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A STUDY ON THE ENERGETIC EFFICIENCY OF DIFFERENT FAT SOURCES AND LEVELS IN BROILER CHICK VEGETABLE DIETS

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ABSTRACT

This study was undertaken to asses the energetic efficiency of calories provided by different fat sources and levels in Avian broiler chick diets, either on isocaloric or excess energy basis. Therefore, nine isocaloric-isonitrogenous diets were formulated. The control (corn-soybean diet) contained no added fat, while sunflower oil, palm oil, dry fat (Ultrakcal dry) or soy lecithin were incorporated into the other eight diets at the expense of energy provided by yellow corn at 2.5% or 5% of the diet. Four more diets having excess ME were obtained by adding each of these fat sources to the control diet at 2.5%. Each diet was fed to four replicates of seven chicks each, during the starting and growing period until 42 days of age. The obtained results could be summarized as follows:

1-Regardless of supplemental fat level, dry fat (Ultrakcal dry) was used less efficiently by chicks compared with the other fat types tested.

2-Sunflower oil, palm oil or soy lecithin can be economically used and included at 2.5 or 5% of chicks diet with no adverse effect on their performance for weight gain and feed conversion.

3-Further improvement in the performance of chicks for weight gain and feed conversion was achieved when each of the different types of fat was added to the control diet at 2.5% as an additional energy source.

4-Ether extract digestibility was enhanced, while that of crude protein, crude fiber and NFE was reduced upon feeding the fat-containing diets.

5-Regardless of dietary fat source, the level of dietary fat in isocaloric -isonitrogenous diets had no effect on dressing percentage, but abdominal plus visceral fat in chicks carcass was increased due to dietary inclusion of fat. Moreover, increasing of the ME content of the control diet by additional fat produced carcasses of higher dressing percentage and more depot fat.

6-Feeding fat-containing diets decreased the moisture and protein contents and concomitantly increased the lipid content in chicks meat.

7- Neither dietary fat source nor its level affected the chicks-meat pH value. However, values of water holding capacity and tenderness of chicks meat were decreased , and color score was increased upon feeding the fat-containing diets.

8-Neither dietary fat source nor its level affected total proteins in the plasma of chicks. On the other hand, concentrations of plasma total lipids, triglycerides and cholesterol were increased concurrently with increasing the dietary fat level.

Key words: Fat, sources, levels, caloric effect, broiler, performance, meat quality, digestibility

INTRODUCTION

There are several studies that document the usefulness of fat supplementation in poultry diets . Therefore most poultry producers utilize different kinds of fats in poultry diets as an energy source to improve the growth and the efficiency of feed utilization (Klaus *et al.*,1995; Ghazalah, 1998 and Sayed, 1999). The effect of fat on the digestibility of the diet was accounted for an increase in the availability of energy to the birds (Garrett and Young, 1975). The efficiency of fat utilization is dependent on its fatty acids content. No significant differences were reported among sunflower oil, soybean oil, rapeseed oil and linseed oil on promotion of growth of broilers (Lopez-Ferrer *et al.*, 1999) and Japanese quail (Badawy, 1997).

In the literature there were conflicted results about the effect of fat itself (Herstad, 1981; Coon *et al.*, 1981; Whitehead, 1985 and El-Samra, 1990) and its extra caloric effect (Jensen *et al.*, 1970, Sell *et al.*, 1976 and Summers, 1984). Therefore, this work aimed to investigate the response of broiler chicks to different dietary levels and sources of fat; as assessed by performance for weight gain and feed conversion, carcass yield, composition and some physical characteristics of meat, some blood constituents and nutrients digestibility. It was also the objective of this experiment to facilitate assessment of the energetic efficiency of calories provided by different types of fat in broiler chick diets ; either on isocaloric or excess energy basis.

MATERIALS AND METHODS

1- Birds, diets and design:

This work was undertaken at Faculty of Agriculture, University of Mansoura during the period from December 1999 to February, 2000. Three hundred and sixty four, one -day old Avian broiler chicks were housed in batteries and allotted to dietary treatments during the experimental period (1-42 days of age). They received starter and grower diets during 1-21 and 22-42 days of age, respectively. Nine isocaloric-isonitrogenous diets were formulated (Tables 1 and 2). The control (corn-soybean diet) contained no added fat. In the other eight diets, however, part of yellow corn was replaced ; at equicaloric level, by sunflower oil, palm oil, dry fat (Ultrakcal dry[1]) and soy lecithin[2] at two inclusion rates of 2.5 and 5.0% of the diet (included-fat diets). Four more diets having excess ME were obtained by adding each of these fat sources to the control diet (corn-soybean diet; Table 3); proportionally replacing all ingredients; at 2.5% of the diet to raise its energy content in proportion of calories provided by each fat source (added-fat diets) and approximately equal level of CP was maintained with no adjustment to the ME contents of these diets. Each diet was fed to four replicates of seven

[1] Ultrakcal dry is a product of Nutri-AD International, Belgium. It contains 14% fiber, 9% ash and 51% vegetable oils (soybean oil, corn oil, rapeseed oil and high oleic palm oil). It contains 6112 kcal ME/kg, whereas its recommended level of usage is between 1-5%. Its chemical composition showed 51.2% ether extract, 6.9% CP and 13.6% crude fiber.

[2] Soybean lecithin is a natural emulsifier, containing phosphatidylcholine, phosphatidylethanolamine and inositol. Its chemical composition showed 95.3% ether extract and 4.6% CP.

Avian broiler chicks. Feed and water were offered *ad libitum* throughout the experiment. Tabulated values of NRC (1994) for nutrient contents of feedstuffs as well as the energy value for soy lecithin reported by Scott *et al.*(1982) were used for formulating the experimental diets.

Table 1. Composition of the experimental diets fed during 1-21 days of age

Ingredients, %	Control, 0.0%	Sunflower oil, % 2.5	Sunflower oil, % 5.0	Palm oil, % 2.5	Palm oil, % 5.0	Dry fat, % 2.5	Dry fat, % 5.0	Soy lecithin, % 2.5	Soy lecithin, % 5.0
Yellow corn	60.83	52.70	44.55	56.49	52.15	55.60	50.35	55.43	50.01
Soybean meal*	35.80	37.36	38.94	36.63	37.46	36.84	37.88	36.85	37.90
Fat[1]	0.00	2.50	5.00	2.50	5.00	2.50	5.00	2.50	5.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vit+Min Mix.[2]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
NaCl	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Dl-methionine	0.17	0.18	0.19	0.18	0.18	0.18	0.18	0.18	0.18
Choline chloride + Vit E	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sand	0.00	4.06	8.12	1.00	2.01	1.68	3.39	1.84	3.71
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated values									
CP, %	22.53	22.60	22.67	22.57	22.61	22.59	22.65	22.59	22.64
ME kcal/kg,	2911	2918	2926	2919	2924	2914	2917	2918	2927
Calcium, %	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Av. P, %	0.38	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Methionine,%	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
TSAA, %	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Lysine, %	1.22	1.24	1.27	1.23	1.24	1.24	1.25	1.24	1.25
Determined values, %									
Moisture	12.02	11.96	11.71	11.91	11.87	11.89	11.71	11.82	11.82
CP	22.48	22.41	22.45	22.41	22.49	22.45	22.47	22.47	22.44
EE	2.41	4.72	7.08	4.70	7.02	4.68	6.98	4.69	7.02
CF	4.09	4.01	3.95	4.02	3.92	4.00	4.01	4.01	3.91
Ash	7.02	10.91	14.31	7.92	8.01	7.72	7.96	8.36	10.02
NFE	52.98	46.99	41.50	50.04	47.69	50.26	47.87	49.55	45.83

*** 48.5% CP soybean meal.**

[1] ME kcal/kg values used in ME calculation are 6112 kcal for dry fat (Ultrakcal producing company), 9659 for sunflower oils (NRC, 1994), 5302 for palm oil (NRC, 1994) and 6500 for soy lecithin (Scott *et al.*, 1982).

[2] Vitamins and minerals mixture provide per kilogram of diet: vitamin A (as all-trans-retinyl acetate); 12000 IU; vitamin E (all rac-α-tocopheryl acetate); 10 IU; k_3 3mg; Vit.D_3, 2200 ICU; riboflavin, 10 mg; Ca pantothenate,10 mg; niacin, 20 mg; choline chloride, 500 mg; vitamin B_{12}, 10μg; vitamin B_6, 1.5 mg; thiamine (as thiamine mononitrate); 2.2 mg; folic acid, 1 mg; D-biotin, 50μg. Trace mineral (milligrams per kilogram of diet) : Mn, 55; Zn, 50; Fe, 30;Cu, 10; Se, .1 and Ethoxyquin 3mg.

Table 2. Composition of the experimental diets fed during 22-42 days of age

Ingredients, %	Control,	Sunflower oil, %		Palm oil, %		Dry fat, %		Soy lecithin, %	
	0.0%	2.5	5.0	2.5	5.0	2.5	5.0	2.5	5.0
Yellow corn	71.94	64.0	55.78	67.84	63.30	66.86	61.65	66.63	61.46
Soybean meal*	24.74	26.32	27.90	25.54	26.48	25.74	26.80	25.80	26.80
Fat[1]	0.00	2.50	5.00	2.50	5.00	2.50	5.00	2.50	5.00
Limestone	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vit+Min Mix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
NaCl	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Dl-methionine	0.17	0.18	0.19	0.18	0.18	0.18	0.18	0.18	0.19
L-lysine	0.10	0.08	0.05	0.09	0.07	0.09	0.07	0.08	0.07
Choline chloride + Vit E	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sand	0.00	3.87	8.02	0.80	1.92	1.58	3.25	1.76	3.43
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated values									
CP, %	18.11	18.18	18.26	18.15	18.19	18.16	18.21	18.16	18.21
ME kcal/kg,	3014	3027	3033	3029	3032	3021	3025	3026	3037
Calcium, %	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Av. P, %	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Methionine,%	0.46	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.48
TSAA, %	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Lysine, %	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Determined values, %									
Moisture	12.11	11.91	11.68	11.90	11.83	11.89	11.70	11.88	11.79
CP	18.41	18.40	18.47	18.43	18.42	18.41	18.46	18.48	18.40
EE	2.72	4.97	7.36	4.96	7.39	4.90	7.30	4.93	7.36
CF	3.98	3.92	3.88	3.91	3.89	3.93	3.90	3.92	3.88
Ash	7.78	11.22	14.91	7.96	9.56	7.98	8.79	9.91	11.96
NFE	56.00	50.58	44.71	53.84	49.91	53.89	50.85	51.88	47.61

*** 48.5% CP soybean meal.**
[1; 2] As shown in Table 1.

2-Measurements:

Chicks were weighed at 21, and 42 days of age. Feed consumption was recorded and feed conversion was calculated at the same ages. At the end of the experimental period (42 days of age) five birds were slaughtered for evaluation of carcass yield and contents of abdominal and visceral fat as well as liver and gizzard.

Meat tenderness and water holding capacity (WHC) were measured according to the method of Volovinskaia and Kelman (1962). Color intensity of meat and dripping were determined according to the methods of Husani *et al.* (1950). Whereas, pH value was measured by pH meter as described by Aitken *et al.* (1962).

Representative samples of breast plus thigh meat and experimental diets and excreta were chemically analyzed for moisture, CP, ether extract (EE) and ash according to A.O.A.C. (1980) and the values for meat composition expressed on dry matter basis.

Digestibility trial was carried out using the total collection method and AME was determined as cited by Aggoor *et al.* (1997). Gross energy (GE) was determined for both experimental diets and excreta by using Bomb Calorimeter. The AME of different fat sources was calculated according to the equation of Sibbald and Slinger (1962):

AME (kcal/kg)=[AME of tested diet-% of basal diet $\times$ AME of basal diet] $\times$100/% of fat

Simultaneously, blood samples were collected from the slaughtered birds of each treatment. Plasma was separated by centrifugation at 3000 rpm for 5 minutes and stored at -20ºC until analysis. Concentrations of plasma total protein (Weichselbaum,1946; and Henry *et al.*, 1974), total lipid (Chabrol and Charonnat,1973), triglycerides (Jacobs and Van Den Mark,1960; Trinder, 1969; and Koditscheck and Umbreit, 1969), total cholesterol (Watson, 1960) were determined.

Table 3. Composition of the starter and grower diets without or with 2.5% additional fed during 1-42 days of age

Ingredients, %	Starter diet fed during 1-21 days of age					Grower diet fed during 22-42 days of age				
	Control, 0.0%	Fat source				Control, 0.0%	Fat source			
		Sunflower oil	Palm oil	Dry fat	Lecithin		Sunflower oil	Palm oil	Dry fat	Lecithin
Yellow corn	60.83	60.83	60.83	60.83	60.83	71.94	71.94	71.94	71.94	71.94
Soybean meal[*]	35.80	35.80	35.80	35.80	35.80	24.74	24.74	24.74	24.74	24.74
Fat[1]	0.00	2.50	2.50	2.50	2.50	0.00	0.00	0.00	0.00	0.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.45	0.45	0.45	0.45	0.45
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vit+Min Mix[2]	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.25	0.25	0.25
NaCl	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.25	0.25	0.25
Dl-methionine	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
L-lysine	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10
Choline chloride + Vit E	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100.0	102.5	102.5	102.5	102.5	100.0	102.5	102.5	102.5	102.5
Calculated values										
CP, %	22.53	21.97	21.97	21.97	21.97	18.11	17.66	17.66	17.66	17.66
ME kcal/kg,	2911	3074	2968	2988	2997	3014	3174	3067	3087	3096
C/P ratio	129	140	135	136	137	166	180	174	175	176
Calcium, %	0.89	0.87	0.87	0.87	0.87	0.84	0.82	0.82	0.82	0.82
Av. P, %	0.38	0.37	0.37	0.37	0.37	0.36	0.35	0.35	0.35	0.35
Methionine,%	0.52	0.51	0.51	0.51	0.51	0.46	0.45	0.45	0.45	0.45
TSAA, %	0.89	0.87	0.87	0.87	0.87	0.78	0.76	0.76	0.76	0.76
Lysine, %	1.22	1.19	1.19	1.19	1.19	1.02	1.00	1.00	1.00	1.00
Determined values, %										
Moisture	12.02	11.86	11.80	11.91	11.88	12.11	11.87	11.85	11.84	11.81
CP	22.48	22.40	22.43	22.46	22.47	18.41	18.46	18.44	18.41	18.47
EE	2.41	4.98	4.96	4.90	4.92	2.72	5.23	5.19	5.18	5.20
CF	4.09	4.10	4.07	4.10	4.09	3.98	3.96	3.94	3.96	3.99
Ash	7.02	7.092	7.10	7.13	7.10	7.78	7.77	7.76	7.70	7.75
NFE,	52.98	50.57	50.64	50.50	50.54	56.00	53.71	53.82	53.91	53.78

[*] 48.5% CP soybean meal.

[1; 2] **As shown in Table 1.**

2-Statistical analysis:

Data were analyzed by the GLM procedure of SAS® Institute(1985) where dietary treatments involving 3 levels and 4 sources of fat with added control un-supplemented diet were arranged in a complete factorial design. All percentages were transformed to their corresponding arc sine before running the analyses. Duncan's New multiple Range Test (Duncan, 1955) was used to test mean differences at $P \leq 0.05$. The data were presented based on the interaction effects of fat sources and levels, whereas the main effects were only tabulated when exhibited significant effects of fat sources or levels.

RESULTS AND DISCUSSION

1- Effect of dietary fat source and level on nutrients excretion, digestibility and calorific value:

Irrespective of dietary fat level, results indicated that excreta voided by chicks fed dry fat (Ultrakcal) had more nitrogen and ether extract contents compared with those fed sunflower oil (Table 6), however, the latter group did not significantly differ from those fed the other fat types, indicating that the utilization of dry fat was lower than the other fat sources. The results revealed also that excreta of broilers fed the control diet (0.0% added fat) contained significantly less nitrogen, ether extract and dry matter than of those fed fat-containing diets (Table 6). Regardless of dietary fat type, increasing the level of added fat significantly improved the ether extract digestibility (Table 5). It is clear also that increased level of added fat decreased protein, NFE and crude fiber digestibilities in groups fed fat-containing diets, yet the control group fed the un-supplemented diet ranked among all in that respect.

It is worth noting that, the best ether extract digestibility was achieved with the group fed diet containing 5% palm oil followed by; in a decreasing order, those fed diets containing 5.0% sunflower oil, 2.5% of added sunflower oil, 5% dry fat, 5% soy lecithin and 2.5% of added soy lecithin (Table 6). Irrespective of dietary fat level, it is apparent that ether extract digestibility in the group fed diet containing sunflower oil was significantly superior to those fed diet containing dry fat (Ultrakcal), but did not differ from that of lecithin and palm-diet (Table 4). In general, including or adding different fat sources improved ether extract digestibility of the experimental diet. It is known that the absorption of lipid may vary according to its source and level (Carew *et al.*, 1972). It is worth noting, that feeding fat containing-diets decreased crude fiber, crude protein and NFE digestibilities compared to the control un-supplemented-diet, and this decrease was more pronounced with elevating dietary fat level (Table 5). However, there are contradictory reports which stated that supplemental fat in chickens diet decreases the rate of digesta passage through the digestive tract, thereby increases the digestibility of the diet (Mateos and Sell, 1980), and improves the utilization of other non-lipid components of the diet (Sibbald and Kramer, 1978 and Sell *et al.*, 1979).

Table 4. Main effect of dietary fat source on the performance of experimental broiler chicks and other criteria of response.

Criteria	Control diet unsuppl-emented	Fat source				SEM	P value
		Sunflower oil	Palm oil	Dry fat	Lecithin		
Performance of chicks:							
Final body weight, g	1632.8^{c}	1723.5^{a}	1680.2^{b}	1592.3^{d}	1673.5^{b}	8.61	0.0001
Feed consumption, g	3657.7^{C}	3613.0^{d}	3658.0^{c}	3691.6^{a}	3669.0^{b}	1.74	0.0001
Feed conversion, g feed /g gain	2.30^{b}	2.16^{c}	2.23^{d}	2.39^{a}	2.25^{c}	0.007	0.0001
Nutrient digestibility:							
Crude protein digestibility	77.9^{a}	74.9^{b}	72.9^{bc}	71.8^{c}	73.1^{bc}	0.77	0.02
Ether extract digestibility, %	47.6^{c}	67.9^{a}	66.2^{ab}	64.3^{b}	65.0^{ab}	1.09	0.04
Ash retention, %	40.58^{ab}	42.86^{a}	31.73^{dc}	26.69^{d}	35.41^{bc}	1.37	0.0001
Carcass yield:							
Dressing, %	63.2^{b}	64.8^{a}	64.3^{a}	63.3^{b}	64.2^{a}	0.06	0.0001
Liver, %	3.19^{c}	3.42^{a}	3.34^{b}	3.21^{c}	3.18^{c}	0.02	0.0001
Giblets, %	6.72^{cd}	6.94^{a}	6.84^{b}	6.78^{c}	6.70^{d}	0.01	0.0001
Meat physical parameters and chemical composition:							
Meat color intensity	0.198^{c}	0.265^{a}	0.266^{a}	0.237^{b}	0.261^{a}	0.003	0.0001
Meat WHC	5.89^{a}	5.45^{c}	5.49^{c}	5.59^{b}	5.43^{c}	0.02	0.001
Meat moisture, %	75.9	74.3	74.2	74.6	74.3	0.06	0.06
Meat Lipid, %	13.0^{c}	17.5^{a}	16.7^{b}	17.0^{ab}	17.4^{a}	0.17	0.01
Meat ash %	5.07	5.04	4.99	4.98	4.97	0.06	NS

abc Means within the same row with no common superscripts differ significantly P≤0.05, NS not significant.

The calculated AME values from chemical composition according to Bolton (1955); using Sibbald and Slinger (1962) equation, were found to be 7727, 7755, 7795 and 7755 kcal/kg for sunflower oil, palm oil, dry fat and soy lecithin, respectively. Whereas, the determined values using bomb calorimeters were found to be 11640, 7960, 8960 and 9440 kcal AME for the aforementioned groups. The calculated values are lower than the determined values and those reported by Sayed (1999) who found that energetic values were 11533, 9617 and 9717 kcal/kg for AME of sunflower oil, palm oil and Ultrakcal dry, respectively. Abd El-Megid (1997) and Ghazalah (1998) found that palm oil had 9.05 kcal/g and higher absorbability than 8.640/g for sunflower oil. Differences in energetic values of fat sources could be attributed to their fatty acids pattern, saturation level and distribution. Young (1961) indicated that either AME or the absorbability of dietary fat differed according to its content of saturated and unsaturated fatty acids. Not only the degree of un-saturation is the single measure for the AME content of fat, but also the distribution of fatty acids in the glycerol molecule (Sibbald and Kramer, 1980). Young and Garrett (1981) and Klaus *et al.*

(1995) demonstrated that source of fat had significant effect on broiler growth and suggested that saturated fats are less digestible for young chicks.

Table 5. Main effect of dietary fat level on the performance of experimental broiler chicks and other criteria of response

Criteria	Control unsuppl-emented	Fat level, 2.5% added	2.5% included	5% included	SEM	P value
Performance of chicks:						
Final body weight, g	1632.8^{b}	1703.0^{a}	1639.7^{b}	1659.4^{b}	7.47	0.05
Feed consumption, g	3657.7^{b}	3677.0^{a}	3661.1^{b}	3635.6^{c}	1.61	0.0001
Feed conversion, g feed/g gain	2.30^{a}	2.22^{c}	2.29^{a}	2.26^{b}	0.005	0.0005
Nutrient digestibility:						
Crude protein digestibility	77.9^{a}	75.0^{b}	74.8^{b}	69.6^{c}	0.63	0.0001
Crude fiber digestibility, %	29.38^{a}	15.78^{b}	14.67^{c}	10.07^{d}	0..03	0.0001
Ether extract digestibility, %	47.6^{c}	65.4^{ab}	63.7^{b}	68.4^{a}	0.91	0.0006
NFE digestibility, %	77.20 ^{a}	74.11^{b}	73.96^{b}	68.10^{c}	0.58	0.0001
Ash retention, %	40.58^{a}	31.77^{c}	37.43^{ab}	33.32^{bc}	1.32	0.02
Carcass yield:						
Dressing, %	63.2^{b}	64.7^{a}	63.4^{ab}	63.8^{ab}	0.05	0.001
Liver, %	3.19^{c}	3.29^{ab}	3.25^{b}	3.33^{a}	0.015	0.0001
Giblets, %	6.72^{b}	6.78^{b}	6.78^{b}	6.89^{a}	0.013	0.0001
Abdominal fat, %	0.98^{c}	1.23^{b}	1.02^{c}	1.34^{a}	0.015	0.0001
Abdominal + visceral fats, %	1.75^{d}	2.42^{a}	1.98^{c}	2.61^{a}	0.035	0.0001
Meat physical parameters and chemical composition:						
Meat color intensity,	0.198^{c}	0.239^{b}	0.244^{b}	0.289^{a}	0.0025	0.0001
Meat tenderness,	2.97^{a}	2.69^{b}	2.68^{b}	2.28^{c}	0.015	0.0001
Meat WHC,	5.89^{a}	5.62^{b}	5.62^{b}	5.24^{c}	0.02	0.001
Meat moisture	75.9^{a}	74.9^{b}	74.7^{b}	73.4^{c}	0.06	0.0001
Meat protein	78.2^{a}	74.1^{c}	75.8^{b}	72.4^{d}	0.26	0.0001
Meat lipid	13.0^{d}	17.3^{b}	15.1^{c}	19.0^{a}	0.22	0.0001
Liver moisture	76.8^{a}	74.8^{b}	74.9^{b}	72.5^{c}	0.10	0.0001
Liver protein	70.1^{a}	65.9^{bc}	66.9^{b}	64.0^{c}	0.43	0.01
Liver lipid	22.0^{c}	25.1^{ab}	24.1^{bc}	27.1^{a}	0.22	0.006
Blood constituents:						
Plasma total lipids, g /100 ml	5.93^{c}	6.81^{b}	6.71^{b}	7.47^{a}	0.07	0.001
Plasma triglycerides mg/100 ml	108.2^{c}	115.7^{b}	117.5^{ab}	122.0^{a}	1.59	0.01
Plasma cholesterol, mg/100 ml	126.6^{d}	155.4^{b}	148.0^{c}	169.3^{a}	4.10	0.001

[abc] **Means within the same row with no common superscripts differ significantly P≤0.05**

2-Effect of dietary fat source and level on growth performance of broiler chicks:

Irrespective of dietary fat level, results indicated that dietary inclusion of sunflower oil, palm oil and soy lecithin significantly improved growth and feed conversion of broilers by 5.6% and 6.1%, 2.9% and 3.0% and 2.5% and 2.2%, respectively; compared to the control-diet fed broilers (Table 4). The group fed sunflower oil-containing diet attained the best performance for growth and feed conversion. Both the two groups fed palm oil or soy lecithin performed equally for growth and exhibited better feed conversion than the control group. The poorest performance for growth and feed conversion, however, was achieved by dry fat (Ultrakcal)-fed-groups (Table 4), and this was associated with higher excreta nitrogen and ether extract contents as a result of lower protein and ether extract digestibilities in this group (Table 4). In accordance with the present results, Sayed (1999) found a superiority of sunflower oil in feeding broiler chicks, whereas Abd El-Megid (1997) showed a superiority of palm oil. In contrast, Badawy (1997) and Lopez-Ferrer *et al.* (1999) reported that different vegetable oils had no significant effect on growth or feed utilization of Japanese quail and broiler chicks, respectively.. The efficiency of fat utilization is dependent on its fatty acids content (Sibbald and Kramer, 1980). Young and Garrett (1981) and Klaus *et al.* (1995) demonstrated that source of fat had significant effect on broiler growth and suggested that saturated fats are less digestible for young chicks.

Regardless of dietary fat source, there were no significant differences in growth of broilers fed isocaloric diets containing 2.5% or 5.0% fat, although upon feeding diets of 5% fat, feed conversion was improved by only 1.31% compared to 2.5% fat-diets and by 1.74% when compared to the control group. This demonstrated that the effect of supplemental fat is mostly due to its calorific effect, since groups fed isocaloric diet containing 2.5% fat or not (control diet), performed equally well for growth and feed conversion (Table 5). Also, Coon *et al.* (1981) observed that body weight gain of broilers fed isocaloric diet containing different levels and types of fats were not affected. However, Herstad, (1981) and El-Samra (1990) found positive responses to adding fat to chicken diets.

On the other hand, when the different fat sources were added to the control diet at inclusion rate of 2.5% in order to increase its energy content, both growth and feed conversion were improved by 4.3 and 3.5% respectively, regardless of dietary fat sources (Table 5) This may indicate the beneficial effect of elevating the energy level in broilers diet by supplemental fat. These enhancements in growth and feed conversion amounted to 7.0, and 7.0% for sunflower oil, 4.4 and 3.5% for palm oil and 4.5 and 3.5% for soy lecithin, but addition of Ultrakcal gave no improvement (Table 7).

These differences observed in the performance of chicks could be attributed either to differences in the additional calories; the different fat sources added to each kg of the control diet; i.e. 160 kcal by sunflower oil, 53 kcal by palm oil and 73 kcal by soy lecithin. Even though, addition of dry fat (Ultrakcal) at 2.5% of control diet increased its energy content by 82 kcal (table, 3) , it did not exerted any beneficial effect on the performance of chicks. This would indicate that Ultrakcal utilized poorly and less efficiently by chicks

compared with the other fat sources. In general , the stimulated growth of broilers fed fat -supplemented diets was associated with increased feed consumption. The results revealed significant interaction between effects of fat level and source on growth and feed conversion (Table 7), indicating that 5% of Ultrakcal impaired growth and feed conversion when compared to the same level of other fat sources. Mortality percentage accounted to 3.3% and was in normal range with the practical value for broiler chicks, moreover it was not related to dietary treatments.

It would be concluded that, a satisfactory broiler chicks performance and economic efficiency could be achieved by raising the energy content of their ordinary corn-soybean diet by additional sunflower oil at 2.5% of the diet, or using a common corn-soybean diet having the accepted energy value but containing sunflower oil at 5% of the diet. Soy lecithin and palm oil could also be added at a level of 2.5% of the common corn-soybean diet for broilers to increase its energy content and improved economic efficiency.

3-Effect of dietary fat source and level on carcass yield and physical characters of meat:

3-1 Carcass parameters:

Regardless of dietary fat level, it was observed that chick groups fed isocaloric -isonitrogenous -diets containing sunflower oil, palm oil, or lecithin produced carcasses of equal dressing percentages, which were significantly higher than the corresponding values obtained with other groups fed either Ultrakcal-containing diet or control diet (Table 4). These differences paralleled to the variations in chicks body weight . Peter *et al.* (1974) reported that, generally, larger birds produce carcasses of higher dressing percentage compared to lean birds.

Irrespective of dietary fat source, the level of dietary fat had no effect on dressing percentage for carcasses of broilers fed the isocaloric-isonitrogenous diets, but abdominal plus visceral fat and liver weight increased significantly due to the dietary inclusion of fat (Table 5). Inconsistently, Griffiths *et al.* (1977), McLeod (1982) and Whitehead (1985) reported that addition of fat, without changing the ME content in broiler chick diets had little effect on the deposition of body fat.

On the other hand, increasing the ME content of the control diet (corn-soybean diet) by fat addition also produced carcasses of higher dressing percentage, with larger liver and more depot fat than those of the control. This coincide well with the results of Fuller and Renden (1979), El-Naggar *et al.* (1997) and Peter *et al.* (1997) who reported that raising of the dietary energy level increased fat deposition in broiler chicks. This is mainly attributed to widening of the C/P ratio in the diets (Leeson and Summers, 1979); but it opposes the conclusion of Coon *et al.* (1981) who stated that increasing of the C/P ratio in broiler diet had no significant effect on abdominal fat.

With the exception of abdominal fat, the interaction between dietary fat source and level significantly affected the relative weights of eviscerated carcass, liver, giblets, and abdominal plus visceral fat in experimental broiler chicks (Table 8)

3-2. Physical characteristics of meat :

Neither dietary fat source nor its level affected the experimental broiler-meat pH value (Table 8). Similarly, Abd El-Ghani (1986), El-Naggar *et al.* (1997) and Kralik *et al* (1997) found that pH value of broiler meat was not affected by dietary energy and level or type of dietary fat.

Color score of the experimental broilers meat was significantly increased upon feeding fat-supplemented diets (Tables 4, 5 and 8). Even though dietary fat addition at the expense of yellow corn in the experimental diets subsequently reduced the xanthophophyll pigment intake, it seems likely that dietary fat enhanced its absorption, thereby accumulated much more with depot fat inside the body of the experimental broilers fed the fat-supplemented diets (Heath and Shaffner, 1972)

Dietary fat source did not influence the experimental broiler-meat tenderness; which was significantly decreased by increasing dietary fat level (Table 5 and 8). However, Harkin *et al.* (1958) observed that fat-supplemented diets had no effect on tenderness of turkey meat; and Lei and Van-Beek (1997) stated that increasing energy level in broiler chicks diet by fat addition had little effect on the tenderness and juiciness of meat.

Meat WHC was significantly affected by either dietary fat source or its level. The meat WHC was decreased upon feeding fat-containing diets (Tables 4, 5 and 8). This occurred concomitantly with increasing fat deposition and less protein content in the meat of experimental broilers fed fat-containing diets compared to their counterparts fed the control diet (Table 5 and 8). It is well recognized that meats containing a relatively higher protein are capable to hold much water than those of a lower protein content (El-Sharkawy, 1984).

No significant differences were detected, however, in the physical characters of meat of the experimental broiler chicks due to the interaction between effects of dietary fat source and its level (Table 8).

4-Effect of dietary fat source and level on chemical composition of meat and liver and blood plasma constituents of experimental birds:

4-1 Chemical composition of meat:

There was a significant decrease in moisture and protein contents, and a concomitant increase in fat content of broilers meat and liver with increasing dietary fat level (Tables 5 and 9). However, Holsheimer (1991) found that feeding isocaloric, isonitrogenous diets containing 8% animal fat, rapeseed oil, sunflower seed oil or coconut fat to broiler chicks had insignificant effect on the protein and fat contents of the carcass.

Meats of groups fed the control diet with 2.5% additional fat , however, had higher fat and lower protein contents, compared to their counterparts fed isocaloric -isonitrogenous diets containing 2.5% fat, regardless of its source. This may be a result of increasing dietary energy level and/or C:P ratio. In this connection, Velue and Baker (1974), Seaton *et al.* (1978), Twining *et al.* (1978) and Jackson *et al.* (1982) reported that increasing energy level by fat addition decreased the protein and increased the fat contents in broiler chicks carcass. Similarly, Fisher (1984) and Bartov (1989) and El-Naggar *et al.*

(1997) reported that widening C:P ratio in broilers finishing diet increased carcass fat.

Ash contents in experimental broilers meat and liver were not affected by dietary treatments, so that the effect of fat source was only presented (Table 4). Likewise, El-Samra (1990) and El-Naggar *et al.* (1997) found that increasing energy level by oil addition or supplementation of the experimental diets with fat/oil had insignificant effect on ash of thigh meat.

4-2 Blood Plasma constituents:

Neither dietary fat source nor its level affected the concentration of total proteins in the plasma of experimental broiler chicks (Table 9). El-Naggar *et al.* (1997) found similar results. On the other hand, the levels of plasma total lipids, triglycerides and cholesterol were correlated, and significantly increased linearly with the increasing of the dietary fat level, irrespective of its source (Tables 5 and 9). This increase in the level of lipid components in the plasma is correlated with increasing abdominal and abdominal plus visceral fat in the experimental broilers which were fed the fat containing-diets. Similar results were reported by Abd El-Ghani (1986) and El-Naggar *et al.* (1997) who found that concentrations of total lipids, triglycerides and cholesterol in broiler serum were correlated positively with each other and increased with increasing the energy level in the diet by cotton seed oil addition. Likewise, Leveille and Fisher (1958) found highly significant positive correlation between levels of cholesterol and total lipids in the plasma of hens fed vegetable and animal fat supplemented-diets. Increasing total serum cholesterol was also found to be a result of feeding oil-supplemented-diets to chicks (Aoyama *et al.*, 1983), or Japanese quails (Badawy, 1997). No significant differences were detected, however, in blood constituents due to the interaction between effects of dietary fat source and level.

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دراسة كفاءة استخدام الطاقة من مصادر ومستويات مختلفة من الدهون في علائق نباتية لكتاكيت اللحم

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***** معهد بحوث الإنتاج الحيواني و الدواجن-مركز البحوث الزراعية-وزراه الزراعة**

أجريت هذه التجربة بهدف دراسة كفاءة استخدام الطاقة من مصادر و مستويات مختلفة من الدهون في العلائق النباتية لكتاكيت اللحم أيفيان، و بناءا علي ذلك قد تم تكوين 9 علائق متساوية في كلا محتواها من البروتين و الطاقة و كانت عليقة الكنترول عليقه نباتية تحتوي علي الذرة و كسب فول الصويا و لا تحتوي علي أي إضافات من الدهون بينما اشتملت العلائق التجريبية الثمان الأخرى علي زيت عباد الشمس، زيت النخيل ، دهن جاف من مصدر تجاري" يلتركال" و ليثيسين فول الصويا بمعدلات 2.5% أو 5% من العليقة و تم تكوين أربعة علائق تجريبية أخري مرتفعة في محتواها من الطاقة بإضافة أي من هذه الدهون إلى عليقة الكنترول بنسبة 2.5% و غذيت كل عليقه إلى أربعة مكررات بكل واحدة 7 كتاكيت غير مجنسة خلال مرحلتي البادئ و النامي حتى عمر 42 يوم. و دلت النتائج علي الآتي:-

1-بغض النظر عن مستوي الدهن بالعليقة اتضح أن كفاءة استخدام الدهن الجاف (يلتركال) كانت أقل مقارنة بمصادر الدهون الأخرى.

2-اتضح أن زيت عباد الشمس و زيت النخيل والليثيسين يمكن استخدامهم في علائق كتاكيت اللحم حتى مستوي 5% دون تأثير ضار على معدلات نمو الكتاكيت و الكفاءة الغذائية.

3-حدث تحسن واضح في معدلات النمو و الكفاءة الغذائية عند إضافة إي نوع من أنواع الدهون إلى عليقة الكنترول بمعدل 2.5% كمصدر إضافي للطاقة.

4-تحسن معدل هضم المستخلص الأثيري بينما انخفض معدل هضم البروتين و الألياف الخام و المستخلص الخالي من النتروجين عند التغذية علي العلائق المحتوية علي الدهن.

5-بغض النظر عن نوع الدهن فان مستواه في العلائق المتساوية في البروتين و الطاقة لم يؤثر في نسبة التصافي و لكنه أدي إلى زيادة دهن التجويف البطنى +دهن الأحشاء في ذبائح الطيور. كما أدي زيادة محتوي العلائق من الطاقة بواسطة الدهون إلى زيادة نسبة التصافي و الدهن المترسب في الذبيحة

6-أدت التغذية علي العلائق المحتوية علي الدهن إلى نقص نسبة الرطوبة و البروتين و زيادة نسبة الدهن في لحوم و كبد الكتاكيت.

7-لم يؤثر كل من مصدر الدهن أو مستواه بالعلائق علي درجة الpH للحوم ذبائح الكتاكيت ، بينما انخفضت قدرة اللحوم علي الاحتفاظ بالماء كما انخفضت طراوتها وارتفعت درجة تركيز اللون بالتغذية علي العلائق المحتوية علي الدهن.

8-لم يؤثر مستوى و نوع الدهن المضاف للعلائق علي محتوي بلازما دم الكتاكيت من البروتينات، بينما ارتفع تركيز كل من الليبيدات الكلية و الجليسريدات الثلاثية و الكولسترول في البلازما بزيادة مستوي الدهن بالعلائق.

من هذه النتائج اتضح أن استخدام زيت عباد الشمس بنسبة 5% أو أضافته بنسبة 2.5% لزيادة مستوي الطاقة في العلائق النباتية لكتاكيت اللحم أديت إلى تحسن معدلات النمو و الكفاءة الغذائية و الاقتصادية للطيور، كما تلاحظ نفس الاتجاه عند استخدام زيت النخيل مع تفوق لزيت عباد الشمس، كما سجلت العليقة المحتوية علي 2.5% كمصدر إضافي للطاقة من الليثسين تحسن في معدلات النمو و الكفاءة الغذائية و الاقتصادية .

Table 6. Effect of dietary fat levels and sources, and increasing the energy content of the control diet by fat addition* on nitrogen and ether extract excretion, and protein, ether extract, crude fiber and NFE digestibilities by experimental chicks

Treatments/ level	Method of addition	Fat source	Excreta dry matter, %	Excreta nitrogen ,%	Excreta ether extract , %	Protein digestibility, %	ether extract digestibility, %	Crude fiber digestibility, %	NFE digestibility, %
Control	----		25.92	3.00	5.48	77.94	47.57	29.38	77.20
2.5%	Added	Sunflower oil	26.97	2.95	6.17	77.25	68.36	19.13	74.29
2.5%	Included	Sunflower oil	26.59	2.98	6.02	76.47	65.95	18.19	74.32
5.0%	Included	Sunflower oil	27.89	2.94	6.52	70.83	69.36	12.12	65.36
2.5%	Added	Palm oil	26.72	3.01	6.23	74.28	63.64	12.63	73.53
2.5%	Included	Palm oil	26.08	3.04	6.13	74.90	64.76	16.49	74.80
5.0%	Included	Palm oil	27.41	3.06	6.60	69.38	70.22	6.47	69.64
2.5	Added	Dry fat	26.82	3.03	6.36	73.67	63.12	15.79	75.57
2.5%	Included	Dry fat	26.47	3.05	6.19	73.39	62.11	12.78	73.62
5.0%	Included	Dry fat	27.36	3.08	6.69	68.20	67.64	10.42	69.60
2.5	Added	Lecithin	26.58	3.01	5.97	74.98	66.32	15.56	73.05
2.5%	Included	Lecithin	26.35	2.98	6.16	74.37	62.11	11.23	73.09
5.0	Included	Lecithin	27.66	2.98	6.77	69.79	66.46	11.27	67.81
SEM			0.083	0.02	0.27	0.66	0.95	3.91	1.22
P value									
Fat source			NS	0.007	0.08	0.02	0.04	NS	0.23
Fat level			0.031	NS	0.0001	0.0001	0.0006	0.0001	0.0001
Source × level			NS	NS	0.08	NS	NS	NS	0.31

*** Fat was included as a part in isocaloric, isonitrogenous diets or added as an energy source to control diet providing approximately equal CP level.**

Table 7. Effect of dietary fat levels and sources, and increasing the energy content of the control diet by fat addition* on body weight (g), feed consumption(g/bird) and feed conversion (g/g) of experimental broiler chicks

Treatments/ level	Method of addition	Fat source	Body weight at			Feed conversion (feed/gain) during ,			Total feed consumed, g/bird	Economic efficiency**,%
			1 day old	21 day old	42 day old	1-21 d old	21-421 day old	1-42 day old		
Control	----		43.2	466.6	1632.8[d]	2.09	2.38[c]	2.30[c]	3657.7[ef]	29.18
2.5%	Added	Sunflower oil	43.4	504.9	1747.3[a]	1.95	2.21[e]	2.14[h]	3650.2[f]	34.16
2.5%	Included	Sunflower oil	43.1	470.3	1683.2[bc]	1.99	2.28[d]	2.20[g]	3616.2[h]	30.69
5.0%	Included	Sunflower oil	43.0	481.1	1740.0[a]	1.93	2.20[e]	2.11[h]	3572.5 [i]	32.48
2.5%	Added	Palm oil	43.6	494.5	1705.1[ab]	2.03	2.29[d]	2.22[fg]	3686.5[c]	31.38
2.5%	Included	Palm oil	43.5	467.8	1649.6[cd]	2.05	2.34[c]	2.27[de]	3655.4[fe]	27.15
5.0%	Included	Palm oil	43.1	467.4	1685.9[bc]	2.01	2.28[d]	2.21[g]	3632.2[g]	27.30
2.5	Added	Dry fat	43.9	480.2	1653.1[cd]	2.07	2.37[c]	2.28[cd]	3676.3[d]	25.38
2.5%	Included	Dry fat	43.3	451.4	1582.3[e]	2.16	2.50[b]	2.41[b]	3712.8[a]	19.14
5.0%	Included	Dry fat	43.4	447.9	1541.5[e]	2.21	2.55[a]	2.46[a]	3685.8[c]	12.06
2.5	Added	Lecithin	43.9	495.8	1706.5[ab]	2.04	2.29[d]	2.22[fg]	3695.1[b]	30.20
2.5%	Included	Lecithin	43.4	466.1	1643.6[cd]	1.81	2.37[c]	2.29[cd]	3659.9[e]	25.85
5.0	Included	Lecithin	43.5	467.1	1670.3[bcd]	2.07	231[d]	2.24[ef]	3652.0 [ef]	24.22
SEM			0.38	5.61	14.50	0.073	0.012	0.089	10.07	------
P value										
Fat source			NS	0.0001	0.0001	0.01	0.0001	0.0001	0.0001	-------
Fat level			NS	0.001	0.05	NS	0.0001	0.0001	0.0001	-------
Source × level			NS	NS	0.007	NS	0.0001	0.0001	0.0001	-------

*** Fat was included as apart in isocaloric, isonitrogenous diets or added as an energy source to control diet providing approximately equal CP level.**

****As relative to total cost.**

abcdefghi **Means within the same column with no common superscripts differ significantly P≤0.05.**

Table 8. Effect of dietary fat levels and sources, and increasing the energy content of the control diet by fat addition* on dressing(%), abdominal fat (%), abdominal plus visceral fats (%), liver (%) and giblets (%) of 42-day old broiler chicks**

Treatments/ level	Method of addition	Fat source	Carcass yield, %					Physical characters of meat			
			Dressing	Abdominal fat	Abdominal + Visceral fats	Liver	Giblets	pH	Color	Tenderness	WHC
Control	----		63.2^{ab}	0.94	1.75^{e}	3.19^{de}	6.72^{de}	7.06	0.198	2.97	5.89
2.5%	Added	Sunflower oil	64.6^{a}	1.24	2.55^{ab}	3.49^{a}	6.95^{a}	7.09	0.246	2.71	5.59
2.5%	Included	Sunflower oil	64.3^{a}	0.97	1.97^{d}	3.39^{ab}	6.94^{a}	7.69	0.244	2.69	5.55
5.0%	Included	Sunflower oil	65.4^{a}	1.28	2.59^{a}	3.38^{bc}	6.95^{a}	7.09	0.303	2.27	5.21
2.5%	Added	Palm oil	64.8 ^{a}	1.21	2.42^{bc}	3.26^{d}	6.76^{bcd}	7.00	0.246	2.70	5.65
2.5%	Included	Palm oil	63.7 ^{ab}	0.99	1.97^{d}	3.29 ^{cd}	6.78 ^{bcd}	7.05	0.254	2.63	5.20
5.0%	Included	Palm oil	64.4^{a}	1.33	2.59^{a}	3.46^{ab}	6.98^{a}	7.07	0.298	2.28	5.20
2.5	Added	Dry fat	63.8^{ab}	1.17	2.31^{c}	3.15^{e}	6.66^{ef}	7.00	0.225	2.69	5.63
2.5%	Included	Dry fat	62.1^{b}	1.03	2.00^{d}	3.27^{d}	6.83^{bc}	7.05	0.220	2.70	5.74
5.0%	Included	Dry fat	61.0^{c}	1.39	2.68^{a}	3.24^{de}	6.84^{b}	7.07	0.265	2.29	5.40
2.5	Added	Lecithin	64.7^{a}	1.20	2.43^{bc}	3.25^{de}	6.74^{cde}	7.07	0.239	2.66	5.60
2.5%	Included	Lecithin	63.5^{ab}	1.01	1.99^{d}	3.06^{e}	6.58^{f}	7.15	0.257	2.68	5.55
5.0	Included	Lecithin	63.6^{ab}	1.31	2.57^{a}	3.25^{de}	6.78^{bcd}	7.02	0.287	229	5.16
SEM			0.08	0.03	0.06	0.03	0.02	0.14	0.004	0.03	0.04
P value :											
Fat source			0.0001	NS	NS	0.0001	0.0001	NS	0.0001	NS	0.001
Fat level			0.0001	0.001	0.0001	0.007	0.0001	NS	0.0001	0.0001	0.0001
Source × level			0.0001	NS	0.02	0.0001	0.0001	NS	NS	NS	NS

*** Fat was included as apart in isocaloric, isonitrogenous diets or added as an energy source to control diet providing approximately equal CP level.**

**** Carcass without heads, neck, intestinal, wings, giblets and legs.**

abcde **Means within the same column with no common superscripts differ significantly P≤0.05**

Table 9. Effect of dietary fat levels and sources, and increasing the energy content of the control diet by fat addition* on chemical composition of meat and liver and plasma constituents of 42-day old broiler chicks

Treatments/ level	Method of addition	Fat source	Meat chemical composition			Liver chemical composition			Plasma constituents			
			Moisture	Crude protein	Ether extract	Moisture	Crude protein	Ether extract	Pro (g/100ml)	Lip (mg/100ml)	Trig (mg/100 ml)	Cho (mg/100 ml)
Control	----		75.9	78.2^{a}	13.0^{f}	76.8	70.1	22.0	3.94	5.93	108.2	126.6
2.5%	Added	Sunflower oil	75.0	73.2^{fg}	18.6^{b}	74.8	65.1	26.2	3.93	6.94	115.9	158.4
2.5%	Included	Sunflower oil	74.8	76.1^{bc}	14.6^{e}	75.0	66.9	23.8	3.94	6.63	117.6	143.1
5.0%	Included	Sunflower oil	73.1	72.1^{gh}	19.1^{ab}	72.2	64.2	27.0	3.85	7.48	122.6	168.9
2.5%	Added	Palm oil	74.8	73.9 ^{ef}	17.1^{c}	74.5	65.9	24.8	3.96	6.72	115.2	155.3
2.5%	Included	Palm oil	74.4	76.4^{b}	14.6^{e}	75.0	67.1	24.1	3.94	6.78	118.2	149.7
5.0%	Included	Palm oil	73.5	73.0^{fg}	18.5^{b}	72.7	63.9	27.2	3.92	7.53	119.3	168.5
2.5	Added	Dry fat	74.8	74.8^{de}	16.8^{c}	75.0	66.5	24.5	3.97	6.86	115.1	159.5
2.5%	Included	Dry fat	75.0	75.5^{bcd}	15.3^{de}	74.6	66.6	24.4	3.93	6.78	117.0	148.9
5.0%	Included	Dry fat	73.9	71.8^{h}	18.9^{ab}	72.8	64.1	27.0	3.93	7.38	122.7	171.3
2.5	Added	Lecithin	75.0	74.7^{de}	16.8^{c}	74.7	66.1	24.6	3.97	6.72	116.6	148.3
2.5%	Included	Lecithin	74.8	75.2^{cd}	15.8^{d}	75.0	66.9	24.1	4.00	6.65	117.3	150.0
5.0	Included	Lecithin	73.2	72.5^{gh}	19.5^{a}	72.4	63.8	27.0	3.88	7.48	123.5	168.6
SEM			0.11	0.47	0.38	0.21	0.76	0.37	0.09	0.13	2.83	7.23
P value:												
Fat s source			0.06	NS	0.01	NS	NS	NS	NS	NS	NS	NS
Fat level			0.0001	0.0001	0.0001	0.0001	0.01	0.006	NS	0.0001	0.008	0.0001
Source × level			0.02	0.009	0.0005	NS	NS	NS	NS	NS	NS	NS

*** Fat was included as apart in isocaloric, isonitrogenous diets or added as an energy source to control diet providing approximately equal CP level.**

abcdefghi **Means within the same column with no common superscripts differ significantly P≤0.05**