870.55	209.00 ^b	1044.50	2650.13 ^c	3903.63 ^c	
Mixture ⁵	143.99	273.05	859.64	2015.42	131.38 ^{ab}	584.99	1121.18	1865.77	216.97 ^a	1054.24	2745.54 ^b	4015.33 ^b	
SEM	2.36	4.53	13.95	38.32	2.96	11.65	32.42	37.72	0.14	6.89	19.10	22.72	
P-value	0.984	0.416	0.593	0.642	0.018	0.703	0.640	0.630	<0.001	0.076	<0.001	<0.001	
L × T (treatments)													
R	Without	144.95	264.50	850.95	1892.53	119.55 ^c	586.45	1008.20	1745.67	186.05 ^g	1031.80 ^{cd}	2636.36 ^c	3854.21 ^c
	Selenium	142.20	286.30	890.22	1960.00	148.26 ^a	600.56	1036.87	1811.47	204.86 ^d	1068.53 ^{ab}	2748.45 ^{ab}	4035.24 ^{ab}
	Choline	145.62	277.00	868.20	1971.73	131.38 ^{bcd}	590.80	1079.93	1825.60	205.90 ^c	1029.14 ^{cd}	2662.47 ^{bc}	3897.51 ^c
	Mixture	143.33	278.10	851.70	1909.73	139.40 ^{abc}	570.40	1025.47	1763.20	216.90 ^a	1024.62 ^e	2675.13 ^{bc}	3913.80 ^{bc}
R-150	Without	143.86	285.90	837.35	2011.73	141.05 ^{ab}	551.45	1134.67	1863.60	201.52 ^f	1048.76 ^{bcd}	2685.33 ^{bc}	3943.05 ^c
	Selenium	145.25	279.65	853.83	2016.80	134.40 ^{bcd}	571.61	1137.60	1870.40	204.15 ^c	1060.25 ^{abc}	2826.44 ^a	4090.83 ^a
	Choline	144.50	271.00	849.29	2060.60	126.50 ^{cde}	578.29	1168.60	1915.50	212.10 ^b	1059.86 ^{abc}	2637.80 ^c	3909.75 ^c
	Mixture	144.64	268.00	867.57	2121.11	123.36 ^{de}	599.57	1216.89	1968.33	217.05 ^a	1083.86 ^a	2815.95 ^a	4116.86 ^a
SEM	3.37	6.41	19.73	54.19	4.19	16.47	45.85	53.34	0.20	9.86	27.35	32.13	
P-value	0.914	0.062	0.672	0.604	<0.001	0.265	0.758	0.636	<0.001	0.013	0.050	0.048	

^{a-g} Means in a column with different superscripts differ significantly ($P \leq 0.05$).

¹ Pooled SEM

² without Se or choline supplementation

³ 0.1 mg Se /Kg diet

⁴ 0.1% choline

⁵ 0.05 mg Se /Kg diet + 0.05% choline

Numerically, all type of addition increase ($P>0.05$) LBW at 41 days and LBWG during the period from 6 to 41 days compared with those fed control diet. On the other hand, chicks fed 0.1% choline had higher values of LBW and LBWG during the period from 6 to 41 days, however, these did not reach a level of statistical significance (Table 2). Similar to the present results, **Emam *et al.* (2014)** reported that no significant difference in final LBW and LBWG was found by different levels of choline supplementation in the triticale diets for broiler chicks (under summer conditions). While, **Vogt (1994)** found that choline supplementation improved growth. Likewise, some reports found no effect of different levels of Se or Se yeast on final LBW of the chickens (**Habibian *et al.*, 2013 and Shourrap *et al.*, 2018**), LBWG, FI and FC (**Payne and Southern, 2005, Yoon *et al.*, 2007 and Shourrap *et al.*, 2018**) and growth performance of broiler (**Choct *et al.*, 2004, Chen *et al.*, 2013 and Boostani *et al.*, 2015**) However, **Yang *et al.* (2012)** show that Se yeast (0.3 mg/kg) could increase daily LBWG and FI by 8.92 and 3.99% and decrease FC by 4.84%, respectively. Also, **Balti *et al.* (2015)** reported that average LBW at the end of the study, it was higher ($P\leq 0.05$) in the group with added 0.4 mg/kg Se as compared with no added Se and with the highest Se content in feed (0.6 mg/kg).

Interaction due to level of ME effect X type of addition (experimental treatments) had insignificantly ($P>0.05$) affected LBW and LBWG at all periods studied except, LBWG during the period from 6 to 12 days which was significantly ($P\leq 0.01$) affected (Table 2). Chicks fed recommended level of ME with 0.1 mg Se/Kg diet as Sel-Plex had higher value of LBWG during the period from 6 to 12 days, however, those fed control diet had the lower value of LBWG during the same period (Table 2). Numerically, as shown in Table 2, all dietary treatments increase LBW at 41 days and LBWG during the period from 6 to 41 days compared with those fed control diet, however, these did not reach a level of statistical significance.

In this respect, **El-sheikh and Ahmad (2006)** demonstrated that supplementation of broilers diets with Sel-Plex significantly ($P\leq 0.05$) improved LBW at 6 weeks of age, LBWG and FC during the period from 0-6 weeks compared to control group. The increasing of LBW with feeding Sel-Plex may be due to the

findings of **Arthur (1992)** who reported that dietary Se improves the growth of broilers because Se plays an important part in regulatory metabolism, in that it plays an essential role in catalyzing the formation thyroid hormones and conversion of T4 to T3, which are important for normal growth and development (**Jianhua *et al.*, 2000**).

Dietary level of ME effect was significant for FI at all periods studied (Table 2). It is clear that, chicks fed R-150 Kcal/Kg diet had significantly higher values of FI during all periods studied (this may be due to the bird's attempt at maintaining a normal energy intake), while, chicks fed control diet had significantly lower values of FI during the same periods.

Similar to the present findings, **Ragab (2013)** and **Emam *et al.* (2014)** found that FI was increased as well as FC was improved by low level of energy (R-100 Kcal/Kg) in the broiler diet during the periods from 24 to 42 and 5 to 42 days as compared with chicks fed control diet. While, **Giachetto *et al.* (2003)** reported that birds fed with high dietary energy level (3200 Kcal ME/kg) had a lower FI and better FC. **Dairo *et al.* (2010)** found that, FI was lower at finisher phases for birds fed diets with low energy-high protein combination and low energy-low protein. In this respect, **Dozier *et al.* (2006)** reported that broilers consume diet to primarily meet energy requirements, while, other research by **Mbajiorgu *et al.* (2011)** failing to observe an effect of dietary energy on FI.

Type of addition had significant ($P \leq 0.01$) effect on FI at all periods studied, except, during the period from 13 to 24 days which was insignificantly affected (Table 2). As shown in Table 2, the highest significant value of FI during the finisher and over all experimental period achieved by addition of 0.1 mg Se/kg diet. Chicks fed diet containing 0.1% choline had the lower value of FI during the period from 25 to 41 days, while, chicks fed control diet had the lower value of FI during the periods from 6 to 12 and 6 to 41 days (the differences between values of FI for chicks fed control diet and those fed diet containing 0.1% choline were not significant during the periods from 25 to 41 and 6 to 41 days), Table (2).

In this respect, **Emam *et al.* (2014)** found that 0.1% choline supplementation (under summer conditions) decrease FI and improve FC during the period from 5 to 42 days of age as compared with those fed choline un-supplement diet.

Interaction due to level of ME effect X type of addition had significantly affected FI during all periods studied (Table 2). Chicks fed diet containing R-150 Kcal/Kg diet with 0.05 mg Se/Kg diet and 0.05% choline had higher values of FI during the periods from 6 to 12, 13 to 24 and 6 to 41 days, however, those fed control diet had the lower values of FI during the periods from 6 to 12, 25 to 41 and 6 to 41 days (Table 2). In this regard, **Emam *et al.* (2014)** indicated that chicks fed control diets with choline supplement had significantly lower value of FI during the period from 5 to 42 days.

Data presented in Table (3) indicate the main effect of level of ME was significant ($P \leq 0.05$ and $P \leq 0.01$) for FC and CPC during the periods from 6 to 12 and 25 to 41 days and CCR during the periods from 25 to 41 and 6 to 41 days. Chicks fed diet containing recommended level of ME had the best FC and CPC values during the period from 6 to 12 days. Chicks fed R-150 Kcal/Kg had the best FC, CPC and CCR during the period from 25 to 41 days, and those fed R-150 Kcal/Kg had the best CCR during the period from 6 to 41 days (Improvement in FC, CPC and CCR of broiler appears to be due to the increase in LBW and LBWG). In this respect, **Kamran *et al.* (2008)** reported that LBWG, FCR were adversely affected and FI increased linearly ($P \leq 0.05$), while, PER and EER were decreased ($P \leq 0.05$), during finisher and overall experimental periods as a result of lowering the dietary CP and ME content, however, EER was decreased with low-ME diets (**Kamran *et al.*, 2008**). Also, increasing dietary energy level could improve FC rate of broilers by reducing FI (**Dozier *et al.*, 2006** and **Ghaffari *et al.*, 2007**). The results cleared that type of addition and interaction due to level of ME effect X type of addition had insignificant effect on FC, CPC and CCR during all periods studied, except, during the period from 6 to 12 days which was significantly ($P \leq 0.01$) affected (Table 3).

As shown in Table 3, chicks fed diet containing 0.05 mg Se/Kg diet and 0.05% choline had worst values of FC, CPC and CCR during the period from 6 to 12 days of age, while, those fed 0.1 mg Se/Kg diet as Sel-Plex had best values of FC, CPC and CCR during the same period. As shown in Tables 2 and 3, numerical improvements in LBW, LBWG and improved FC and CCR were frequently observed when addition of 0.1% choline during the period from 6 to 41 days of age.

Table 3: Effect of dietary energy levels with or without selenium and choline supplementation on feed conversion (FC), crude protein conversion (CPC) and caloric conversion ratio (CCR) of broiler chickens.

Items	FC, g (age period, days)				CPC (age period, days)				CCR (age period, days)				
	6-12	13-24	25-41	6-41	6-12	13-24	25-41	6-41	6-12	13-24	25-41	6-41	
Level of metabolizable energy (ME, Kcal./Kg diet (L))													
Recommended (R)	1.544 ^b	1.799	2.655 ^a	1.956	0.325 ^b	0.345	0.480 ^a	0.375	4.618	5.574	8.437 ^a	6.078 ^a	
R-150	1.629 ^a	1.878	2.410 ^b	1.920	0.345 ^a	0.358	0.435 ^b	0.369	4.628	5.542	7.298 ^b	5.668 ^b	
SEM ¹	0.030	0.030	0.060	0.020	0.010	0.010	0.010	0.010	0.080	0.090	0.180	0.080	
P-value	0.031	0.74	0.007	0.324	0.017	0.122	0.007	0.389	0.933	0.810	<0.001	<0.001	
Type of addition (T)													
Without ²	1.516 ^b	1.853	2.530	1.914	0.320 ^b	0.355	0.457	0.367	4.425 ^b	5.611	7.863	5.805	
Selenium (Se) ³	1.483 ^b	1.850	2.666	1.958	0.313 ^b	0.353	0.482	0.375	4.321 ^b	5.589	8.280	5.938	
Choline ⁴	1.660 ^a	1.821	2.397	1.907	0.351 ^a	0.348	0.433	0.367	4.838 ^a	5.502	7.446	5.772	
Mixture ⁵	1.686 ^a	1.830	2.536	1.974	0.356 ^a	0.349	0.458	0.379	4.909 ^a	5.531	7.880	5.978	
SEM	0.040	0.040	0.080	0.030	0.010	0.010	0.020	0.010	0.110	0.120	0.260	0.110	
P-value	<0.001	0.945	0.206	0.511	<0.001	0.925	0.206	0.502	<0.001	0.930	0.212	0.525	
L × T (treatments)													
R	Without	1.582 ^{bcd}	1.783	2.676	1.966	0.333 ^{bcd}	0.342	0.484	0.377	4.732 ^{ab}	5.524	8.504	6.108
	Selenium	1.414 ^d	1.812	2.756	1.957	0.298 ^d	0.347	0.498	0.374	4.230 ^c	5.615	8.759	6.086
	Choline	1.607 ^{bc}	1.775	2.508	1.925	0.338 ^{bc}	0.340	0.453	0.370	4.805 ^{ab}	5.500	7.969	5.975
	Mixture	1.573 ^{bcd}	1.826	2.679	1.978	0.331 ^{bcd}	0.350	0.484	0.379	4.705 ^{ab}	5.657	8.515	6.145
R-150	Without	1.449 ^{cd}	1.923	2.385	1.861	0.307 ^{cd}	0.368	0.431	0.356	4.117 ^c	5.697	7.222	5.501
	Selenium	1.553 ^{bcd}	1.887	2.576	1.959	0.329 ^{bcd}	0.359	0.465	0.375	4.411 ^{bc}	5.563	7.801	5.790
	Choline	1.714 ^{ab}	1.867	2.286	1.889	0.363 ^b	0.355	0.413	0.364	4.870 ^{ab}	5.503	6.923	5.570
	Mixture	1.800 ^a	1.834	2.393	1.971	0.381 ^a	0.349	0.432	0.380	5.113 ^a	5.406	7.245	5.811
SEM	0.050	0.060	0.120	0.050	0.010	0.010	0.020	0.010	0.150	0.170	0.370	0.150	
P-value	0.008	0.755	0.961	0.699	0.008	0.708	0.962	0.622	0.009	0.714	0.965	0.742	

^{a-d} Means in a column with different superscripts differ significantly ($P \leq 0.05$).

¹ Pooled SEM

² without Se or choline supplementation

³ 0.1 mg Se /Kg diet

⁴ 0.1% choline

⁵ 0.05 mg Se /Kg diet + 0.05% choline

Similarly, **Emam *et al.* (2014)** indicated that 0.1% choline supplementation (under summer conditions) improve ($P>0.05$) CPC, CCR and increase ($P>0.05$) GR, PI during the period from 5 to 42 days as compared with those fed cho. un-supplement diet (0.0%), however, these did not reach a level of statistical significance. **Waldroup *et al.* (2006)** reported that, numerical improvements in LBW and significantly improved FC were frequently observed when addition of 1000 mg of choline/kg over the birds fed the unsupplemented diets at 35, 42, 49, and 56 d of age. **Dilger *et al.* (2007)** reported that supplementation of the cho. free basal diet with graded levels of choline resulted in linear increases in LBWG, FI and improved FC. Also, **Jadhav *et al.* (2008)** found that a significant increase in LBW and significant improvement in FC was observed in choline supplemented broilers when compared with control birds. These results disagree with those of **Waldroup and Fritts (2005)** who reported that choline supplementation had no significant effect on FC. Moreover, **Rafeeq *et al.* (2011)** found that the supplementation choline as choline chloride might have disturbed the ion balance and resulted in lower FI and LBWG.

As shown in Table 3, chicks fed diet containing recommended level of ME with 0.1 mg Se/Kg diet as Sel-Plex had the best values of FC and CPC during the period from 6 to 12 days of age. While, chicks fed diet containing R-150 Kcal/Kg with 0.05 mg Se/Kg diet and 0.05% choline had worst values of FC, CPC and CCR during the during the same period.

Data presented in Table (4) indicate the main effect of level of ME was insignificant for GR and PI at all periods studied, except, GR during the period from 6 to 41 days and PI during the period from 25 to 41 days, which was significantly ($P\leq 0.05$ and $P\leq 0.01$) affected (Table 4). Chicks fed diet containing recommended level of ME had lower values of GR and PI during the same previous periods, and those fed R-150 Kcal/Kg had higher values of GR and PI during the same period.

Type of addition had insignificant effect on GR and PI at all periods studied, except, the period from 6 to 12 days, which was significantly ($P\leq 0.05$ and $P\leq 0.01$) affected (Table 4). Chicks fed 0.1 mg Se/Kg diet had higher values of GR and PI during the period from 6 to 12 days (Table 4).

Table 4: Effect of dietary energy levels with or without selenium and choline supplementation on growth rate (GR) and performance index (PI) of broiler chickens.

Items	GR (age period, days)				PI (age period, days)				
	6-12	13-24	25-41	6-41	6-12	13-24	25-41	6-41	
Level of metabolizable energy (ME, Kcal./Kg diet (L))									
Recommended (R)	0.636	1.026	0.730	0.801 ^b	18.692	49.474	76.029 ^b	49.539	
R-150	0.624	1.017	0.789	0.816 ^a	17.610	46.739	88.491 ^a	52.647	
SEM ¹	0.010	0.010	0.010	0.010	0.470	1.210	2.640	1.150	
P-value	0.257	0.399	0.000	0.025	0.125	0.131	0.002	0.077	
Type of addition (T)									
Without ²	0.619 ^b	1.015	0.755	0.803	18.691 ^{ab}	46.971	79.205	50.004	
Selenium (Se) ³	0.658 ^a	1.010	0.747	0.809	20.001 ^a	48.637	79.318	50.656	
Choline ⁴	0.614 ^b	1.030	0.771	0.815	17.113 ^b	48.654	86.655	52.439	
Mixture ⁵	0.630 ^{ab}	1.030	0.765	0.806	16.800 ^b	48.163	83.862	51.273	
SEM	0.010	0.010	0.010	0.010	0.670	1.710	3.730	1.630	
P-value	0.021	0.454	0.657	0.647	0.005	0.892	0.478	0.785	
L × T (treatments)									
R	Without	0.584 ^c	1.050 ^{ab}	0.725	0.793	17.160 ^{bcd}	48.906	73.039	48.014
	Selenium	0.681 ^a	1.017 ^{abc}	0.712	0.802	21.452 ^a	50.801	76.000	50.796
	Choline	0.620 ^{bcd}	1.030 ^{ab}	0.752	0.808	17.918 ^{bcd}	50.342	80.846	50.959
	Mixture	0.660 ^{ab}	1.006 ^{abc}	0.730	0.800	18.241 ^{bcd}	47.847	74.231	48.386
R-150	Without	0.654 ^{abc}	0.979 ^c	0.785	0.813	20.223 ^{ab}	45.037	85.370	51.994
	Selenium	0.634 ^{bcd}	1.004 ^{bc}	0.781	0.815	18.550 ^{abc}	46.473	82.637	50.516
	Choline	0.609 ^{cde}	1.029 ^{ab}	0.789	0.822	16.309 ^{cd}	46.967	92.464	53.918
	Mixture	0.599 ^{de}	1.054 ^a	0.799	0.813	15.359 ^d	48.479	93.493	54.161
SEM	0.020	0.010	0.020	0.010	0.940	2.380	5.280	2.300	
P-value	<0.001	0.002	0.867	0.976	0.006	0.763	0.746	0.649	

^{a-c} Means in a column with different superscripts differ significantly ($P \leq 0.05$).
 choline supplementation ³ 0.1 mg Se /Kg diet ⁴ 0.1% choline

¹ Pooled SEM ² without Se or
⁵ 0.05 mg Se /Kg diet + 0.05% choline

Numerically, as shown in Table 4, all type of addition insignificant increase ($P > 0.05$) GR and PI during the period from 6 to 41 days especially when addition of 0.1% choline as compared with those fed control diet. In this respect, **Dilger et al. (2007)** determined that the minimal concentration of dietary choline for chicks to achieve maximal growth rate was 722 mg/kg diet is optimal for normal growth.

The results cleared that interaction due to level of ME effect X type of addition had insignificant effect on GR and PI at all periods studied, except, GR during the periods from 6 to 12 and 13 to 24 days and PI during the period from 6 to 12 days which was significantly ($P \leq 0.01$) affected (Table 4). Chicks fed diet containing recommended level of ME with 0.1 mg Se/Kg diet as Sel-Plex had higher values of GR and PI during the period from 6 to 12 days of age. It can be concluded that ME can be reduced from the recommended level by 150 Kcal/Kg without affecting LBW, LBWG, FI, FC, CPC, CCR, GR and PI (Tables 2, 3 and 4). Numerically, as shown in Tables 2, 3 and 4, all dietary treatments increase LBW, LBWG, GR and PI during the

period from 6 to 41 days compared with those fed control diet, however, these did not reach a level of statistical significance. It can be concluded that, dietary ME can be reduced from the recommended level up to 150 Kcal/Kg diet and supplement these diets with 0.1 mg Se/Kg diet as Sel-Plex or/and 0.1% choline without affecting LBW, LBWG, GR and PI.

Slaughter parameters%: As shown in Table 5, neither level of ME, type of addition nor interaction due to level of ME effect X type of addition had any significant effect on slaughter parameters%, except, level of ME effect with blood and feathers and type of addition with dressing% and bursa which was significantly ($P \leq 0.05$) affected. Chicks fed R-150 Kcal/Kg had higher blood and feathers. Chicks fed diet containing 0.1 mg Se/Kg diet as Sel-Plex had higher value of dressing % (Table 5). Similar to the present results, **Shourrap *et al.* (2018)** found that dressing% was increased with dietary organic Se (0.3 and 0.4 ppm/kg) supplementations. In this regard, **Balti *et al.* (2015)** found that dressing % ranged from 66.9 to % 69.5% (0.6 and 0.0 mg Se /kg diet, respectively) and significantly ($P \leq 0.01$) differed between those two groups of duck. **Choct *et al.* (2004)** found that birds receiving organic Se in their diet had improved eviscerated weight and breast yield. A number of studies that used different forms of Se reported that dietary Se (or Se yeast) supplementations, did not affect breast and carcass yields of broilers (**Payne and Southern, 2005 and Yang *et al.*, 2012**).

Similarly, under summer conditions no significant differences as a result of level of ME on carcass characteristics, except, heart and total giblets%, which were significantly affected (**Emam *et al.*, 2014**). As occurred with the current study, some researchers found no significant effect of high energy diet on abdominal fat (**Giachetto *et al.*, 2003**) and breast meat yield of broiler (**Dozier *et al.*, 2006**), but caused deposition of excess abdominal or/and carcass fat in broiler (**Ghaffari *et al.*, 2007**). In addition, this fat was generally considered to be waste product when broiler were processed additional, which indicated the economic loss for broiler producers. Further, **Dairo *et al.* (2010)** demonstrated that the body fat deposition significantly increased in chicks fed high and normal energy inclusion in the diets resulting into a high C/P ratio. However, **Dozier and Moran (2002)** reported that feeding broiler diets formulated to

contain suboptimum levels of CP and ME impaired the quantity and yield of carcass parts.

Emam *et al.* (2014) indicated that under summer conditions neither choline nor interaction between choline x level of ME Kcal/Kg diet had any significant effect on carcass characteristics. **Waldroup and Fritts (2005)** demonstrated that addition of 1000 mg/kg of choline significantly improved breast meat yield at 42 d but not at 49 days. While, **Waldroup *et al.* (2006)** reported that, no significant effects on dressing% and significant improvements in breast meat yield were frequently observed when addition of 1000 mg of choline/kg over the birds fed the unsupplemented diets at 42, 49, or 56 days of age.

Blood constituents: As shown in Table 6, no significant ($P>0.05$) differences were detected in blood constituents due dietary ME Kcal/Kg diet, type of addition and interaction due to level of ME effect X type of addition, except, interaction due to level of ME effect X type of addition, which was significantly ($P\leq 0.05$) affected of total leucocytes. Chicks fed diet containing R with 0.1% choline had lower value of total leucocytes, while, those fed diet containing R-150 Kcal/Kg diet with 0.1% choline had higher value of total leucocytes at the end of the experiment. No significant differences were observed in blood constituents as a result of choline%, dietary level of ME Kcal/Kg diet and interaction between choline% x dietary ME (**Emam *et al.*, 2014**).

In addition, **Romaniuk *et al.* (1995)** showed that there was no significant effect of Sel-Plex on hemoglobin (HB). Se deficiency does not necessarily affect neutrophil numbers but rather different aspects of neutrophil function. Se deficit damages both cellular and humoral immunity (**Arthur *et al.*, 2003**).

Se stimulates the immune system, strengthening proliferation of activated T lymphocytes (**Rayman, 2000**). Daily intake of 200 µg of Se causes increased reaction of lymphocytes to antigenic stimulation and increase of their ability to mature to cytotoxic lymphocytes destroying tumour cells. The activity of natural killers increases, too. This mechanism is closely connected with increased numbers of receptors for interleukin-2 on the surface of the activated lymphocytes and natural killers. These interactions are critical for clonal expansion and differentiation to cytotoxic T cells (**Rayman, 2000 and Arthur *et al.*, 2003**).

Table 5: Effect of dietary energy levels with or without selenium and choline supplementation on some slaughter parameters% of broiler chickens.

Items	Live body weight (g)	Blood& feather	Total giblets	Abdominal fat	Half breast	Half rear	Breast meat	Rear meat	Carcass weight after evisceration	Dressing	Bursa	Thymus	Tibia		
													Weight	Ash	
Level of metabolizable energy (ME, Kcal/Kg diet (L))															
Recommended (R)	1934.8	7.67 ^b	5.23	1.91	17.12	14.40	88.12	86.89	62.33	67.55	0.11	0.45	0.237	45.43	
R-150	2053.9	8.65 ^a	5.02	2.09	16.71	14.48	88.30	87.78	61.78	66.80	0.10	0.38	0.220	49.13	
SEM ¹	79.84	0.27	0.25	0.32	0.36	0.33	0.42	0.77	0.55	0.47	0.01	0.04	0.010	1.25	
P-value	0.323	0.032	0.578	0.696	0.444	0.858	0.766	0.439	0.504	0.290	0.437	0.260	0.215	0.070	
Type of addition (T)															
Without ²	1956.2	8.23	5.49	2.01	16.54	14.56	88.28	87.34	60.32	65.81 ^c	0.14 ^a	0.48	0.216	46.36	
Selenium (Se) ³	1992.7	8.05	5.59	1.84	16.77	13.96	89.10	87.79	62.88	68.47 ^a	0.09 ^{bc}	0.29	0.231	47.23	
Choline ⁴	2014.0	8.03	4.88	2.40	17.07	14.13	88.24	86.67	61.29	66.17 ^{bc}	0.12 ^{ab}	0.48	0.228	49.17	
Mixture ⁵	2014.5	8.35	4.53	1.76	17.27	15.11	87.22	87.55	63.74	68.27 ^{ab}	0.07 ^c	0.40	0.240	46.36	
SEM	112.91	0.38	0.35	0.45	0.51	0.47	0.60	1.09	0.78	0.66	0.01	0.06	0.010	1.77	
P-value	0.980	0.915	0.176	0.744	0.755	0.365	0.249	0.897	0.056	0.043	0.023	0.121	0.623	0.658	
L × T (treatments)															
R	Without	1897.0	7.86	5.40	1.93	17.10	14.01	89.09	86.64	61.11	66.52	0.17	0.51	0.218	44.89
	Selenium	1964.4	7.31	5.60	2.14	17.56	14.25	89.62	89.40	64.57	70.17	0.06	0.24	0.243	46.04
	Choline	1964.0	7.81	5.23	2.07	16.64	13.68	87.74	84.82	59.89	65.11	0.13	0.54	0.241	45.05
	Mixture	1914.0	7.72	4.67	1.51	17.16	15.65	86.02	86.71	63.75	68.42	0.08	0.50	0.247	45.74
R-150	Without	2015.5	8.60	5.58	2.09	15.98	15.11	87.46	88.04	59.52	65.11	0.11	0.46	0.214	47.83
	Selenium	2021.0	8.78	5.58	1.53	15.97	13.66	88.58	86.18	61.19	66.77	0.11	0.33	0.219	48.41
	Choline	2064.0	8.25	4.54	2.74	17.50	14.59	88.74	88.52	62.69	67.23	0.12	0.42	0.216	53.28
	Mixture	2115.0	8.99	4.39	2.00	17.38	14.57	88.42	88.38	63.72	68.11	0.06	0.30	0.232	46.99
SEM	159.67	0.53	0.49	0.63	0.72	0.66	0.84	1.54	1.11	0.94	0.02	0.08	0.020	2.51	
P-value	0.973	0.765	0.828	0.755	0.347	0.323	0.139	0.224	0.109	0.095	0.128	0.394	0.917	0.544	

^{a-c} Means in a column with different superscripts differ significantly ($P \leq 0.05$).

¹ Pooled SEM

² without Se or choline supplementation

³ 0.1 mg Se /Kg diet

⁴ 0.1% choline

⁵ 0.05 mg Se /Kg diet + 0.05% choline

Table 6: Effect of dietary energy levels with or without selenium and choline supplementation on some blood parameters of broiler chickens.

Items	Hemoglobin (g/dL)	Hematocrit (Ht) %	Red blood cells (RBCs), 10 ⁶ /mm ³	Mean Cell Volume (MCV μ 3)	Total leucocytes (TLC)/cmm	Lymphocyte (LYMP%)	Neutrophils%		Eosinophils (ESINO%)	Basophils (BASO%)	Glutathione peroxidase (GSH-Px), U/ml	
							SEGMENT	STAFF				
Level of metabolizable energy (ME, Kcal./Kg diet (L))												
Recommended (R)	10.91	36.38	2.71	142.79	138.70	57.33	39.42	1.63	1.63	0.00	964.39 ^a	
R-150	10.72	35.72	2.65	136.58	139.78	59.87	35.37	1.63	3.04	0.08	876.43 ^b	
SEM ¹	0.19	0.63	0.07	2.13	1.12	3.04	2.81	0.25	0.47	0.08	5.72	
P-value	0.473	0.466	0.584	0.061	0.510	0.566	0.330	1.00	0.055	0.454	0.000	
Type of addition (T)												
Without ²	10.98	36.68	2.68	141.83	136.37	57.17	39.50	1.50	1.83	0.00	900.10 ^c	
Selenium (Se) ³	10.83	36.17	2.66	137.00	142.00	63.75	31.50	1.75	3.00	0.00	948.20 ^a	
Choline ⁴	10.70	34.92	2.72	140.25	140.07	60.00	36.75	1.25	2.00	0.00	905.30 ^{bc}	
Mixture ⁵	10.75	36.42	2.67	139.67	138.52	53.50	41.83	2.00	2.50	0.17	928.03 ^{ab}	
SEM	0.24	0.79	0.09	2.69	1.42	3.85	3.56	0.31	0.60	0.09	7.24	
P-value	0.863	0.559	0.977	0.731	0.130	0.415	0.347	0.476	0.626	0.570	0.005	
L × T (treatments)												
R	Without	11.20	36.97	2.83	139.33	136.40 ^{bc}	61.00	36.67	1.00	1.33	0.00	934.87
	Selenium	10.95	37.65	2.67	141.50	142.95 ^{ab}	68.00	28.00	2.00	2.00	0.00	986.70
	Choline	10.60	33.05	2.72	146.00	134.75 ^c	56.00	41.00	1.50	1.50	0.00	952.60
	Mixture	10.90	37.87	2.61	144.33	140.70 ^{abc}	44.33	52.00	2.00	1.67	0.00	983.40
R-150	Without	10.77	36.40	2.52	144.33	136.33 ^{bc}	53.33	42.33	2.00	2.33	0.00	865.33
	Selenium	10.70	34.70	2.65	132.50	141.05 ^{abc}	59.50	35.00	1.50	4.00	0.00	909.70
	Choline	10.80	36.80	2.72	134.50	145.40 ^a	64.00	32.50	1.00	2.50	0.00	858.00
	Mixture	10.60	34.97	2.73	135.00	136.33 ^{bc}	62.67	31.67	2.00	3.33	0.33	872.67
SEM	0.34	1.12	0.12	3.81	2.01	5.44	5.04	0.44	0.84	0.13	10.24	
P-value	0.858	0.083	0.397	0.199	0.035	0.104	0.074	0.382	0.937	0.570	0.256	

^{a-c} Means in a column with different superscripts differ significantly ($P \leq 0.05$).

¹ Pooled SEM

² without Se or choline supplementation

³ 0.1 mg Se /Kg diet

⁴ 0.1% choline

⁵ 0.05 mg Se /Kg diet + 0.05% choline

The cell-mediated immunity in broiler chickens (lymphocyte proliferation ratio) increased linearly with dietary organic Se concentration (**Rama Rao *et al.*, 2013**).

The effects of level of ME, type of addition and treatments on blood plasma GSH-PX activity from Cobb strain are presented in Table 6. GSH-PX activity were significantly ($P \leq 0.01$) affected by level of ME and type of addition. Chicks fed diet containing recommended level of ME had higher value of GSH-PX at 41 days, and those fed R-150 Kcal/Kg had lower value of GSH-PX. As shown in Table 6, chicks fed 0.1 mg Se/Kg diet as Sel-Plex had higher value of GSH-PX at 41 days and those fed control diet had the lower value of GSH-PX. Interaction due to level of ME effect X type of addition had insignificant effect on GSH-PX. Similar to the present results, **Shourrap *et al.* (2018)** demonstrated that at five weeks of age, supplementation of broiler diet with organic Se (0.4, 0.5 and 0.6 ppm/kg) increased activities of GSH-PX compared to control group (0.2 ppm/kg Se enriched yeast). **Boostani *et al.* (2015)** reported that dietary Se supplementation raised activity of GSH-PX in serum and tissues. Further more, **Chen *et al.* (2013)** reported that oxidation resistance of broiler was significantly improved with higher level of dietary Se. **Hu *et al.* (2012)** observed that the maximum response of serum GSH-Px activity to dietary Se occurred by the 0.15 mg Se /kg in broiler diet. **Balti *et al.* (2015)** stated that at the end of the study, significantly higher ($P \leq 0.01$) enzymatic activity was determined in groups with 0.4 mg/kg and 0.6 mg/kg added Se compared to groups with lower levels of Se in their diets (0 mg/kg and 0.2 mg/kg). Lipid peroxidation in plasma decreased, while activities of GPx and glutathione reductase in plasma increased linearly with Se. GSH-PX activity was not correlated with dietary Se concentrations (**Zoidis *et al.*, 2014**).

Chemical composition of broiler meat: Level of ME had insignificantly affected chemical composition of broiler meat (Table 7). Type of addition and interaction due to level of ME effect X type of addition had insignificant effect on chemical composition of broiler meat, except, moisture%, which was significantly ($P \leq 0.01$) affected (Table 7). Carcass part insignificantly influenced chemical composition of broiler meat except, protein and fat% which was significantly affected. Rear part had higher fat% than the breast part (5.28 vs. 1.00%), however, breast part had higher protein% (consequently lower fat%) than rear part (Table 7).

Similarly, **Ragab and Osman (2008)**, revealed no significant difference among dietary treatments as increasing energy level in chemical composition of broiler meat%. Also, **Sevcikova et al. (2006)** did not find any differences between control (no added Se) and Se-yeast group in dry matter, protein and intramuscular fat of breast and thigh muscles of broilers. However, **Pappas et al. (2012)** found that the intramuscular fat content of breast muscle tissue increased as the supplemented level of Se increased.

Generally, the discrepancies in responses often observed in the researches or studies in chicks fed energy, Se and/or choline supplemented diets can be partly due to other factors. Such as, the degree of energy restriction, diets composition, the strain and age of the chickens used and rearing environment conditions, whether or C/P ratio imbalances. Also, may be differences in experimental designs and conditions between these previous studies and our study could be responsible for the variations observed. In this respect, **Havenstein et al. (2003)** demonstrated that bird sex, age and strain influenced the response of growing chicken to level of dietary energy, also highlighted other factors that may effect the comparison of energy level such as nutrient density and the nature of diet ingredients.

Economic efficiency (EEf): Results in Table 8 showed that, EEf values during the period from 6 to 41 days of age improved in chicks fed all experimental diets, except, chicks fed diet containing recommended level of ME with 0.05 mg Se/Kg diet as Sel-Plex plus 0.05% choline (the lowest corresponding values, being 0.126 and 95.74%, respectively), as compared with those fed the control diet. Chicks fed diet 7 (R-150 Kcal/Kg diet plus 0.1% choline) had the best Economic and relative efficiency values being 0.251 and 191.34%, respectively, followed by chicks fed diet 8 (R-150 Kcal/Kg diet+ 0.05 mg Se/Kg diet + 0.05% choline), being, (0.248 and 188.43%, respectively), then chicks fed diet 5 (R-150 Kcal/Kg diet), being (0.221 and 168.21%, respectively) as compared with those fed the control diet. The relative efficiency varied between 100.0% to 191.34%, which is of minor importance relative to other factors of production. So, determination of the dietary energy content should be made on economic and not biological criterion. However, **Cerrate et al. (2007)**

demonstrated that the nutrient requirements of broilers are principally determined as a purpose of the best birds performance such as LBW or FC.

Table 7: Effect of dietary energy levels with or without selenium and choline supplementation on chemical composition of broiler meat%.

Items	Moisture	Protein	Fat	Ash	NFE	
Level of metabolizable energy (ME) Kcal/Kg (L)						
Recommended (R)	74.34	19.14	3.20	2.10	1.23	
R-150	73.94	19.42	3.08	2.34	1.22	
SEM ¹	0.18	0.61	0.64	0.17	0.01	
P-value	0.116	0.745	0.898	0.326	0.678	
Type of addition(T)						
Without ²	74.21 ^b	19.92	2.73	1.90	1.23	
Selenium (Se) ³	74.01 ^{bc}	18.73	3.41	2.62	1.22	
Choline ⁴	73.30 ^c	19.84	3.44	2.19	1.22	
Mixture ⁵	75.03 ^a	18.62	2.96	2.16	1.23	
SEM	0.25	0.86	0.90	0.24	0.01	
P-value	0.001	0.580	0.930	0.231	0.964	
Carcasse part						
Front	74.42	21.26 ^a	1.00 ^b	2.10	1.23	
Rear	73.86	17.30 ^b	5.28 ^a	2.34	1.23	
SEM	0.26	0.24	0.19	0.17	0.01	
P-value	0.136	<0.001	<0.001	0.330	0.761	
L × T (treatments)						
R	Without	73.59 ^{cd}	19.94	3.44	1.80	1.23
	Selenium	74.63 ^{bc}	18.23	3.49	2.43	1.23
	Choline	73.39 ^d	19.78	3.26	2.35	1.22
	Mixture	75.75 ^a	18.61	2.59	1.81	1.23
R-150	Without	74.84 ^{ab}	19.91	2.03	2.01	1.22
	Selenium	73.39 ^d	19.24	3.33	2.82	1.22
	Choline	73.22 ^d	19.91	3.63	2.02	1.23
	Mixture	74.30 ^{bcd}	18.63	3.33	2.51	1.23
SEM	0.35	1.21	1.28	0.34	0.01	
P-value	0.003	0.969	0.846	0.506	0.902	

^{a-d} Means in a column with different superscripts differ significantly ($P \leq 0.05$).

¹ Pooled SEM ² without Se or choline supplementation ³ 0.1 mg Se /Kg diet

⁴ 0.1% choline ⁵ 0.05 mg Se /Kg diet + 0.05% choline

In this regard, **Dozier *et al.* (2006)** established that no economic benefit was realized with using high level of AME (over 3220 kcal/kg diet) with changing diet and meat prices. More over, **Abdel-Samai *et al.* (2007)** found that economic efficiency was decreased linearly by fat supplementation increased in the diets.

It would be concluded that, no simple guideline can exist with regard to formulation of broiler diets suitable for the different seasons and geographical locations or for the selection of the Economically optimal combination of nutrition and environmental temperature. Therefore, dietary ME can be reduced from the recommended level up to 150 Kcal/Kg diet and supplement these diets with choline, Se without affecting Cobb broiler performance.

Table 8: Effect of dietary energy levels with or without selenium and choline supplementation on economic efficiency (EEf) of broiler chickens.

Items	Level of metabolizable energy (ME, Kcal./Kg diet (L))							
	Recommended (R)				R-150			
Type of addition	Without ¹	Selenium (Se) ²	Choline ³	Mixture ⁴	Without	Selenium	Choline	Mixture
Diet (D)	D1	D2	D3	D4	D5	D6	D7	D8
a ₁	0.1861	0.2049	0.2059	0.2169	0.2015	0.2042	0.2121	0.2171
b ₁	591.80	596.80	594.80	595.80	567.40	572.40	570.40	571.40
a ₁ x b ₁ =c ₁	110.10	122.26	122.47	129.23	114.34	116.86	120.98	124.02
a ₂	1.0318	1.0685	1.0291	1.0246	1.0488	1.0603	1.0599	1.0839
b ₂	575.90	580.90	578.90	579.90	548.00	553.00	551.00	552.00
a ₂ x b ₂ =c ₂	594.21	620.71	595.77	594.18	574.72	586.32	583.98	598.29
a ₃	2.6364	2.7485	2.6625	2.6751	2.6853	2.8264	2.6378	2.8160
b ₃	570.40	575.40	573.40	574.40	545.10	550.10	548.10	549.10
a ₃ x b ₃ =c ₃	1503.8	1581.5	1526.7	1536.6	1463.8	1554.8	1445.8	1546.2
(c ₁ +c ₂ +c ₃)=c _{total}	2208.1	2324.4	2244.9	2260.0	2152.8	2258.0	2150.7	2268.6
d	1472.1	1472.1	1472.1	1472.1	1472.1	1472.1	1472.1	1472.1
e = c _{total} + d	3680.2	3796.5	3717.0	3732.1	3624.9	3730.1	3622.8	3740.6
f	1.8925	1.9600	1.9717	1.9097	2.0117	2.0168	2.0606	2.1211
g	2200.0	2200.0	2200.0	2200.0	2200.0	2200.0	2200.0	2200.0
f x g=h	4163.6	4312.0	4337.8	4201.4	4425.8	4437.0	4533.3	4666.4
h - e =i	483.40	515.51	620.84	469.34	800.90	706.90	910.51	925.83
EEf = i / e	0.1314	0.1358	0.1670	0.1258	0.2209	0.1895	0.2513	0.2475
r	100.00	103.37	127.16	95.74	168.21	144.28	191.34	188.43

¹ without Se or choline supplementation ² 0.1 mg Se /Kg diet ³ 0.1% choline ⁴ 0.05 mg Se /Kg diet + 0.05% choline
a₁, a₂ and a₃ average feed intake (Kg/bird) during the periods of starter, grower and finisher, respectively.
b₁, b₂ and b₃ price / Kg feed (P.T.) during the periods of starter, grower and finisher, respectively (based on average local market price of diets during the experimental time).
c₁, c₂ and c₃ feed cost (P.T.) during the periods of starter, grower and finisher, respectively.
Total feed cost (P.T.) = c_{total} = (c₁+c₂+c₃)
d other costs (including chick pries and other management costs(passed on feed cost = 60% of total cost))
Total cost = c_{total} + d = e
Average LBWG (Kg/ bird) f
Price / Kg live weight (P.T.) g.....(according to the local market price at the experimental time).
Total revenue (P.T.) = f x g = h
Net revenue (P.T.) = h - e =i
Economical efficiency = (i / e)(net revenue per unit feed cost).
Relative efficiency r.....(assuming that economic efficiency of the control group (1) equals 100).

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تأثير مستويات الطاقة مع أو بدون إضافة السيلينيوم والكولين علي أداء بداري التسمين رمضان محمد سلامة إمام

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أجري هذا البحث لدراسة تأثير استخدام مستويين من الطاقة الممتلئة (المستوي الموصي به، المستوي الموصي به - ١٥٠ كيلو كالوري/كجم عليقة) مع أربعة أنواع من الإضافات (بدون إضافة سيلينيوم أو كولين، ٠.١٠ مللجم سيلينيوم/كجم عليقة في صورة سيلينيوم عضوي (سل بلس)، ٠.١٠ % كولين و ٠.٠٥ مللجم سيلينيوم/كجم عليقة + ٠.٠٥ % كولين). في نظام عملي ٢ x ٨ للحصول علي ٨ معاملات غذائية علي أداء بداري التسمين. كان العدد الإجمالي ١٩٢ كنبوت غير مجنس من سلالة كب وغذيت الكنكايت عمر يوم ولمدة ٥ أيام علي عليقة المقارنة.

وتم تلخيص النتائج المتحصل عليها كما يلي :

الأداء: الكنكايت المغذاه علي عليقة تحوي المستوي الموصي به - ١٥٠ كيلو كالوري طاقة ممثلة/كيلو جرام عليقة كانت الاعلي معنويا في وزن الجسم عند عمر ٤١ يوم ووزن الجسم المكتسب، كمية الغذاء المستهلكة، معدل النمو، ومعامل الأداء الإنتاجي خلال الفترة من ٦-٤١ يوم، بينما الكنكايت المغذاه علي عليقة تحوي المستوي الموصي به من الطاقة ممثلة كانت الأقل معنويا خلال نفس الفترات السابقة. الكنكايت المغذاه علي عليقة تحوي المستوي الموصي به - ١٥٠ كيلو كالوري طاقة ممثلة/كيلو جرام عليقة كانت الأفضل معنويا في كفاءة تحويل كل من الغذاء، البروتين والطاقة خلال الفترة من ٢٥ إلي ٤١ يوم، والتي تغذت علي عليقة تحوي المستوي الموصي به - ١٥٠ كيلو كالوري طاقة ممثلة/كيلو جرام عليقة كانت الأفضل معنويا في كفاءة تحويل الطاقة خلال الفترة من ٦ إلي ٤١ يوم.

لم يؤثر معنويا نوع الإضافة ولا التداخل بين مستوي الطاقة ونوع الإضافة (المعاملات التجريبية) علي وزن الجسم ووزن الجسم المكتسب وكفاءة تحويل كل من الغذاء، البروتين والطاقة، معدل النمو، ومعامل الأداء الإنتاجي خلال الفترة من ٢٥ إلي ٤١ يوم و٦-٤١ يوم (فترة الناهي والفترة الكلية للتجربة). الكنكايت المغذاه علي عليقة تحوي المستوي الموصي به من الطاقة الممتلئة مع إضافة ٠.٠٥ مللجم سيلينيوم/كجم عليقة و ٠.٠٥ % كولين كانت الاعلي معنويا في كمية الغذاء المستهلكة خلال الفترة من ٦-٤١ يوم.

قياسات الذبحة% وقياسات الدم: لم يكن هناك أي تأثير معنوي لأي من مستوي الطاقة أو نوع الإضافة ولا التداخل بين مستوي الطاقة ونوع الإضافة علي قياسات الذبحة% وقياسات الدم، فيما عدا نوع الإضافة مع النسبة المئوية للتصافي والبرسا والتي تأثرت معنويا. الكنكايت المغذاه علي عليقة تحوي 0.1 مللجم سيلينيوم/كجم عليقة كانت الاعلي في النسبة المئوية للتصافي. أيضا التداخل بين مستوي الطاقة ونوع الإضافة والتي كان له تأثير معنوي علي total leucocytes. الكنكايت المغذاه علي عليقة تحوي المستوي الموصي به من الطاقة الممتلئة - ١٥٠ كيلو كالوري طاقة ممثلة/كيلو جرام مع إضافة ٠.١٠ % كولين كانت الاعلي معنويا في total leucocytes في نهاية التجربة.

تأثر معنويا نشاط أنزيم الجلوتاتيون بيروكسيداز بكل من مستوي الطاقة الممتلئة ونوع الإضافة، الكنكايت المغذاه علي عليقة تحوي ٠.١٠ مللجم سيلينيوم/كجم عليقة كانت الاعلي معنويا في نشاط أنزيم الجلوتاتيون بيروكسيداز عند ٤١ يوم.

التحليل الكيمائي للحم بداري التسمين: لم يكن هناك أي تأثير معنوي لأي من مستوي الطاقة أو نوع الإضافة ولا التداخل بين مستوي الطاقة ونوع الإضافة علي التحليل الكيمائي للحم بداري التسمين فيما عدا الرطوبة % والتي تأثرت معنويا.

الكفاءة الاقتصادية: تحسنت قيم الكفاءة الاقتصادية والنسبية للكنكايت المغذاه علي كل المعاملات التجريبية خلال الفترة من ٦-٤١ يوم من العمر فيما عدا الكنكايت المغذاه علي عليقة تحوي المستوي الموصي به من الطاقة الممتلئة مع إضافة ٠.٠٥ مللجم سيلينيوم/كجم عليقة و ٠.٠٥ % كولين (كان لها أقل القيم (٠.١٢٦ و ٩٥.٧٤ علي التوالي)) عند مقارنتها بتلك المغذاه علي عليقة المقارنة. فكانت أحسن قيمة للكفاءة الاقتصادية والنسبية للكنكايت المغذاه علي عليقة تحوي المستوي الموصي به من الطاقة الممتلئة - ١٥٠ كيلو كالوري طاقة ممثلة/كيلو جرام مع إضافة ٠.١٠ % كولين (٠.٢٥١ و ١٩١.٣٤ علي التوالي).

يمكن التوصية بأنه يمكن خفض مستوي الطاقة الممتلئة عن المستوي الموصي به بمعدل ١٥٠ كيلو كالوري/كيلو جرام عليقة مع إضافة ٠.١٠ مللجم سيلينيوم عضوي (سل بلس)/كجم عليقة و ٠.١٠ % كولين بدون التأثير علي الأداء الإنتاجي لسلالة الكب.