

# Effect of oil source and antioxidant supplementations on growth performance and meat quality of Japanese quail males

Y. A. ATTIA<sup>1</sup>, A. E. ABD-EL-HAMID<sup>1</sup>, F. A. ABD EL-GHANY<sup>2</sup> and H. I. HABIBA<sup>1</sup>

<sup>1</sup>Animal and Poultry Production Department, Faculty of Agriculture, Alexandria University Damanhour, 22516, Egypt, e-mail: [yfat\\_alexu40@hotmail.com](mailto:yfat_alexu40@hotmail.com)

<sup>2</sup> Animal Production Research Institute, ARC, Ministry of Agriculture, Egypt

---

**Abstract:** The effect of dietary 0.3 and 6% distilled fatty acids (DFA) without or with 50 ppm of Vit. E and/or 0.2 ppm of organic selenium (Selplex®) in Japanese quail (JQ) male all-mash diets was tested during 21-49 d of age. The DFA was gradually replaced 50 and 100% of the 3% sunflower oil in the control diet. Growth performance, digestibility of nutrients, meat quality and plasma constituents and fatty acid profiles of liver and muscle were investigated.

Growth and FCR were improved ( $p<0.05$ ) due to dietary inclusion of 3 and 6% DFA levels. Digestibility of DM, CP, and CF was improved ( $p<0.05$ ) due to Vit. E addition. Organic Se alone or with Vit. E improved ( $p<0.05$ ) digestibility of lipid. Liver lipid (%) was increased ( $p<0.05$ ) due to inclusion of 3% DFA. Meanwhile, liver (%) was decreased ( $p<0.05$ ) due to inclusion of 3 and 6% DFA. Inclusion of 6% DFA increased ( $p<0.05$ ) TBARS, while the opposite trend was shown with 3% DFA or when Vit. E was supplemented to the 0 and 6%DFA diet. Moreover, Vit. E with Se resulted in further decrease in TBARS and this was evident in 6% DFA containing diet. Dietary inclusion of 6% DFA increased TUFA in muscle, while decreasing PUFA/MUFA ratio. Addition of Vit. E to 3% DFA diet decreased muscle TUFA, while induced the opposite trend in the 6% DFA diet. The increase in the TUFA due to Vit. E addition to 6% DFA diet was concurred with increasing PUFA. There was a decrease in muscle SFA/TUFA ratio due to Se addition to 0 and 3% DFA diets, while Vit. E plus Se resulted in a similar effect in 6% DFA diet. In conclusion, 3% of DFA could be included in JQ male diets during 21-49 d of age without adverse effects on growth performance, digestibility of nutrients, and meat quality, while addition of Vit. E with Se could permit inclusion of 6% DFA without affecting meat quality, while improved shelf life of meat.

---

**Keywords:** Japanese quail; oil sources; antioxidants; growth performance; quality and fatty acid profiles of meat

## Introduction

Distillates fatty acids are by-product of edible oil refining, and usually contain a high proportion of free fatty acids and little of neutral oils. Their use in poultry nutrition was acknowledged (Dorgham *et al.*, 2000). Fats/ oils and especially free fatty acids are very susceptible to oxidation and can lead to the development of rancidity and off color changes or change of texture, and this can have a dramatic effect on food and feed quality and thus on human and animal health. The requirement for Vit.E is complicated by its positive relationship with dietary intakes of the PUFAs (Basu and Dickerson, 1996). Se from the group of oligo-elements that found in glutathione peroxidase, an essential enzyme for protection of tissues against free radicals and oxidation (Surai and Dvorska, 2002). The possibility of replacing 3% dietary sunflower oil by 0, 3 and 6% of DFA and the effect of Vit.E and/or organic Se on productive performance, meat quality, and plasma constituents was investigated with JQ males during 21-49 d of age period.

## Materials and methods

Three levels of DFA at 0, 3 and 6% were tested in isocaloric, isonitrogenous diets to replace 50 and 100% of the 3% dietary sunflower oil (Table 1) without or with 50 ppm of vitamin E ( - Tocopherol acetate Agrifax Davicl Knight, UK.) and/ or 0.2 ppm of organic Selenium (Sel-plex<sup>®</sup>, Selenium yeast Brewer's dried yeast produced by Alltech, INC., USA). Thus, the experimental design was 3×4 factorial arrangement. Each diet was fed to four replicates of 15 JQ males. Each replicate was housed in wood cages (50×60×50 cm) during 21-49 d of age. Thus, 720, 21 d old JQ were used and offered *ad libitum* water and mash form of feeds. Birds were illuminated with 24h of light daily. Birds were weighed (g) individually and BWG was calculated.

**Table (1) Composition and calculated analyses of the experimental diets and fatty acid profiles of the oil sources**

Ingredients, (g/kg)	Distillated fatty acid, %		
	0.0	3.0	6.0
Yellow corn	450	440	425
Soybean meal (44%CP)	472	477	481
DFA	0	30	60
Wheat bran	14	3.8	0
Sunflower oil	30	15	0
Limestone	4.5	4.2	4
Dicalcium phosphate	20.5	21	21
Vit+Min mix <sup>1</sup>	3	3	3
NaCl	3	3	3
DL-methionine	3	3	3
Total	1000	1000	1000
Calculated values			
ME kcal/kg diet	2879	2882	2874
Crude protein,%	24.99	24.96	24.95
Methionine,%	0.67	0.67	0.69
TSAA, %	1.06	1.06	1.06
Lysine,%	1.40	1.40	1.40
Ca,%	1.06	1.07	1.01
Available P, %	0.50	0.50	0.50
Selenium, mg/kg	0.172	0.163	0.160
Vitamin E, mg/kg	21.0	20.7	20.3
<b>Fatty Acid</b>	<b>Carbon atom</b>	<b>Sunflower oil</b>	<b>DFA</b>
Capric	C <sub>10:0</sub>	....	0.349
Lauric	C <sub>12:0</sub>	....	0.899
Myristic	C <sub>14:0</sub>	0.225	1.099
Palmitic	C <sub>16:0</sub>	14.597	18.914
Palmitolitic	C <sub>16:1</sub>	0.262	0.874
Stearic	C <sub>18:0</sub>	5.929	7.303
Oleic	C <sub>18:1</sub>	24.193	26.217
Linoleic	C <sub>18:2</sub>	41.170	37.328
Arachidic	C <sub>20:0</sub>	13.025	6.517
Eicosenic	C <sub>20:1</sub>	....	....
Behenic	C <sub>22:0</sub>	0.599	0.499
Erucic	C <sub>22:1</sub>	....	....
SFA	%	34.375	35.58
TUFA	%	65.625	64.420
SFA/TUFA	%	0.524	0.552
MUFA	%	24.455	27.09
PUFA	%	41.170	37.328
PUFA / MUFA	%	1.684	1.378

<sup>1</sup>Vitamins and minerals mixture provide per kg of diet vitamin A (as all-trans-retinyl acetate); 12000 IU; vitamin E (all rac- $\alpha$ -tocopheryl acetate); 10 IU; k<sub>3</sub> 3mg; Vit.D<sub>3</sub>, 2200 ICU; riboflavin, 10 mg; Ca pantothenate, 10 mg; niacin, 20 mg; choline chloride, 500 mg; vitamin B<sub>12</sub>, 10 $\mu$ g; vitamin B<sub>6</sub>, 1.5 mg; thiamine (as thiamine mononitrate); 2.2 mg; folic acid, 1 mg; D-biotin, 50 $\mu$ g. Trace mineral (milligrams per kilogram of diet) Mn, 55; Zn, 50; Fe, 30; Cu, 10; Se, 0.1 and Ethoxyquin 3mg.

Feed intake (FI) was recorded for each replicate and thereby FCR as g feed/g BWG was calculated. Apparent digestibility of DM, CP, EE and CF was done as cited by Aggoor *et al.* (2000)

using total collection method with three replicates of 4 males each/treatment. At 49 d of age, 6 JQ males were slaughtered after fasting overnight, processed and the weight of carcass and internal organs were taken and expressed as (%) of live body weight. Chemical composition and physical characteristics of meat were done using a sample of 50 % of breast meat + 50 % of thigh meat. The DM, CP, EE and crude ash (CA) of meat and liver lipid, feeds and excrement were determined according to AOAC (1990) and expressed in dry matter basis. Meat tenderness and WHC, pH and color were carried out as cited by Aggoor *et al.* (2000). Six blood samples were collected in heparinized tubes of each treatment at 42 days of age.

Plasma was separated by centrifugation at 3000 rpm for 10 minutes and stored at -18°C until analysis. Plasma total protein, total lipids, total cholesterol, AST and ALT were determined as cited by Aggoor *et al.* (2000). Plasma LDL and HDL were determined according to the method of Fruchart (1982) and Gordon and Amer (1977), respectively. The fatty acids of meat and liver were prepared according to the method of Brockerhoff (1965), and the methyl esters of fatty acids were dissolved in chloroform and aliquots of this solution were subjected to the Gas-Liquid Chromatographic (GLC) technique. Thiobarbituric acid reacting substances (TBARS) (mg/100 g meat) were determined spectrophotometrically according to the method of Ohkawa *et al.* (1979). Statistical analysis was done using nested analyses of the GLM of SAS® (SAS, Institute (1990), while main differences were compared using Student-Newman-Keuls-Test.

## Results and discussion:

Growth and FCR were similarly improved ( $p<0.05$ ) due to 3 and 6%DFA vs. 0% DFA, while FI was not affected by DFA level. There was no significant interaction between DFA level and antioxidants in BWG, FI and FCR. Also, Dorgham *et al.* (2000) indicated that DFA could be used as ME source in broiler diets up to 4%.

**Table (2): Effects of distilled fatty acid (DFA) levels and/or 50 ppm of Vitamin E and 0.2 ppm of organic selenium on body weight gain, feed intake, feed conversion ratio during 21-49 d of age of Japanese quail males, and digestibility of nutrients**

Treatment	BWG, g	Feed intake, g/chicks	FCR, g/g	DM, %	CP, %	EE, %	CF, %	No of dead chicks
Main effect of DFA, %								
0	76.7 <sup>b</sup>	675.1	8.76 <sup>a</sup>	81.9 <sup>a</sup>	79.4 <sup>a</sup>	83.3 <sup>a</sup>	47.0 <sup>a</sup>	6.0
3	81.4 <sup>a</sup>	669.8	8.22 <sup>b</sup>	80.7 <sup>b</sup>	76.4 <sup>b</sup>	83.5 <sup>a</sup>	39.1 <sup>c</sup>	11.0
6	81.0 <sup>a</sup>	662.4	8.03 <sup>b</sup>	79.4 <sup>c</sup>	76.4 <sup>b</sup>	82.0 <sup>b</sup>	42.6 <sup>b</sup>	3.0
P value	0.01	NS	0.01	0.0001	0.001	0.0001	0.0001	...
SEM	0.6	4.1	0.17	0.8	0.6	0.5	0.6	...
Interaction between DFA and antioxidants								
0×0	75.7	693.4	9.15	82.1	78.5	80.9	44.4	1.0
0×Vit.E	79.0	669.1	8.49	82.2	80.7	84.2	49.2	2.0
0×Se	79.3	653.8	8.23	80.7	78.2	81.3	48.2	3.0
0×Vit.E+Se	74.8	683.9	9.17	82.7	80.0	86.6	46.0	0.0
3×0	77.3	659.5	8.44	80.5	77.8	82.9	41.5	1.0
3×Vit.E	83.1	689.0	8.33	79.0	75.7	82.0	41.0	4.0
3×Se	84.8	660.8	7.77	84.9	77.2	85.2	39.8	5.0
3×Vit.E+Se	80.9	670.0	8.36	78.2	74.7	83.8	34.0	1.0
6×0	78.8	668.5	8.41	80.7	77.6	79.4	38.9	1.0
6×Vit.E	77.4	653.7	8.17	80.3	74.6	81.0	47.8	2.0
6×Se	84.2	668.7	7.79	78.2	75.9	83.7	41.0	0.0
6×Vit.E+Se	83.2	658.5	7.74	78.2	77.4	83.8	42.0	0.0
P value	NS	NS	NS	0.01	0.0001	0.0001	0.0001	...
SEM	2.1	8.27	0.34	1.6	1.2	1.1	1.3	...

<sup>a-b</sup> Means within a column with different superscript differ ( $p<0.05$ ); NS, not significant.

Digestibility of most nutrients was decreased ( $p<0.05$ ) by inclusion of either level of DFA, with the effect of 6% was more severe for digestibility of DM and EE%, while 3% had more severe effect on CF digestibility. Number of dead chicks varied from one to five chicks/treatment while one chick

dead of each control groups, meaning that up to 6% DFA had no adverse effect on mortality of JQ-males. There were no negative effects ( $p>0.05$ ) of different DFA levels and their interaction on dressing and most of body organs (data not shown). Similar results were reported by Aggoor *et al.* (2000) and El-Hussieny *et al.* (2002).

There was interaction ( $p<0.05$ ) between antioxidants and DFA levels on DM, CP, EE and CF digestibility. Digestibility of DM was decreased due to Se addition to the 0 and 6% DFA diets and due to addition of Vit E with Se to 3 and 6 and %DFA diet. While DM digestibility was improved due to Se addition to 3% DFA level. Addition of Vit.E with or without Se to 0%DFA diet improved digestibility of CP by 2.8 and 1.9%, and EE by 4.1 and 7.1% and CF by 10.8 and 3.6 compared to its respective control. Also, addition of Se with or without Vit.E to 3 and 6% DFA levels improved EE digestibility by 2.8 and 1.1% and 5.4 and 5.5% respectively compared to its respective control. These results indicated that the effect of Vit.E and/or Se on nutrient digestibility depends on DFA level.

Meat moisture (%) was decreased ( $p<0.05$ ), while ash (%) was increased ( $p<0.05$ ) by 10.9% due to inclusion of 6% DFA compared to the control. However, CP and EE (%) of meat and abdominal fat were not affected ( $p<0.05$ ) by DFA level. Liver EE (%) was increased ( $p<0.05$ ) by 7.6 and 9.6% due to inclusion of 3% DFA compared to 0 and 6% DFA level, respectively. Meanwhile, liver (%) was decreased ( $p<0.05$ ) by 8.7 and 8.2% due to dietary inclusion of 3 and 6% DFA compared to the control diet. These results indicated that up to 6% DFA did not negatively affect protein and lipid (%) of muscle and liver and thereby DFA level and antioxidants did not affect physical characteristics of meat (data not shown). Also, Shrivastav and Panda (1993) indicated that neither 2.5 or 5% of dietary groundnut oil nor beef tallow altered dressing yield nor abdominal fat content in quails, while muscle fat (%) was higher ( $p<0.05$ ) of groundnut oil fed group.

**Table (3): Effects of distilled fatty acids (DFA) levels and/or 50 ppm of Vitamin E and 0.2 ppm of organic selenium on chemical composition of meat and liver and abdominal fat (%) of JQ males**

Treatment	Moist ure %	Protein %	Ether Extract %	Ash %	Abdominal fat, %	Liver fat %	Liver, %	TBARS
Main effect of DFA, %								
0	67.06 <sup>a</sup>	70.55	21.86	3.86 <sup>b</sup>	0.22	9.53 <sup>b</sup>	1.84 <sup>a</sup>	5.56 <sup>b</sup>
3	67.27 <sup>a</sup>	71.02	21.19	3.95 <sup>b</sup>	0.34	10.25 <sup>a</sup>	1.68 <sup>b</sup>	5.32 <sup>c</sup>
6	66.08 <sup>b</sup>	69.57	22.14	4.28 <sup>a</sup>	0.14	9.35 <sup>b</sup>	1.69 <sup>b</sup>	8.02 <sup>a</sup>
P value	0.001	NS	NS	0.0001	NS	0.0001	0.05	0.0001
SEM	0.23	0.42	0.84	0.04	0.06	0.09	0.05	0.005
Interaction between DFA and antioxidants								
0×0	65.95	72.65	21.98	3.30	0.20	10.58	1.68	8.21
0×Vit.E	66.90	70.59	20.58	4.28	0.11	9.90	1.87	3.15
0×Se	68.13	65.59	25.23	4.45	0.36	9.27	1.93	6.17
0×Vit.E+Se	67.28	73.11	19.68	2.78	0.20	8.39	1.89	4.17
3×0	64.83	72.90	20.50	2.90	0.45	10.17	1.62	4.25
3×Vit.E	66.68	70.81	20.18	3.88	0.17	11.13	1.85	7.29
3×Se	68.78	70.53	23.00	4.40	0.44	10.14	1.71	4.89
3×Vit.E+Se	68.80	69.85	21.08	4.63	0.30	9.58	1.55	4.86
6×0	72.00	71.72	21.33	4.73	0.19	10.53	1.71	9.98
6×Vit.E	61.88	68.54	20.00	4.78	0.32	7.79	1.79	7.84
6×Se	63.28	67.38	25.73	2.58	0.10	10.04	1.52	11.65
6×Vit.E+Se	67.15	70.64	21.50	5.03	0.01	9.06	1.73	2.62
P value	0.0001	0.01	0.05	0.0001	NS	0.0001	NS	0.0001
SEM	0.45	0.85	0.57	0.09	0.11	0.17	0.09	0.02

<sup>a-c</sup> Means within a column with different superscript differ ( $p<0.05$ ); NS, not significant.

There was interaction ( $p<0.05$ ) between DFA level and antioxidants on moisture, CP, EE and ash (%) of meat and fat of liver (%). Nonetheless, there was no interaction ( $p>0.05$ ) on abdominal fat and liver (%). Results indicated that nutrient deposition in muscle and liver are depends on DFA level and the type of antioxidants due to its specific mode of action.

Liver fat (%) of the control group was decreased due to addition of Vit.E and/or Se, with strong effect of the combination than Vit.E or Se alone, (20.7 vs. 6.43 and 12.4% respectively), indicating a synergistic effect between the two antioxidants for controlling lipid deposition in liver of 0 and 3%

DFA groups with the corresponding value was 5.8% for 3%DFA group, showing that Vit.E with Se had a greater effect on 0%DFA diet. However, this synergistic effect was diminished in 6% DFA diet as it had less effect than that of the Vit.E (14.0 vs. 26.0%). However, Vit.E increased liver lipid (%) by 9.4% of the 3% DFA group compared to its respective control. This indicated that the effect of antioxidants on meat and liver lipids might be depended on fatty acid profile of the experimental diets. PUFA does not limit Vit.E absorption; however they might increase its degradation in the gastrointestinal tract (Villaverde *et al.*, 2004). In this regard, Aydin (2005) reported that streulic acid and CLA inhibit the activity of delta-9 desaturase enzyme in the liver and cause lower level of oleic acid, which has a great influence in the secretion of triacylglycerols from the chicken hepatocytes compared to other fatty acids such as linoleic and palmitic acids. In this regard, the stearic, oleic and MUFA were higher of DFA than those of sunflower oil, while PUFA and linoleic were higher of sunflower oil.

Inclusion of 6% DFA ( $p<0.05$ ) increased TBARS, while 3% ( $p<0.05$ ) decreased it compared to the control group. Similarly, Sheehy *et al.* (1993) and Galvin *et al.* (1997) indicated that caution should be exercised in the use of oxidized oils in poultry diets if undesirable changes in composition and oxidative stability of carcass lipids are to be avoided since muscle  $\alpha$ -tocopherol level decreased.

There was an interaction ( $p<0.05$ ) between DFA level and antioxidants on TBARS. Results indicated that Vit.E and/or Se decreased TBARS of the control group by different magnitude with Vit.E had the strong effect (61.6%). However, Vit.E had less effect on the 6% DFA (21.4%). Evidently, Vit E with Se to the 6% DFA diet decreased TBARS by 73.7 and 66.6 and 77.5% compared to the control, Vit.E and Se supplemented groups respectively. Similarly, Surai and Dvorska (2002) found that Sel-plex without or with Vit.E could improve antioxidant defiance in thigh muscle and decrease ( $p<0.05$ ) lipid peroxidation during long-term meat storage at  $-20^{\circ}\text{C}$ . In conclusion, Vit.E with Se decreased TBARS of group fed 6% DFA, whereas Vit.E is sufficient for 0% DFA diet. Evidently, arachidic acid was increased due to inclusion of 3% DFA. However, increasing DFA to 6% decreased arachidic acid (Table 4). Addition of Vit.E to diets containing 3% DFA increased oleic acid of liver. It was found that when unsupplemented diets were compared, muscle palmitic acid was increased due to inclusion of 3 and 6% DFA compared to the control diet. While, palmitoleic and stearic were decreased, whereas linoleic was increased due to feeding diet containing 6% DFA. Obviously, there was an increase in oleic acid, but a decrease in arachidic acid of muscle with increasing the level of DFA compared to 0%DFA. There was an increase in stearic and arachidic acids in liver of groups fed 3% DFA and in palmitic and stearic acids in liver of groups fed 6% of DFA compared to 0%DFA. Linoleic acid of muscle was decreased due to addition of Vit.E and Se to the control diet and 3% DFA, too. However, Vit.E without or with Se increased linoleic acid of muscle of 6% DFA level. Clearly Se decreased linoleic acid of muscle of the 0 and 3% DFA groups with the effect being greater of the later group (Table 4). Arachidic acid of liver was decreased by Vit.E and Se addition to all groups, while a combination decreased it further. Addition of Vit.E to the control diet increased linoleic acid of liver, while Vit E with Se induced similar effect in 3 and 6%DFA.

Dietary 6% DFA decreased SFA and increased TUFA in muscle, the increase in TUFA was accompanied with increasing MUFA and to some extent PUFA, however, PUFA/MUFA ratio was not greatly affected compared to 0%DFA, although it was increased compared to 3% DFA level (Table 4). The changes in liver SFA and TUFA and SFA/TUFA were contrary to those shown in muscle. However, liver PUFA/MUFA was increased due to 6% DFA compared to 0% DFA. Addition of Vit.E to 3 and 6% DFA diets increased the SFA in muscle and decreased the TUFA compared to its respective controls, while had no effect on 0% DFA group (Table 4). Vit E decreased SFA and increased TUFA and decreased TSA/TUFA of liver of 3% DFA group, while the opposite trends were shown in groups fed 0 and 6%DFA. Evidently, SFA/TUFA of muscle was decreased due to Se addition to 0 and 3% DFA diets, while increased it of 6% DFA diet. Whilst, Se induced the contrary trend in SFA/TUFA of liver. On the other hand, Vit E or Se decreased the PUFA/MUFA of muscle of 0 and 3% DFA, while induced the contrary trend of 6% DFA group. Also, Vit E increased PUFA/MUFA of 0 and 6% DFA levels of liver, while decreased it of 3%DFA. Addition of Se increased PUFA/MUFA of liver of 0% DFA and has small effect on 3% DFA, while decreased it of 6%DFA. Addition of Vit. E with Se to 6% DFA diet increased PUFA/MUFA of muscle, while had no effect on 0%DFA and decreased it of 3% DFA diet (Table 4). Meanwhile, Vit E with Se increased PUFA/MUFA ratio by different magnitude of liver of levels. These indicated that the changes in fatty acid profile of muscle and liver depend on level of DFA and type of antioxidants. In this regard, Kralik

*et al.* (1997) reported that SFA and PUFA in abdominal fat depended on dietary fat sources and dietary  $\alpha$ -tocopheryl acetate, however increasing dietary PUFA from 15 to 61 g/kg, decreased total fatty acid of thigh by 17%, but did not affect breast meat fatty acids (Cortinas *et al.*, 2004).

**Table (4): Effects of distilled fatty acids (DFA) levels and/or 50 ppm of Vitamin E and 0.2 ppm of organic selenium on meat and liver fatty acid composition.**

Criteria	DFA %											
	0				3				6			
	0	Vit.E	Se	Vit.E +Se	0	Vit.E	Se	Vit.E +Se	0	Vit.E	Se	Vit.E +Se
Fatty acid profile of meat												
Lauric	0.43	0.42	0.72	0.43	0.65	0.52	0.44	0.47	0.72	0.47	0.59	0.39
Myristic	1.41	1.56	2.02	2.15	1.56	1.55	2.50	1.13	1.41	0.90	1.48	1.17
Palmitic	17.3	21.5	21.0	19.5	20.88	25.7	21.8	23.0	19.3	23.3	22.8	15.1
Palmitolitic	4.27	3.69	3.09	5.34	4.13	4.22	4.49	3.99	2.25	4.11	4.24	2.32
Stearic	10.9	10.1	9.7	11.0	10.05	11.7	9.5	11.3	8.84	10.3	11.9	9.46
Oleaic	28.4	30.2	34.2	28.0	30.0	28.7	28.3	31.5	33.8	26.9	27.7	31.2
Linoleaic	24.6	23.5	22.5	25.0	23.4	21.1	17.7	22.3	25.9	28.4	25.6	29.7
Arachidic	10.3	7.1	5.57	6.50	7.28	3.39	2.86	4.51	5.47	1.94	1.88	6.76
Eicosenic	...	...	...	...	....	...	5.55	....	....	....	....	1.00
Behenic	2.39	2.09	1.24	2.04	2.05	3.32	1.23	1.88	2.41	3.70	3.77	1.93
Erucic	...	....	....	...	....	....	5.71	....	....	...	....	0.97
SFA	42.8	42.6	40.3	41.6	42.5	46.0	38.2	42.3	38.1	40.7	42.5	34.9
TUFA	57.2	57.4	59.7	58.4	57.5	54.0	61.8	57.7	61.9	59.3	57.5	65.1
SFA/TUFA	0.75	0.75	0.69	0.71	0.74	0.85	0.62	0.73	0.62	0.68	0.74	0.53
MUFA	32.6	33.9	37.2	33.4	34.1	32.9	44.1	35.4	36.0	30.9	31.9	35.4
PUFA	24.6	23.5	22.5	25.0	23.4	21.1	17.7	22.3	25.9	28.4	25.6	29.7
PUFA/MUFA	0.75	0.69	0.61	0.75	0.68	0.64	0.40	0.63	0.72	0.92	0.80	0.85
Fatty acid profile of liver												
Lauric	0.49	0.28	1.04	0.18	0.32	0.45	0.47	0.42	0.79	0.60	0.37	0.55
Myristic	1.21	0.74	1.55	0.69	0.93	1.29	1.21	0.85	1.39	1.51	1.37	0.77
Palmitic	15.1	21.0	23.6	21.1	15.7	21.6	27.0	23.8	18.6	26.7	16.4	25.6
Palmitolitic	3.48	2.21	2.68	1.86	2.71	2.87	2.79	2.21	2.74	2.42	3.26	0.66
Stearic	9.06	18.8	13.8	21.2	13.3	11.8	17.9	19.6	13.8	13.7	7.95	22.3
Oleaic	32.1	20.9	27.2	22.7	27.3	30.9	24.1	22.1	29.7	24.9	38.7	13.7
Linoleaic	24.4	26.8	20.4	31.0	24.5	23.4	21.4	26.2	23.8	24.6	22.5	26.2
Arachidic	8.13	1.38	5.13	0.70	12.7	4.69	2.01	1.28	6.32	1.94	7.32	1.08
Eicosenic	2.79	...	....	....	....	...	....	....	...	....	....	1.10
Behenic	2.60	7.70	4.69	0.56	2.68	2.86	3.22	3.57	2.60	3.63	2.12	8.09
Erucic	0.73	....	....	....	....	....	....	....	....	....	....	....
SFA	36.6	50.2	49.7	44.4	45.6	42.8	51.7	49.5	43.5	48.0	35.6	58.4
TUFA	63.4	49.8	50.3	55.6	54.4	57.2	48.3	50.5	56.3	52.0	64.4	41.6
SFA/TUFA	0.58	1.04	0.99	0.80	0.84	0.75	1.07	0.98	0.77	0.93	0.55	1.41
MUFA	39.0	23.1	29.9	24.6	29.9	33.8	26.9	24.3	32.5	27.4	41.9	15.4
PUFA	24.4	26.7	20.4	31.0	24.5	23.4	21.4	26.2	23.8	24.6	22.5	26.2
PUFA/MUFA	0.62	1.16	0.68	1.26	0.82	0.69	0.80	1.08	0.73	0.90	0.54	1.70

<sup>a-c</sup> Means within a column with different superscript differ ( $p < 0.05$ ); NS, not significant.

Inclusion of 3 or 6% of DFA decreased ( $p < 0.05$ ) plasma glucose, total protein and total lipids, while plasma albumin/globulin ratio were increased ( $p < 0.05$ ) with 3 and 6% DFA compared to 0% DFA, with the effect of 3% DFA was more apparent ( $p < 0.05$ ). Also, plasma triglycerides were increased ( $p < 0.05$ ) when 6% DFA was fed. Although, plasma cholesterol was not ( $p < 0.05$ ) affected by DFA level, plasma HDL/LDL was narrowed ( $p < 0.05$ ) due to 6% level compared to 0 and 3% DFA levels (Table 5). Oloyo and Ogunmoded (1993) found that 2% palm oil supplementation increased blood phospholipids and decreased accumulation of other lipid fractions in both organs and blood. While, blood, liver and kidney cholesterol level were not affected by 2% fat. However, Verma *et al.* (1995) showed that fat addition alone had no effects on HDL and LDL+VLDL of Japanese quail. It seems therefore that, the effect of fat/oil on plasma lipids and its fractions depends on type and levels of dietary fat/oil and hepatic secretion of VLDL. Plasma ALT was decreased ( $p < 0.05$ ) due to dietary inclusion of 3 and 6% DFA, with the effect of 3% DFA was more evident ( $p < 0.05$ ). However, DFA

level had no harmful effect on plasma AST (Table 5). Also, dietary oil increased ( $p<0.05$ ) plasma total protein, globulin, glucose, total lipids, triglycerides cholesterol, GOT and GPT (Hamdy *et al.*, 2003).

There were interactions ( $p<0.05$ ) between DFA level and the antioxidants on biochemical constituents of plasma indicating that the effect of the antioxidants depends on DFA level. Plasma glucose was decreased and plasma protein and plasma albumin/globulin was increased due to Vit.E addition to 0%DFA, while Se without or with Vit.E decreased plasma glucose of 3% DFA and plasma albumin/globulin group of 0%DFA, and had the opposite trend on plasma glucose of 6% DFA group (Table 5). Plasma total protein was decreased due to Se to 0%DFA. However, plasma total protein was increased by different magnitude due to antioxidants addition to 3 and 6% DFA groups. Also, Vit.E with Se decreased plasma albumin/globulin of 3% DFA group, and increased it of 6% DFA group considerably, while Se alone decreased it of 6%DFA (Table 5). These results indicated that synergistic negative and positive effects between Vit.E and Se were noticed on plasma albumin/globulin ratio of 3 and 6% DFA level, respectively. Results by Kumar *et al.* (2005) indicated that serum total protein and albumin levels were reduced when vitamin E and Se were supplemented.

**Table (5): Effects of distilled fatty acids (DFA) levels and/or 50ppm Vitamin E and 0.2 ppm organic selenium on biochemical constituents of blood of 49 d old Japanese quail males**

Treatment	Glucose	Total protein	Albumin/Globulin	Total lipid	Cholesterol	Triglyceride	HDL/LDL	AST	ALT
Main effect of DFA, %									
0	138.4 <sup>a</sup>	5.31 <sup>a</sup>	0.32 <sup>c</sup>	228.5 <sup>a</sup>	217.2	173.9 <sup>b</sup>	10.41 <sup>a</sup>	22.94	9.96 <sup>a</sup>
3	129.3 <sup>b</sup>	4.26 <sup>b</sup>	0.52 <sup>a</sup>	189.2 <sup>b</sup>	208.1	174.0 <sup>b</sup>	7.76 <sup>b</sup>	22.81	8.79 <sup>c</sup>
6	129.0 <sup>b</sup>	4.14 <sup>b</sup>	0.49 <sup>b</sup>	194.5 <sup>b</sup>	228.1	228.3 <sup>a</sup>	3.48 <sup>c</sup>	21.88	9.43 <sup>b</sup>
P value	0.0001	0.0001	0.0001	0.0001	NS	0.0001	0.0001	NS	0.001
SEM	1.1	0.08	0.06	2.7	2.0	2.7	0.49	0.35	0.19
Interaction between DFA and antioxidants									
0×0	142.8	5.08	0.31	216.0	185.4	166.4	16.2	22.00	9.36
0×Vit.E	127.7	6.23	0.47	221.8	239.1	267.5	9.11	20.75	13.60
0×Se	138.0	4.55	0.23	246.5	222.2	125.3	14.38	24.00	8.25
0×Vit.E+Se	145.1	5.40	0.25	229.6	222.2	136.4	1.95	25.00	8.63
3×0	135.0	4.00	0.58	228.9	185.3	213.7	5.06	22.75	8.53
3×Vit.E	133.0	4.23	0.62	120.3	169.6	122.0	3.39	25.00	8.63
3×Se	124.2	4.43	0.55	226.3	174.1	180.3	2.63	20.75	8.80
3×Vit.E+Se	124.9	4.30	0.37	180.8	303.6	179.9	3.28	22.75	9.20
6×0	127.6	3.68	0.45	211.1	255.6	304.3	3.13	22.75	9.63
6×Vit.E	124.7	3.90	0.45	229.6	204.0	205.2	2.04	20.75	9.20
6×Se	133.5	4.98	0.33	136.2	249.3	237.6	3.39	20.00	9.20
6×Vit.E+Se	130.2	4.00	0.90	201.1	203.3	166.0	5.34	21.00	9.68
P value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.001	0.001	0.0001
SEM	2.2	0.16	0.07	5.3	1.0	1.0	0.99	0.69	0.37

<sup>a-c</sup> Means within a column with different superscript differ significantly.

Plasma total lipids was increased due to Se addition to 0%DFA, while it was decreased due to Vit E without or with Se addition to 3% DFA group, and Se addition to 6% DFA group. Plasma cholesterol was decreased due to Vit E addition to 3 and 6% DFA groups and due to Se addition to 3% DFA group. Also, Vit E with Se decreased plasma cholesterol of 6% DFA group, however, did not differ of that of group supplemented with Vit E alone (Table 5). Plasma triglycerides of all experimental groups were decreased by different magnitude due to Se addition without or with Vit.E, and due to Vit.E addition to 3 and 6% DFA levels. It is clear that Vit E with Se had a synergistic effect on plasma triglyceride of only 6% DFA. Interestingly, Se overcame the increase in triglyceride due to Vit.E of 0%DFA group, while Vit.E induced the opposite trend in 3% DFA group. This means that the effect of Se and/or Vit.E depends on source of oil and its fatty acid contents.

Plasma HDL/LDL ratio was decreased due to Vit.E and further decreased due to a combination of both antioxidants of 0%DFA group. Also, Vit.E without or with Se decreased plasma HDL/LDL by similar extent of 3% DFA level. While, Se induced the same effect but with greater influence (Table 5). Obviously, Vit.E decreased plasma HDL/LDL level of the 6% DFA diet, while a Vit E with Se yield favorable effect of 6% DFA level. Plasma AST was increased due to addition of Se without or with Vit.E to 0%DFA. However, Vit.E increased plasma AST of 3% DFA level (Table 5). Evidently,

Vit.E and/or Se decreased plasma AST by similar magnitude of the 6% DFA diet. Plasma ALT was increased due to Vit.E addition to 0%DFA. However, Vit.E and/or Se had little effect on plasma ALT of 3 and 6% DFA levels, meaning that up to 6% DFA had no adverse effect on liver functions. In conclusion, the effect of antioxidants on plasma constituents depends on DFA level and its fatty acids.

## **References**

- AGGOOR, F. A., ATTIA, Y. A. and QOTA, E. M. (2000). A study on the energetic efficiency of different fat sources and levels in broiler chick vegetable diets. *J. Agric. Sci. Mans. Univ.* 25: 801-820.
- AOAC (1990). *Official Methods of Analysis*. 15th edn, Arlington, Virginia, USA
- AYDIN, R. (2005). Type of fatty acids, lipoprotein secretion from liver and fatty liver syndrome in laying hens. *Inter. J. of Poult. Sc.* 4:917-919.
- BASU, T. K and DICKERSON, J. W. (1996). *Vitamins in human health and disease*. CAB Inter. UK
- BROCKERHOFF, H. (1965). Stereo specific analysis of triglyciedes. An analysis of human depot fat. *Arch. of Biochem. and Biophysics.* 110:586
- CORTINAS, L, VILLAVERDE, C., GALOBART,J., BAUCCELLS, M.D., CODONY, R. and BARROETA, A. C. (2004). Fatty acid content in chicken thigh and breast as affect by dietary polyunsaturation level. *Poult. Sci.* 83:1155-1164.
- DORGHAM, S. A, RADWAN, M. S., ASKER, N. E. and AWAD, ABEER R. M. (2000). The effect of using pitch oil and distillated fatty acid on broiler performance. *Egypt. Poult. Sci.* 20:567-581.
- EL-HUSSEINY, O. M. Y, SOLIMAN, A. Z., ABD-ELSAMEE, M.O. and OMAR, I. I. (2002). Influence of dietary lipid sources and levels on laying hen performance, egg quality and nutrients utilization. *Egypt. Poult. Sci.* 22:763-791.
- FRUCHART, J. C. (1982). Speration of low density lipoprotein and determination of cholesterol and phospholipids bound to the fraction. *Rev. Fr. Des. Laboratories.* 103:7-17.
- GALVIN, K, MORRISSEY, P. A. and BUCKLEY, D. J. (1997). Influence of dietary vitamin E and oxidized sunflower oil on the storage stability of cooked chicken muscle. *Br. Poult. Sci.*, 38:499-504.
- GORDON, T and AMER, M. (1977). Determination of high density lipoprotein cholesterol. *J. Med.* 62:707.
- HAMDY, A. M., SOLIMAN, M. A., ABDALLA, A. G. and ISMAIL, Z. S. (2003). Effect of dietary polyunsaturated fatty aids on some immune response of broiler chicks. *Egypt. Poult. Sci.* 23:601-616.
- KRALIK, G, PETRICEVIC, A., IVETIC, D. and VUKADINOVIC, B. (1997). Meat quality of chicken broilers as influenced by dietary fat. *Poult.Meat Quality.* 4&5:216-222.
- KUMAR, P. A, SATHYANARAYANA, M. L., VIJAYASARATHI, S. K., GOWDA, R. N. S. and SUGUNA-RAO (2005). Effect of vitamin E and selenium on serum biochemical parameters in broiler chicken feed with aflatoxin and ochratoxin. *Indian Vet. J.*,82:522-525.
- OHKAWA, H, OHISHI, N. and YAGI, K. (1979). Assay for lipid peroxides in animal tissues by tiobarbituric acid reaction, *Anal. Biochem.* 95: 351-358.
- OLOYO, R. A and OGUNMODED, B. K. (1993). Preliminary investigation on the effect of dietary supplemental biotin and palm kernel oil on blood, liver and kidney chicks. *Arch. of Anim. Nut.* 42:263-272.
- SAS Institute (1985). *SAS® User's Guide: Statistics*. Ver. 5 Edn., SAS Institute Inc., Cary, NC, USA.
- SHEEHY, P. J., MORRISSEY, P. A. and FLYNN, A. (1993). Influence of heated vegetable oils and alpha- tocopheryl acetate supplementation on alpha-tocopherol, fatty acids and lipids peroxidation in chicken muscle: *Br. Poult. Sci.* 34:367-381.
- SHRIVASTAV, A. K and PANDA, B. (1993). Influence of levels of various fat sources on the performance and carcass composition of quail broilers. *Indian J. of Anim. Sci.* 63:993-997.
- SURAI, P. F. AND DVORSKA, J.E. (2002). Effect of selenium and vitamin E on lipid peroxidation during storage. 11<sup>th</sup> Europ. Poult.Conf. Bremen.
- VERMA, N. D, PANDA, J. N., SINGH, K. B. and SHRIVASTAV, A. K. (1995). Effect of feeding cholesterol and fat on cholesterol of Japanese quail. *Indian J. of Poult. Sci.*, 30:218-223.
- VILLAVERDE, C, CORTINAS, L., BARROETA, A. C., MARTIN-ORUE, M. S. and BAUCCELLS, M. D. (2004). Relationship between dietary unsaturation and vitamin E in poultry. *J of Animal Physiology. and Animal. Nut.* 88:143-149.