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Effect of Oil Supplemented Diet on Growth Performance and Meat Quality of Broiler Chickens

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Abstract

The study was carried out to examine how the fatty acid compositions of oils (soybean and palm oils) were reflected in the products and their effects on the growing performance of broilers. Feed consumption, body weight, abdominal fat/carcass yield and fatty acid levels of abdominal fat were determined. During treatment (day 0 to 38), the highest growth rate was recorded in control group while the lowest was in broilers fed a ration containing soybean oil. At the end of trial, the carcass fat content was generally higher in all treated groups compared to the control. Fatty acids composition was found to be greatly influenced by the dietary fat. The highest level of poly-unsaturated fatty acid was obtained from the group fed ration contained soybean oil. Consequently, the compositions of fatty acids from these sorts of animal products presented for human consumption was seen to highly alter depending on animal nutrition.

Keywords: Palm oil; Soybean oil; Broilers; Carcass performance; Fatty acid composition

Introduction

The inclusion of fat and oil is a common practice in modern poultry production to increase the energy content of diet. The addition of fat to diets, besides supplying energy, improves the absorption of fat-soluble vitamins, diminishes the pulverulence, increases the palatability of the rations, and increases the efficiency of the consumed energy (lower caloric increment). Furthermore, it reduces the passage rate of the digesta in the gastrointestinal tract, which allows a better absorption of all nutrients present in the diet 1 [1]. High energy diets have been shown to improve growth and feed efficiency [2,3].

A number of different fat sources are available for poultry from the vegetable sources and the rendering industry observed that feeding with diets containing fish oil to broilers caused lower feed consumption and body weights and poorer feed conversion efficiency than feeding the control diet [3]. These authors attributed the reduced performance levels to lower palatability.

Oils added to the rations of animals are effective on the fatty acid composition and amount of abdominal fat. In fact, fatty acids composition of oils used in poultry rations are reflected in the animal products because dietary fatty acids are incorporated with little change into the bird body fats [4]. Thus, the type of fat used in the feed influence the composition of broiler body lipids. Abdominal fat is a good indicator of chicken body fats because it is very sensitive to changes in dietary fatty acid composition [5-7]. In this context, Sanz and others [7] have reported that broiler chickens fed with diets enriched of polyunsaturated fatty acids have less abdominal fat or total body fat deposition than do broiler chickens fed with diets containing saturated fatty acids.

Therefore, this research was carried out to find out of the fatty acid compositions of oils added to the chicken rations as an energy source, and to examine the effects of these oils on broiler performances, and reflection of the fatty acid compositions in abdominal fat.

Materials and Method

Experimental animals

A total of 1200 one day old female chickens (*Gallus gallus*) (body weight (BW) of 40.2 ± 0.5 g) acquired from a commercial hatchery were weighed and allotted to three treatment groups. Each treatment included 8 replicate pens with 50 birds per pen. The three treatments were isocaloric and isoproteic with the following characteristics: Diet group I (control) had no added fat; Diets group II and III contained 3% of added soybean oil and palm oil, respectively. Composition and the fatty acid profiles of the experimental rations are provided in Table 1 and 2.

Broilers were kept in temperature-controlled rooms. The temperature of the room was maintained at 33 ± 1°C for the first 3 day, after which the temperature was gradually reduced by 3°C a week until reaching 24°C. The temperature of the room was then maintained at 24°C for the remainder of the experiment. Artificial light was provided 24 h/day by the use of fluorescent lights. The experiment was conducted in 3 phases consisting of a starter phase from day 1 to 16, a middle phase from day 17 to 25 and a finisher phase from day 26 to 38.

Initial live body weight was recorded and then at weekly intervals thereafter. Weighed quantity of feed was offered daily and refusal was recorded to determine the feed consumption. Feed conversion ratio (FCR) was calculated from the body weight gain and feed consumption. All the chicks were vaccinated against Newcastle disease, Infectious Bursal disease and Hydropericardium Syndrome, as per recommended schedule.

At the end of experiment, all chickens were slaughtered at a local abattoir (Chahia, Tunisia) to collect data on carcass characteristics. Hot carcass weight of birds was obtained by removing the skin, head,

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Aliment	Stade	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Starch (%)
Control	S 1	12.56 ± 0.04	22.66 ± 0.09	2.98 ± 0.06	8.21 ± 0.14	43.99 ± 0.01
	S 2	12.18 ± 0.10	21.57 ± 0.10	3.29 ± 0.02	7.54 ± 0.26	46.16 ± 0.02
	S 3	13.29 ± 0.06	20.41 ± 0.09	3.73 ± 0.05	7.49 ± 0.10	40.51 ± 0.01
Soybean oil	S 1	10.70 ± 0.06	20.78 ± 0.11	3.91 ± 0.06	8.67 ± 0.11	29.53 ± 0.14
	S 2	12.50 ± 0.05	20.00 ± 0.04	3.69 ± 0.11	7.70 ± 0.13	31.93 ± 0.18
	S 3	12.29 ± 0.03	19.75 ± 0.11	5.25 ± 0.06	7.28 ± 0.11	33.20 ± 0.25
Palm oil	S 1	12.50 ± 0.04	21.68 ± 0.04	4.72 ± 0.08	7.61 ± 0.18	40.23 ± 0.03
	S 2	11.42 ± 0.04	20.12 ± 0.04	5.12 ± 0.08	8.34 ± 0.18	39.00 ± 0.03
	S 3	12.09 ± 0.08	17.54 ± 0.1	8.50 ± 0.04	8.80 ± 0.19	48.29 ± 0.04

S1: From 1 to 16 days; S2: from 17 to 25 days; S3: from 26 to 38 days

Table 1: Chemical composition of ration.

Fatty acids	Group 1	Group 2	Group 3
Lauric C12:0	Nd	Nd	Nd
Myristic C14:0	0.39	0.35	0.47
Palmitic C16: 0	23.89	21.36	24.53
Palmitoleic C16:1	6.12	3.14	4.08
Stearic C18:0	5.14	6.95	5.45
Oleic C18:1	43.51	37.10	45.65
Linoleic C18:2	19.72	28.96	18.74
Linolenic C18:3	0.81	1.46	0.65
Arachidonic C20:0	0.20	0.18	0.13
SFA	29.62	28.84	30.58
MUFA	49.36	40.24	49.73
PUFA	20.59	30.42	19.39

Nd: Non detected
SFA: Saturated Fatty Acids.
MUFA: Monounsaturated Fatty Acids
PUFA: Polyunsaturated Fatty Acids
Groups I: Standard ration without oil inclusion; Group II: Ration containing soybean oil; Group III: Ration containing palm oil.
Table 2: Fatty acid content in the feeding.

feathers, lungs, toes with feet and gastrointestinal tract. Internal organs, i.e., liver, heart and gizzard were weighed immediately after slaughtering. Chicken meat from thigh and abdominal muscles were collected, vacuum packed and frozen at -20°C until further analyses were completed.

Chemical analysis of feed samples

The finely ground feed samples were analyzed to determine dry matter (934.01), ash (942.05) and crude protein (2001.11) content according to AOAC methods [8]. The total lipid content of was analyzed using ether extraction with diethyl ether reagent, procedure 920.39 [8]. All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean ± standard deviation.

Meat quality measurements

Proximate composition: Thawed and homogenized meat samples were analyzed according to the AOAC methods to determine moisture (930.15) and ash (942.05) [8]. Total nitrogen content was determined by using the Kjeldahl method according to the AOAC method number 984.13 [8]. Crude protein was estimated by multiplying total nitrogen content by the factor of 6.25. The total lipid content of the meat was analyzed using the chloroform/methanol (1:2) fat extraction method (920.39). All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean ± standard deviation.

Fatty acid analysis: Experimental diets and homogenized freeze-dried meat were analyzed for fatty acid composition. For this purpose, 10 g samples were extracted using a choloroform:methanol (2:1, *v/v*) mixture according to the method described by Folsh and others [9]. Next, 20 to 25 mg of the extracted fat was saponified with 0.5 M methanolic sodium hydroxide and then methylated with boronitrifluoride in methanol using the method described by Ao and others [10]. The fatty acid methyl esters obtained were then separated and analyzed by gas chromatography HP6890 (Agilent, Waldbronn, Germany) equipped with a flame ionization detector and DB-WAX capillary column (30 m × 0.25 mm internal diameter) with a film thickness (0.25 µm) in the stationary phase. Helium was used as the carrier gas. An oven temperature of 50°C was held 1 min, raised to 100°C at 50°C/min, held 1 min, raised to 150°C at 3°C/min and raised to 220°C at 2°C/min. The injector and the detector temperatures were both set at 255°C. Fatty acids were identified by matching their retention times with those of their relative standards.

Color analysis

Meat samples were tested for color change at days 2, 1 and 7 using a standard chromameter (8 mm aperture, Model CR-300; Minolta Camera Co. Ltd., Osaka Japan.) Evaluations were conducted at the center of each muscle section. Measurements were performed directly on muscle and the L*, a*, and b* values were determined. A glass plate was placed over the light port of the apparatus and was standardized using black and white reference. The L*, b*, and a* values indicate lightness (0=dark, 100=white), yellowness (+60=yellow, −60=blue), and redness (+60=red, −60=green) respectively. Color measurements were determined at room temperature (20°C) on the surface of each muscle samples at three randomly selected locations by using diffuse illuminant and 0° angle observer.

Texture analysis: Texture profile analysis (TPA) was done by using a texturometer (texture analyzer, Lloyd Instruments, Ltd., West Sussex, UK). The center cores of samples were cut (2 cm in diameter, 2 cm height) and placed between flat plates and a cylindrical probe (12 mm in diameter). Then, samples were compressed to 50% of their original height in a double cycle at a constant rate of 40 mm/min. The texture profile parameters, namely hardness (N) and elasticity (mm) were computed from the resulting force-deformation curves.

Statistical procedures

All measurements were carried out in triplicate. Data were subjected to analysis of variance (ANOVA) using the General Linear Models procedure of the Statistical Analysis System software of SAS Institute (SAS, 1990). Differences among the mean values of the various treatments were determined by the least significant difference (LSD) test, and the significance was defined at $p<0.05$. The differences equal

to or more than the identified LSD values were considered statistically significant.

Results and Discussion

Dietary requirements

Table 1 shows the composition of the experimental diets. As can be seen, broilers have different feed requirements in terms of energy and proteins during different stages of their growth. Young broilers have a high protein requirement for the development of muscles, feathers and other body organs. As the broilers grow, their energy needs for fattening up increase while their protein requirements decrease. They, therefore, require higher protein content in their starter rations than in the grower and finisher rations. This is explained by the fact that bile salt concentration in the intestine of broilers during the first week of life is not sufficient to allow efficient micella formation with the fatty acids [11]. In this context, Larbier and others [12] reported that the nutritional requirements of broilers vary with age.

According to pontes and others [5], when commercial feed fats are used to increase energy in feed diets they are usually added at the rate of 2 to 7 percent of the diet's total dry matter. Total fat levels exceeding 8% can cause digestive disturbances, diarrhea and reduce feed intake. In the formulated diets presented in Table 1, the total fat matter did not exceed 7% of the diet's total dry matter with the exception of the finisher ration supplemented with palm oil in which the crude fat content was slightly higher than the requirements (8.5%). Despite this, no health problems occurred during the trial. Therefore, from the comparison made between the nutritional requirements found in literature and the results obtained by analyzing the experimental diets presented in Table 1, the experimental diets formulated for this study could be considered as satisfying the nutritional needs of growing chickens.

Effects of oil inclusion on body weight gain, food intake and organs weight

It is of interest to mention that no toxic effects were observed when the chickens were administered with the samples. During the experiment, no unusual changes in behavior, locomotive activity, or signs of intoxication were observed during and post-treatment.

The body weight (g) of the experimental groups were determined and reported in Figure 1. All chickens showed significant increase in body weight compared to their initial values (40 g). The highest growth rate was recorded in control group while the lowest was in broilers fed a ration containing soybean oil. There was no significant difference between the control and the palm oil supplemented group, indicating

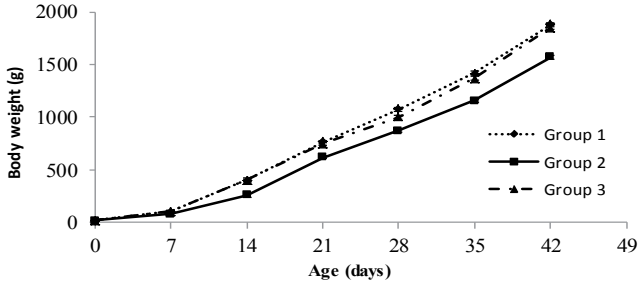

Figure 1: Effects of dietary treatment on body weight (g). Data are expressed as mean ± SD for weight of ten rats in each group. Groups I fed by standard ration without oil inclusion; Group II fed by ration containing soybean oil; Group III fed by ration containing palm oil.

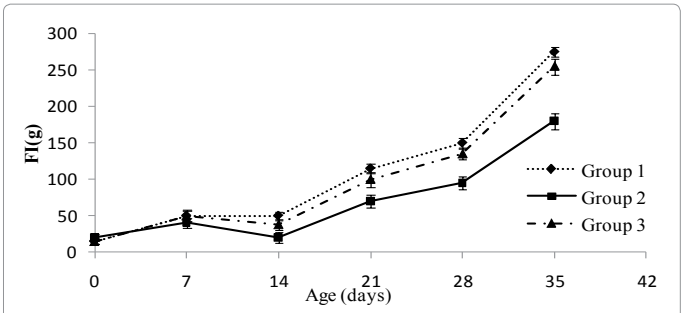

Figure 2: Effects of dietary treatment on food intake (g). Data are expressed as mean ± SD for weight of ten rats in each group. Groups I fed by standard ration without oil inclusion; Group II fed by ration containing soybean oil; Group III fed by ration containing palm oil.

that inclusion of palm oil in broiler rations did not have any adverse effects on body weight.

The daily food intakes (FI) among the experimental groups are shown in Figure 2. Data show that feed intake was unaffected by dietary oil inclusion in the starter phase (0-16 day) indicating the lack of influence of dietary fatty acid composition on the performance of broilers at this age. However, during the following periods, food consumption was greater for chickens fed standard diet and palm oil-based diet than those receiving soybean oil diets. These results indicate that addition of soybean oil in the broiler diets depress feed intake.

Similar results were found with the use of different fatty-acid profiles added to broiler diets [13]. Newman and others [14] observed that the dietary inclusion of polyunsaturated fatty acids (n-3 and n-6 sources) improved the feed conversion ratio of broilers; however, at an older age (3 weeks). The different effect of soybean and palm oil on feed consumption may be due to the fatty acid compositions which are not similar in the two oils. Table 2 reports the fatty acid profile of the experimental diets. The diet containing palm oil showed considerably high amounts of long chain saturated fatty acids such as palmitic (16:0), palmitoleic (16:1) and oleic (18:1) acids while the soybean oil-based diet is rich in linoleic (18:2) and linolenic (18:3) acid. According to Attach and Leeson [15], chickens consumed significantly more feed when they were fed palmitic and stearic acids than when they were fed linoleic or linolenic acids. Thus, the increasing levels of unsaturated fatty acids in diet by soybean oil inclusion decrease the feed intake. This could be due to the high energy yield capability of soybean. The saturated fatty acids in palm oil have low digestibility than the unsaturated fatty acids in the soybean oil.

The organ weight changes serve as a sensitive indication of the general health status of animals. The results of the effect of the different diets on live weight gain, carcass and relative organ weights after 38 day treatment are shown in Table 3. There were significant differences ($p<0.05$) among dietary groups in live weight gain and carcass weight while the thigh, liver, heart and gizzard were similar ($p>0.05$) among the diets. The abdominal fat deposit was generally higher in the treated groups compared to the control. It also was found that, the highest abdominal fat level was observed in broilers that consumed ration with palm oil which is rich in saturated fatty acids. This indicates that dietary fatty acid profile can affect abdominal fat deposition. In this context, Sanz and others [16] reported that the utilization of saturated fats resulted in greater abdominal fat deposits than unsaturated fats. According to Sanz and others [7], the utilization of a source of unsaturated lipids reduces fat and increases protein on the broiler carcasses. The difference in protein accretion was attributed to the level

Parameter	Group 1	Group 2	Group 3
Thig	$358.00^{X} \pm 1.56$	$349.60^{X} \pm 1.49$	$350.10^{X} \pm 2.21$
Liver	$2.32^{X} \pm 0.45$	$2.61^{X} \pm 0.62$	$2.34^{X} \pm 0.28$
Heart	$0.53^{X} \pm 0.08$	$0.61^{Y} \pm 0.09$	$0.52^{X} \pm 0.12$
Gizzard	$1.30^{X} \pm 0.27$	$1.35^{X} \pm 0.10$	$1.30^{X} \pm 0.21$
Extra fat	$7.31^{X} \pm 0.42$	$8.54^{Z} \pm 0.17$	$9.86^{Y} \pm 0.47$

Values are given as mean ± S.D for 10 rats in each group.

$^{x, y}$ in the same line indicate significant differences ($p<0.05$); Groups I fed by standard ration without oil inclusion; Group II fed by ration containing soybean oil; Group III fed by ration containing palm oil.

Table 3: Effect of dietary oil on organ weights and carcass parameters of chickens.

Parameters	Group 1	Group 2	Group 3
Dry matter (%)	$27.56^{X} \pm 0.45$	$28.07^{X} \pm 0.50$	$29.83^{Y} \pm 0.41$
Moisture	72.44 ± 0.45	71.93 ± 0.50	70.17 ± 0.41
Fat (%MS)	$5.43^{X} \pm 0.05$	$8.36^{Z} \pm 0.26$	$7.7^{Y} \pm 0.17$
Protein (%MS)	$22.12^{X} \pm 0.40$	$21.28^{Y} \pm 0.42$	$22.29^{X} \pm 0.26$
Ash (%MS)	$0.91^{X} \pm 0.03$	$1.07^{Z} \pm 0.01$	$1.06^{Y} \pm 0.02$

Values are given as mean ± S.D (n=10)

$^{x, y}$ in the same line indicate significant differences ($p<0.05$). Groups I fed by standard ration without oil inclusion; Group II fed by ration containing soybean oil; Group III fed by ration containing palm oil.

Table 4: Effect of dietary oil on the body composition of chickens.

of saturation of the fat, since the energy derived from unsaturated fat may be used for other metabolic purposes, whereas the energy derived from saturated sources is less promptly utilized and accumulates as body fat. In general, corporal fat accumulation may be considered the result of the balance between the fat absorbed from the diet, the endogenous synthesis of fat (lipogenesis) and the catabolism of fat by β-oxidation (lipolysis).

Effects of oil inclusion on chemical composition of chickens meat

The effect of adding oil and consequently increasing energy density in the diets resulted in a change in body composition (Table 4). There were no statistically significant differences among treatments regarding protein ash and moisture content. However, the carcass fat content was higher in the treated groups compared to the control. The increase in fat content indicated that the amount of energy consumed by the chicks was excessive. It was also possible that the reasons for the high fat content in the treated groups could be due to the widening of calorie: protein ratio as calorie: protein ratio has been shown by Shen and others [17] to affect body composition and particularly the fat content. Zollitsch and others [18] reported that an increased fat content of the diets produced higher abdominal fat deposits in birds.

A number of investigators have reported on the effect of carcass fatness on the organoleptic properties of tenderness, juiciness, and flavor. Aleksandrs Jemeïjanovs and others [19] found that the increase of intramuscular fat causes improvement of the organoleptic qualities or "eating quality of meat", which can be named also the dietetic quality and that the fat-free meat has a neutral taste, and hence it is tasteless. In the same context, Lessire [20] also demonstrated that body fat has a positive impact in improving organoleptic characteristics of chicken's meat.

Fatty acid profiles of muscles

The fatty acid composition (percentage of total fatty acids) of the intramuscular fat is displayed in Table 5. As can be seen, monounsaturated fatty acids (MUFA) comprised the greatest percentage

Fatty acids	Group 1	Group 2	Group 3
Lauric C12:0	Nd	Nd	Nd
Myristic C14:0	0.40	0.35	0.47
Palmitic C16: 0	23.97	21.50	24.10
Palmitoleic C16 :1	5.31	4.56	4.78
Stearic C 18:0	5.50	6.54	5.80
Oleic C 18:1	43.99	40.58	43.01
Linoleic C 18:2	18.02	23.43	19.95
Linolenic C 18:3	0.70	1.49	0.75
Arachidonic C20:0	0.22	0.22	0.23
SFA	30.09	28.61	30.60
MUFA	49.30	45.18	47.79
PUFA	18.72	24.92	20.70

Nd: Non detected
SFA: saturated fatty acids.
MUFA: monounsaturated fatty acids
PUFA: Polyunsaturated fatty acids
Groups I fed by standard ration without oil inclusion; Group II fed by ration containing soybean oil; Group III fed by ration containing palm oil.

Table 5: Fatty acids compositions of abdominal fat, %.

of fatty acid for carcass meat, with oleic acid, the predominant constituent. This could be explained by the fact that oleic acid was the predominant fatty acid in all diets. The polyunsaturated fatty acids (linoleic and linolenic acids) content was significantly ($p<0.05$) higher in the group fed by ration containing soybean oil. This result clearly showed that appreciable quantities of the most of the major fatty acids in the diet were deposited as carcass fat. The increasing level of linoleic and linolenic acid is more pronounced because these acids are readily absorbed and deposited within the chicken's fat depot. Soybean oil not only caused large increases in level of linoleic and linolenic acids in the carcass lipids, but also reduced the quantity of saturated fatty acids. In this context, Waldroup and Waldroup [21] showed that the amount of polyunsaturated fatty acids in the diet had a strongly positive effect on the amount of polyunsaturated fatty acid in the adipose tissue and a strongly negative effect on the amount of saturated and monoenoic fatty acids.

On other hand, as can be seen, the inclusion of palm oil in the diet did not change markedly the pattern of most fatty acids in carcass when compared to the control. The exception was myristic acid which increased significantly.

In summary, the results of this study demonstrate that the fatty acid composition of the adipose tissue of the broiler is significantly influenced by the fatty acid composition of the diet.

Meat quality

Meat color has been reported as the most important factor when consumers assess meat quality since they relate color to freshness.

Results obtained for color values are shown in Table 6. A significant difference between the investigated samples regarding the nature of the incorporated oil was observed. The a* and L* values of muscles decrease when oil was added to diet whereas the b* values increase and this for 1 day after pm and inversely for 7 days after pm. The results showed that control muscle after 1 day pm presented the highest value of L*, this value decrease after 6 days of storage traducing a slight increase in the darkness of muscle.

The decrease of the value of a* and the increase in the value of b* for muscle from chicken receiving the supplemented diet traduce a slight loss of the red color and an increase in yellow color of muscle,

Parameters	Group 1	Group 2	Group 3
24 hours p, m,			
L*	49,71^{X} ± 0.32	49.3.1^{Y} ± 1.48	49,31^{X} ± 1.25
a*	4.85^{X} ± 0.37	4,27^{X} ± 0.98	8,07^{Y} ± 1.09
b*	5,80^{X} ± 0.14	6.92^{Y} ± 0.84	4.42^{Z} ± 1.24
7 days p, m,			
L*	54.4^{X} ± 0.71	51,12^{Y} ± 0.95	50,23^{Z} ±1.05
a*	6,00^{X} ± 3.62	4,87^{X} ± 0.12	4.13^{X} ± 0.49
b*	3.57 ^{X} ± 1.78	1,48^{X} ± 1.35	7.73^{Y} ± 0.40
Hardness (80%)	16.611^{X} ± 1.78	51.611^{Z}± 1.78	4.13^{Y} ± 1.78
Elasticity (80%)	3.701^{X} ± 0.52	5.391^{Y}± 0.78	4.898^{Y} ± 0.68

Values are mean of 3 replicates
Pm: post mortem

L*: Lightness, a*: redness, b*: yellowness
$^{x, y}$ in the same line indicate significant differences ($p<0.05$). Groups I fed by standard ration without oil inclusion; Group II fed by ration containing soybean oil; Group III fed by ration containing palm oil.

Table 6: Sensory Evaluation.

this tendency was totally inversed after 6 days of storage.

The results obtained from the TPA compression tests are shown in Table 6. The abdominal fat hardness showed a marked variation depending on the dietary fatty acids. As can be seen, the increasing levels of saturated fatty acids in diet by palm oil inclusion led to a marked increase in muscles hardness. Controversially, the tenderness was significantly ($p<0.05$) higher in the group fed by ration containing soybean oil. This effect might be attributed to its high content of polyunsaturated fatty acids. It can be also concluded that the addition of fat to diets, improves the masticability and elasticity of chicken's meat. This can be the lipoproteins formed after ingestion of dietary fat.

Conclusion

It can be said that compositions of fatty acids from animal products produced for human consumption could be changed depending on nutritional conditions; to increase the energy content of diet, the composition of fatty acids added to poultry rations are of importance and to use soybean and palm oil in poultry rations would subsequently affect human health in a positive manner by increasing 18:2 and 18:3 fatty acid contents in animal product.

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