International Journal of Agriculture Innovations and Research
Volume 3, Issue 2, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 09/08/2014 | Accepted on : 25/08/2014 | Published : 18/09/2014

Effects of Feeding Broiler Chickens on Diets Contained Semi-Refined or Frying Sunflower Oil on Their Growth Performance and Carcass Traits

Khalid M. Gaafar
Department of Nutrition and Clinical Nutrition
Faculty of Veterinary Medicine, Sadat City University-Egypt
Email: gaafar_kh@yahoo.com

Abstract – **Because of high cost of refined vegetable oil as feed energy source for poultry and successful results with dietary supplementation of some refining oil wastes for broilers, finding of energy feeds alternatives for poultry nutrition seems to be essential. The current experiment was conducted to compare the growth performance of broilers fed control diets contained refined sunflower oil as energy source with other two groups fed diets contained frying oil or acidulated soap stock as energy sources. They fed on iso-caloric starter, grower, and finisher diets contained 2.5%, 3%, and 3.5% of these energy sources at 0-14 days, 14-28, and 28-42 day of age, respectively. No significant difference were obtained for different parameters of growth performance, carcass parts and traits of groups fed diets contained refined sunflower oil or frying oil or acidulated soap stock of sunflower oil waste. An increased plasma HDL and reduced plasma VLDL for groups fed diets contained frying oil or acidulated soap stock. A negative relationship between plasma cholesterol and triglyceride values was observed in the groups fed diets contained frying oil or acidulated soap stock and the control birds fed diets contained refined sunflower oil. Furthermore, plasma malondialdehyde concentrations increased in the birds fed diets contained frying oil and those fed diets contained acidulated soap stock compared to the control group. It was concluded that normal frying sunflower oils and acidulated soap stock of sunflower oils can be used as economic alternative feed oils for quality refined sunflower oils as energy sources in the broiler`s diets.**

Keywords – **Broilers, Frying Oil, Sunflower Oil, Oil Wastes.**

I. Introduction

Energy is one of the most important nutrients of broiler chicken's diets, because of its regulatory role for feed intake, which affect the nutrients balance of diet. Fats are most valuable source of energy in poultry rations [25]. Approximately 70% of the total cost of poultry diets is related to meeting energy needs [46]. Plant oils are traditionally used in poultry feed to suffice energy requirement and preserve space for other ingredients especially protein. Many different grades of fat have been used as energy source in poultry feeding. Regarding the economical demands of broiler farm, specially feed ingredient cost, cheaper high energy sources are favorable selects, when corn is major proportion of diet. The alternative low cost energy sources such as restaurant waste oil [21] and vegetable oil refining wastes [2] such as acidulated vegetable oil soap stock are used in experimental studies with successful results. Restaurant or kitchen grease is primary vegetable oil that has been used for deep frying of food products. Vegetable oil heated under adverse condition (exposed to high oxygen level) for long period may reduce the metabolizable energy of the oil due to increase of polymer, free fatty acids or ring compounds which are less utilized sometimes to the extent of being anti-nutritional factors [30], [5], [32], [49], and [24] formation, whereas the small increase in polymer and free fatty acids content of oil used under normal heating in restaurants or kitchens has no adverse effect on the quality of the fat feeding to poultry [19], [24], [37], and its energy could be comparable to the poultry fat [26]. Other new source of fats is acidulated vegetable oil soap stock that is a by-product of the caustic refining process of plant oil. This by-product has traditionally been used by fatty acid producers and animal feed manufacturers. It contains 75 to 95 percent free fatty acids and variable amounts of triglycerides, sterols, tocopherols, pigments and other fat soluble materials [35]. Nevertheless, according to human consumption of the refined oils and their high prices, it has considered to use oil refining by-products such as acidulated vegetable soap stock or frying oil as poultry feed. The aim of this work was to study the effects of feeding diets contained frying oil or acidulated vegetable soap stock on the growth performance and carcass traits of broilers.

II. Materials and Methods

Birds and treatments

The experiment was carried out under the protocol approved by the faculty of veterinary medicine, Sadat city University, Egypt. A total of 90 of one day old chicks "$cobb_{500}$" were raised to 42 days old and allotted randomly to 3 floor pens for three experimental groups with 30 birds in each. The first was considered as control group because of balancing the poultry diets with high ME source became a routine work to justify and balance the calories protein ratio of diets. The control group fed on starter, grower, and finisher diets using sunflower oil to satisfy their energy needs[35] during 0-2Wks, 2-4Wks, and 4-6Wks of age, respectively. Other two groups of chicks were designed to receive two oil`s treatments {T1 and T2}, the first fed on diets contained frying sunflower oil of normal kitchen use {T1} whereas the second fed on diets contained acidulated soap stock of sunflower oil {T2} during starting (0-2Wks), growing (2-4Wks), and finishing (4-6Wks) periods. Diets for the three groups are isocaloric

and isonitrogenous for the same experimental period as shown in Table 1.

Management and housing

Top-dressed litter with 2 inch of fresh pine wood shavings was used as bedding. The temperature was set at 30 to 33°C during the first week and was reduced by 2 °C per week until 20 °C was reached. Relative humidity was about 60 to 80%. The lighting program was 23L:1D. The chicks were vaccinated according strain`s vaccination program. Access to feed and water was provided on an *ad libitum* basis.

Birds` performance measurements

Body weight and feed intake were monitored on a pen basis weekly and calculated individually, while weight gain, relative growth rate [12)] and feed conversion ratio [45)] values were calculated individually at the end of starting (0-14day of age) and finishing (14-42 day of age) periods. Mortality was also recorded on a daily basis in each pen. Chickens were killed by cervical dislocation at the end of the trial. Six birds per treatment group were randomly selected for determining carcass traits. They were de-feathered, eviscerated and dressed. Liver, gizzard, proventriculus, thigh and breast were collected, weighed and calculated as percentage of live weight.

Sampling and Methods of analysis

Representative samples of mixed rations and used oil and oil` products were taken for chemical analysis[4)]. Fatty acids profile was determined using official method of analysis No. 969.33. At the end of 5th week of age, blood samples were obtained from wing veins and directly liquated into 2-mL sterile vials, and allowed for one hour at room temperature (23Cº) for complete coagulation and for 3h in refrigerator (4Cº) for complete separation of serum before centrifugation at 1500 rpm, 6Cº for 20 min. The serum samples were used for determination of triglycerides [16}, total cholesterol [3], high density lipoprotein HDL [29], low density lipoprotein LDL [23], very low density lipoprotein VLDL [23] and malondialdehyde, glutathione reductase using Spectrophotometer and commercially available kits (Biosystem S.A, Costa Brava, 30, Barcelona, Spain) according to manufacturer's instructions. Blood parameters were estimated only at the end of experiment to evaluate the effects of long period of oil`s feeding for chickens.

Table 1: Composition of different used diets and their calculated nutrients contents

Ingredients	**Sunflower oil (NRC Energy)**			**Frying sunflower oil**			**Acidulated sunflower oil**		
	Starter	**Grower**	**Finisher**	**Starter**	**Grower**	**Finisher**	**Starter**	**Grower**	**Finisher**
Yellow corn	54.0	58.75	62.0	54.0	58.75	62.0	54.0	58.75	62.0
Soybean meal	34.4	30.0	26.0	34.5	30.0	26.0	34.4	30.0	26.0
Corn gluten 60	5.0	4.5	5.0	5.0	4.5	5.0	5.0	4.5	5.0
Vegetable oil	2.5	3.0	3.5	-	-	-	-	-	-
Frying oil	-	-	-	2.5	3.0	3.5	-	-	-
A.Soap stock	-	-	-	-	-	-	2.5	3.0	3.5
Dicalcium-P.[1]	1.70	1.5	1.4	1.70	1.50	1.4	1.70	1.5	1.4
Lime stone	1.5	1.4	1.3	1.40	1.40	1.3	1.50	1.4	1.3
Common salt	0.30	0.30	0.3	0.30	0.30	0.3	0.30	0.30	0.3
Premix[2]	0.30	0.30	0.3	0.30	0.30	0.3	0.30	0.30	0.3
DL-methionine[3]	0.15	0.12	0.10	0.15	0.12	0.10	0.15	0.12	0.10
L-lysine[4]	0.15	0.13	0.10	0.15	0.13	0.10	0.15	0.13	0.10
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis									
ME Kca/kg	2965	3050	3125	2965	3050	3125	2965	3050	3125
CP%	22.1	20.2	19.1	22.1	20.2	19.1	22.1	20.1	19.1
ME Kcal/CP%	134.1	151	163.6	134.1	151	163.6	134.1	151	163.6
EE%	4.01	4.65	5.25	3.24	4.98	5.27	5.4	6.35	7.28
Calcium%	1.11	1.0	0.95	1.11	1.00	0.95	1.11	1.0	0.95
Total phos.%	0.75	0.68	0.60	0.75	0.67	0.60	0.75	0.66	0.61
DL.methionine%	0.56	0.53	0.51	0.57	0.54	0.51	0.56	0.53	0.51
L.lysine%	1.18	1.11	1.0	1.15	1.10	1.10	1.16	1.10	1.0

[1]Dicalcium phosphate, 18% granular phosphate and 23 % calcium..

[2]Premix of Altoba company: 1.5 kg vitamins mixture contains: vitamin A 12000000 IU, vitamin D3 3000000 IU, vitamin E 40000 mg, vitamin K3 3000 mg, vitamin B1 2000 mg, vitamin B2 6000 mg, vitamin B6 5000 mg, vitamin B12 20 mg, niacin 45000 mg, biotin 75 mg, folic acid 2000 mg, pantothenic acid 12000 mg. In addition to 1.5 Kg of minerals mixture contains: manganese 100000 mg, zinc 600000 mg, iron 30000 mg, copper 10000 mg, iodine 1000 mg, selenium 200 mg and cobalt 100 mg. [5]DL-Methionine, Met AMINO® (DL-2-amino-4-(methyl-thio)-butane acid,

[3]DL-methionine, α-amino-Y-methyl-oily acid) by Feed Grade 99% (EU).

[4]L-Lysine HCL 99% (Feed Grade) L-Lysine: 78.0% Min (Indonesia)

Table 2: Chemical analysis of the used feed oil sources

Items	Value		
	Vegetable oil%	Frying oil	Acidulated soap stock
Peroxide No. (mmol O2/Kg)	9.5	14.4	7.4
Iodine No.	129.22	119.78	99.82
Fatty acid Profile (% of total fatty acids):			
Caprylic (C 8:0)	2.06	2.95	2.41
Myristic (C 14:0)	0.11	0.22	0.14
Palmitic (C 16:0)	9.39	9.76	21.0
Palmitioleic (C 16:1 w7)	0.16	0.24	0.13
Stearic (C 18:0)	3.98	3.8	5.44
Vaccinic (C 18:1 w7)	1.22	1.23	1.13
Oleic (C 18:1n9)	21.5	23.73	19.34
Linoleic (C 18:2)	55.0	53.4	45.9
Linolenic (C 18:3)	3.81	3.32	2.56
Gamma linolenic {18:3 (t)6}	0.31	0.30	0.30
Arachidonic acid (C20:0)	0.3	0.28	0.5
Behaneic (22:0)	0.41	0.20	0.72
Gadoleic {20:1 (t)9}	0.13	0.13	0.20
Unidentified acids	0.99	0.44	0.23
SFA	16.50	17.5	30.2
UFA	83.5	82.5	69.8
UFA:SFA	5.06	4.71	2.31
Oleic: Plamitic (O:P)	2.29	2.43	0.92
Linoleic: Plamitic (L:P)	5.86	5.47	2.19
(L+O)/P	8.15	7.90	3.1

Statistical analysis

Experimental data were analyzed as a randomized block design. All data were subjected to one-way ANOVA by the GLM procedure using the SPSS 18.00 statistical package (SPSS Ltd., Surrey, UK). Duncan's test was carried out to assess any significant differences at the probability level of $P < 0.05$ among the experimental treatments.

III. Results and Discussion

Fats of vegetable origin have high unsaturated fatty acid content with high degrees of metabolizable energy, which are well absorbed, utilized as a source of energy, and increased growth performance of the bird [52]. Our result`s data in table 3, showed that no significant differences in different growth performance parameters such as body weight, RGR, weight gain, feed conversion, and feed intake of broilers either from 0 day to 14th day or from 14th day to 42 day of age. However, there were numerical increases in total relative growth rates and during the starting period (0–14 day) of control birds compared to the birds of other treatments. Also, growth rates were higher in all groups of birds during the starting period (0–14 day) than those of finishing period (14–42 day). Collectively, an increased growth performance of broilers fed diets contained frying oil or acidulated soap stock were observed, however frying oil had high peroxide number and acidulated soap stock had low quality grade. Although, the increased growth performance, there were higher mortality percentages specially for birds fed acidulated soap stock, which needs further investigation for the effect of oil`s quality on the health of birds. Our finding were in agreement with the finding of Menge and Beal [31], Bornstein, et al. [10], and Moraes et al. [34] who found an improved growth performance of broilers fed on diets contained acidulated soap stock. Also Abdelgadir [1] stated an increased body weight and improved feed conversion of broilers fed on diets contained frying oil whereas leo [24] found no differences in growth performance between groups of chickens fed on diets supplemented with refined oil and heated oil. An increase in the content of unsaturated fatty acids in relation to saturated fatty acids increases the absorption of the saturated fatty acids [53]. Our oil analysis data in table 2, showed an increased saturated fatty acids and it's relatively increases in acidulated soap stock and frying oil, respectively. As shown in table (2), iodine number values as indicator for instauration were the lowest value for acidulated soap stock followed by that of frying oil compared to sunflower oil. Consequently, the ratio between unsaturated to saturated fatty acids in acidulated soap stock and frying oil compared to control group are 4.71, 2.31, and 5.06, respectively. Ketels and De Groote [22] stated that the ratio of unsaturated fatty acids to saturated fatty acids must be more than 2.5 or more than 4 in the work of Stahly [47] to improve fat digestibility. Furthermore, as a result of heating of frying oil,

polyunsaturated fatty acids losses occurred and caused a relative increase of saturated fatty acids and monounsaturated fatty acids of heated oil as previously recorded by heating sunflower [11]-[20] or lin seed [50] oils. A synergism between saturated and unsaturated fatty acids improved fat digestibility, and the result was good impact on its metabolizable energy content [39]-[40] and consequently on growth performance. In addition to that, the unsaturated vegetable oils cause to decline energy loss in broiler's excreta and eventually provide higher metabolizable energy [55]. Furthermore, Zanini et al. [54] stated unaffected dietary ME levels and efficiency by feeding broilers on heated oils. These might be proved the improvement of growth performance of birds fed on acidulated soap stock and frying oil compared to those fed on control diet contained refining oil.

Our results data in table (4) revealed no significant difference in carcass traits, parts, and abdominal fat between groups. Vegetable acidulated soap stock and frying oils, which are all typically high in free fatty acids, have been shown to support excellent growth performance in poultry feeds [28], that was comparable to control birds fed on diets contained quality refined oil. The insignificant effect of oil source on % carcass and its traits in our study completely agreed with finding of Crespo and Esteve-Garcia [13] and Tabiedian et al. [48]. Recent study for Monfaredi et al. [33] showed that carcass and liver weights didn't affected by soybean oil or beef tallow inclusion in broiler chick's diet. Although the increased dietary supply from unsaturated fatty acids reduced the abdominal fat content [42]-[55], the difference between treatments in our study for abdominal fat was insignificant. This might be due to slightly increased saturated fatty acids of acidulated soap stock (USFA/SFA: 2.31) and losses of polyunsaturated fatty acids as a result of thermal treatment of frying oil and caused a relative increase of saturated fatty acids and monounsaturated fatty acids (USFA/SFA: 4.71) compared to the control oil contained feed (USFA/SFA: 5.06). This has been previously reported in heated linseed oil [50] and sunflower oil [20].

Plasma triglycerides and VLDL reduced in the groups fed on diets contained frying oil and acidulated soap stock, which was insignificant for triglycerides and significant for VLDL compared to control group. While, the plasma cholesterol, HDL and LDL increased for the same groups. This increase was significant for HDL and insignificant for cholesterol and LDL compared to the control group. A negative relationship between cholesterol and triglyceride values was observed in the groups fed on the diets contained frying oil and that contained acidulated soap stock and the control birds fed on diets contained refined oil. The cholesterol values of the group fed on control diet contained quality refined oil were the lowest, and the triglyceride values of this group were the highest. The cholesterol values of groups fed the acidulated soap stock` diets were the highest and the triglyceride values were the lowest followed by those of groups fed the frying oil `diet. In previous studies, animals fed diets rich in cholesterol or saturated fat had elevated carcass cholesterol and blood cholesterol levels [20]-[44]. Therefore, diet ingredients can be manipulated to change blood values [43]-[9]-[51]. These results might be due to increased free and saturated fatty acids content of acidulated soap stock, which are relatively increased in frying oil. This increased free fatty acids leading to faster β-oxidation of these free fatty acids, decreased plasma triglycerides [27] and increased plasma HDL concentrations. Saturated fatty acids increase the amount of high density lipoprotein (HDL) and cholesterol more than polyunsaturated fatty acids because saturated fatty acids don't oxidized easily compared with unsaturated fatty acids and also their effects are stable [38]-[44]-[18]. Some studies, however, do not agree. Fan et al. [15], for example, found that diets containing different fat sources did not affect blood cholesterol values. Researchers such as Guyton and Hall [17] and Bachorik, et al. [7] have also shown that increased serum HDL is able to decrease the negative effect of high blood cholesterol.

Malondialdehyde as well as other carbonyl compounds are naturally occurring byproducts of polyunsaturated fatty acids peroxidation [14] while, glutathione reductase activity was assayed by following the reduction of glutathione [8]. In our results, plasma malondialdehyde and glutathione reductase concentrations increased in the group fed on diet contained frying oil and also in the group fed acidulated soap stock compared to the control group. These increases were significant for malondialdehyde but insignificant for glutathione reductase in the group fed frying oil and both were numerically increased in the group fed acidulated soap stock. Heating of oil increased oxidation of fatty acids, which consequently increase the peroxidation products such as malondialdehyde. The increased plasma malondialdehyde levels were a direct reflection of glutathion reductase activity in the birds fed on diets contained frying oil, where its sequela was increased peroxide number as shown in table (2). These results were in agreement with the conclusion of Rodriguez and Ruiz, [41] who stated that the decrease in activity of glutathione reductase in red blood cells is a positive feedback mechanism in response to reduced lipid peroxidation. The rise of lipid peroxidation resulted in increased malondialdehyde level in blood and tissues [36]-[6]. However, the occurrence of fatty acids per-oxidation and increased peroxide number of frying oil as a result of heating, the growth performance of broilers fed frying oil and acidulated soap stock were improved. The meat quality of these birds might be affected. Further investigations on broiler`s meat quality are needed because Bou et al. [11] showed that the content of various *trans* fatty acid isomers increased in meat from broilers fed oxidized (moderate heating up to 60C° and very oxidized (excessive heating up to 195C°) oils and its discriminate analysis showed that *ditrans*-conjugated linoleic acid content was able to distinguish chicken meat from chickens fed sunflower oils heated at 190 to 195°C.

Table 3: Effect of oil supplementation on the growth performance of broilers along the experiment (at 2 Ws and 6Ws of age)

Items	units	Control	T1	T2
At the end of 14 days of age:				
Average body weight	(g/bird)	607.4±7.4[a]	603.4±16.4[a]	576.2±17.2[a]
Relative growth rate[*]	(%)	171.4±0.01[a]	169.9±0.01[ab]	168.8±0.01[ab]
Feed conversion ratio	ratio	1.89±0.03[b]	1.91±0.06[b]	1.97±0.07[b]
Feed intake	(g/bird)	1053.9	1035.8	1012.4
From 14-42 days of age:				
Relative growth rate	(%)	106.0 ± 0.01[ab]	103.3±0.03[b]	106.5±0.03[ab]
Feed conversion ratio	ratio	1.89±0.04[b]	1.97±0.08[b]	1.98±0.07[b]
Feed intake	(g/bird)	2584.0	2473.4	2542.8
Total performance (0-42 days)				
Total Average body weight	(g/bird)	1984.5±21.4[a]	1906±43 [a]	1895±41.6[a]
Total relative growth rate	(%)	191 ± 0.002[a]	190.0±0.003[ab]	190.5±0.002[ab]
Total feed conversion ratio	ratio	1.88±0.02[a]	1.91±0.05[bc]	1.95±0.04[bc]
Total feed intake	(g/bird)	3637.9	3509.2	3561.82
Mortality	(%)	6.6	10.0	16.0

[abcd]Values in the same row with a different superscript differ significantly at P < 0.0
[*]Relative growth rate = $(W_2-W_1)/(W_1+W_2)/2*100$ [12]

Table 4: Effect of oil supplementation on the carcass traits of broilers

	Control	T1	T2	P
Dressing %	78.6 ± 0.01	77.0 ± 0.00	74.7 ± 0.01	NS[*]
Eviscerated%	83.9 ± 0.01	82.1 ± 0.01	81.1 ± 0.01	NS
Thigh %	9.30 ± 0.01	10.3 ± 0.00	9. 8 ± 0.00	NS
Breast%	13.4 ± 0.01	13.9 ± 0.01	14.3 ± 0.00	NS
Liver %	2.00 ± 0.00	2.10 ± 0.01	2.10 ± 0.01	NS
Gizzard %	2.10 ± 0.01	2.20 ± 0.00	2.30 ± 0.00	NS
Preventriculus %	0.40 ± 0.00	0.50 ±0.01	0.50 ± 0.01	NS
Abdomonal fat%	2.70 ± 0.01	2.70 ± 0.01	2.80 ± 0.00	NS

[abcd]Values in the same row with a different superscript differ significantly at P < 0.05
[*]NS: insignificant effect

Table 5: Effect of oil supplementation on blood parameters of broilers

Items mg/dl	Control	T1	T2	P
Triglycerides	180.1 ± 11.0	157.7 ± 4.8	164. 7±5.5	NS[*]
Cholesterol	240.0 ± 8.6	249 ± 14.1	255.7±16.2	NS
HDL	43.50 ± 2.0[b]	59.4 ±1.6[a]	50. 7±4.2[ab]	
LDL	154.0 ± 10.0	159.5±3.5	186.1±6.4	NS
VLDL	37.0 ± 0.60[a]	33.4±1.00[bc]	32.9±1.10[bc]	
Malondialdehyde	8.60 ± 0.50[b]	11.8 ± 0.30[a]	9.1 ± 0.30[b]	
Glutathione reductase	7.10 ± 0.20	7.80 ± 0.30	7.40 ± 0.10	NS

[abcd]Values in the same row with a different superscript differ significantly at P < 0.05
[*]NS: insignificant effect

IV. Conclusion

It was concluded that normal frying sunflower oils and acidulated soap stock of sunflower oils can be used as economic alternative feed oils for quality refined sunflower oils as energy sources in the broiler`s diets. Further investigations are needed to adjust the effect of quality`s degree of acidulated soap stock and frying oils on the meat quality and broiler`s health because of relatively high mortality in our study.

Acknowledgment

My faithful thanks to a Master student Ahmad Said Elzenary for his help to achieve this work

REFERENCES

[1] Abdelgadir MO. Use of dietary plant oils in broiler rations. Ph.D thesis, University of Sudan, Sudan 2009.

[2] Alizadeh S., M.H. Shahir, H. Amanlo, N. Baradaran and Z. Asadi Kermani. Sunflower oil production wastes (acidulated soap stock) as an energy source in broiler chickens diet. The International and The 4 th National Congress on Recycling of Organic Waste in Agriculture, 2012, Isfahan, Iran.

[3] Allian, C.C.; Poo, L.S.; Chan, S.G.; Richmond, W. And Fu, P.C. Enzymatic determination of total serum cholestrol.Clin.Chem., 1974, 20:470-475.

[4] AOAC. Official Methods of the AOAC. 17th ed., 2000, Assoc.Off. Anal. Chem. Int., aithersburg, MD.

[5] APOC. Cooking oil and palm oil in frying. American Palm Oil Council, 2004. www.APOC.com .

[6] Ates B, Dogru M. I., Gul M., Erdogan A., Dogru A. K., Yilmaz I., Yurekli M. and Esrefoglu M. Protective role of caffeic acid phenethyl ester in the liver of rats exposed to cold stress. Fundamental and Clinical Pharmacology, 2006, 20: 283-289.

[7] Bachorik, P. S., R. I. Levy, and B. M. Rifkind. 1991. Lipids and dyslipoproteinemia. Pages 188–239 in Clinical and Diagnosis Management by Laboratory Methods. J. B. Henry, ed. 18th ed.

[8] Beutler E, Duron O, Kelly B. M. Improved method for the determination of blood glutathione. J Lab Clin Med., 1983, 61:882–888.

[9] Blanch, A., and M. A. Grashorn. Effect of different dietary fat sources on general performance and carcass yield in broiler chickens. In Proc. 12th Eur. Symp., 1995, Pages 71–75. Qual. Poult. Meat, Zaragoza, Spain.B. Saunders Company Inc., Philadelphia.

[10] Bornstein, M., Plavnik, S., I. and Lev. Y. Body weight and or fatness as potential determinants of the onset of egg production in broiler breeder hens. Brit. Poult. Sci., 1984, 25:323-341.

[11] Bou, R. R., Codony A., Tres, M. D., Baucells,† and F. Guardiola. Increase of Geometrical and Positional Fatty Acid Isomers in Dark Meat from Broilers Fed Heated Oils. Poultry Science, 2005, 84:1942–1954

[12] Brody S. Bioenergetics and growth.1stEd.,Baltimore,USA., 1945, 502-507.

[13] Crespo, N. and Esteve-Garcia, E. Dietary fatty acid profile modifies abdominal fat deposition in broiler chickens. Poult. Sci., 2001, 80, 71-78.

[14] Cortinas L., Barroeta A. Villaverda C., Galobart J. Guardiola F., Baocells MD. Influence of the dietary polyunsaturated levels on chicken meat quality: lipid oxidation. Poultry Science, 2005, 84: 48-55.

[15] Fan, Q., J. Feng, S. Wu, K. Specht, and S. She. Nutritional evaluation of rice bran oil and a blend with corn oil. Nahrung, 1995, 39:490–496.

[16] Fassati, P. and Principe, L. Measurement of serum triglyceride colorimetrically with an enzyme that produce H2O2. Clin Chem., 1982, 28(10): 2077-2080.

[17] Guyton, A. C., and J. E. Hall. Metabolism and temperature regulation. Textbook of Medical Physiology. 9th ed., 1996, Pages 855–876, W. B. Saunders Company, London.

[18] Hrdinka, C., W. Zollitsch, W. Knaus, and F. Lettner. Effects of dietary fatty acid pattern on melting point and composition of adipose tissues and intramuscular fat of broiler carcasses. Poult. Sci., 1996, 75:208–215.

[19] Janssen WKKA. Polymer levels in commercial fats: their effect on energy level and performance of broilers. Centre for Poultry Research and Extension, the Netherlands 1985, Pages 65-91.

[20] Juane´da, P., S. B. de la Pe´rrie`re, J. L. Se´be´dio, and S. Gre´goire. Influence of heat and refining on formation of CLA isomers in sunflower oil. J. Am. Oil Chem. Soc., 2003, 80:937–940.

[21] Karamouz H, Aghdam Shahriar H, Salamatdoust R. Response of male broiler to different levels of food industries residual oil on serum lipoproteins, lipid peroxidation and total antioxidant status. American-Eurasian Journal of Agricultural & Environmental Sciences, 2010, 6, 252–25.

[22] Ketels, E., and G. De Groote. Effect of ratio of unsaturated to saturated fatty acids of the dietary lipid fraction on utilization and metabolizable energy of added fats in young chicks. Poult. Sci., 1989, 68:1506-1512.

[23] Lee, R. D., Nieman D. C. Nutritional Assessment (2nd ed), 1996, St Louis, MO: Mosby.

[24] Leo SJ. Kitchen Grease Safe For Poultry? Poultry Science, 1992, the University of Georgia, Athens, CA 30602-2772.

[25] Lesson S. and J. D. Summer. Commercial poultry Nutrition. 3rd edition, 2005, Nottingham University Press.

[26] Leeson S., Summers J. D. Nutrition of the chicken. 4th ed. Ontario: University Books 2001;pp: 413.

[27] Leyton, J., P. J. Drury, and M. A. Crawford. Differential oxidation of saturated and unsaturated fatty acids in vivo in the rat. Br. J Nutr., 1987, 57:383-393.

[28] Lipstein, B., and S. Bornstein. "Extra-Caloric" Properties of Acidulated Soybean-Oil Soapstock for Broilers during Hot Weather. Poult. Sci., 1975, 54:396-404.

[29] Lopez-Virella, M. F.; Stone, P.; Ellis, S. and Colwell, J. A. cholesterol determination in highdensity lipoproteins separated by three different methods. Clin Chem, 1977, 23:882-884.

[30] Mansoor M. M. The Oils and Fats, the Chemistry, Public Health and Industrial Techniques. Almaareif Monchaa Editor, Alexandria, Egypt, 2003;40-46.

[31] Menge, H., and R. E. Beal. The use of neutralized soybean oil soapstock for broilers. Poult. Sci., 1973, 52:219-222.

[32] MFN. Protect your vegetable oil. Medicinal Food News 2004, www.MFN.com

[33] Monfaredi A, Rezaei M, Sayyahzadeh H. Effect of supplemental fat in low energy diets on some blood parameters and carcass characteristics of broiler chicks. South African Journal of Animal Science 2011; 41(1):24-32.

[34] Moraes M. L., Ribeiro A. M. L., Kessler M, Cortes M. M., Ledur V. S., Cura E, Brazilian Journal of Poultry Science, 2009, 11, 161-167.

[35] NRC. Nutrient requirement of poultry. National Research Council, 1994, National Academy Press, Washington

[36] Okutan H, Ozcelik N, Yilmaz H. R. and Uz E. Effects of caffeic acid phenethylester on lipid peroxidation and antioxidant enzymes in diabetic rat heart. Clinical Biochemistry, 2005, 38: 191-196.

[37] Pesti G. M., Bakalli R. I., Qiao M., Sterling K. G. A comparison of eight grades of fat as broiler feed ingredients. Poultry Science, 2002;81:382-390.

[38] Rand, N. T., H. M. Scott, and F. A. Kummerow. Dietary fat in the nutrition of the rowing chick. Poult. Sci., 1958, 37:1075–1085.

[39] Renner, R., and F. W. Hill. Factors affecting the absorbability of saturated fatty acids in the chick. J Nutr., 1961a, 74:254.

[40] Renner, R., and F. W. Hill. Utilization of Fatty Acids by the Chicken. J Nutr., 1961b, 74:259-264.

[41] Rodriguez-Martinez M. A., Ruiz-Torres A. Homeostasis between lipid peroxidation and antioxidant enzyme activities in healthy human aging. Mech Ageing Dev, 2001, 66:213–222

[42] Sanz, M. Higher lipid accumulation in broilers fed on saturated fats than in those fed on unsaturated fats. Brit Poultry Sci., 1999, 40:95-101.

[43] Siegel, S. H., M. S. Hammad, M. R. Leach, G. F. Barbato, H. M. Green, and L. H. Marks. Dietary cholesterol and fat saturation effects on plasma esterified and unesterified cholesterol in selected lines of Japanese quail females. Poult. Sci., 1995, 74:1370–1380.

[44] Simopoulos, A. P. Evolutionary aspects of omega-3 fatty acids in the food supply. Prostaglandins Leukot. Essent. Fatty Acids, 1999, 60:421–429.

[45] Singh, K.S. and Panda, B. Feed efficiency. "Poultry Nutrition", 1992, 2 nd Ed. Kalyam Publishers, Rajinder Nagar, India.199.

[46] Skinner, J.T., A.L. Waldroup and P.W. Waldroup. Effects of dietary nutrient density on performance and carcass quality of broilers 42 to 49 days of age. J. Appl. Poult. Res., 1992, 1: 367-372

[47] Stahly, T. S. Fats in animal nutrition, ed. J. Wiseman. London: Butterworths., 1984, 313-331.

[48] Tabiedian, A., G.H. Sadeghi and J. Pourreza. Effect of dietary protein levels and soybean oil supplementation on broiler performance. Int. J. Poult. Sci., 2005, 4: 799-803.

[49] TNC. Reducing free fatty acids in frying oil. TechNeed Challenge 2008, www.yet2.com

[50] Wolff, R. L. Heat-induced geometrical isomerization of α-linolenic acid: Effect of temperature and heating time on the appearance of individual isomers. J. Am. Oil Chem. Soc., 1993, 70:425–429.
[51] Verma, N. D., J. N. Panda, K. B. Singh, and A. K. Shrivastav. Effect of feeding cholesterol and fat on serum cholesterol of Japanese quail. Indian J. Poult. Sci., 1995, 30:218–223.
[52] Young, R. J., and N. R. Artman. The energy value of fats and fatty acids for chicks. Poult. Sci., 1961, 40:1653-1662.
[53] Young, R. J., and R. L. Garrett. Effect of oleic and linoleic acids on the absorption of saturated fatty acids in the chick. J Nutr. 1963, 81:321.
[54] Zanini, S.F., G.L. Colnago, M.R. Bastos, B.M.S. Pessotti, F.P. Casagrande, V.R. Lima, 2006. Oxidative stability and total lipids on thigh and breast meat of broilers fed diets with two fat sources and supplemented with conjugated linoleic acid. Lebensmittel-Wissenschaft und-Technologie, 39: 717-723.
[55] Zollitch, W., Knaus, W., Aichinger, F., and Lettner, F. Effects of different dietary fat sources on performance and carcass characteristics of broiler. Anim. Feed Sci. and Tech., 1997, 66: 63 – 69.

AUTHOR'S PROFILE

Khalid Mahmoud Mohamed Gaafar

Date and place of birth: 11th August, 1967, Abou Rakba, Ashmoun, Minoufyia, Egypt
Nationality: Egyptian
Status: Associate Professor
Department: Nutrition and Clinical Nutrition, Faculty of Veterinary Medicine, Sadat City University
Degrees obtained:

a) Bachelor of veterinary Medicine, Faculty of Vet. Med., Banha branch, Zagazig University, Egypt, 199.
b) Master of Vet. Med., Faculty of Vet. Med., Kafr Elsheikh branch, Tanta University, Egypt, 1996.
c) Doctor Vet. Med, Leipzig University, Germany, 2005
d) Associate Professor, Egyptian Scientific Committee, 2010.