EFFECT OF CHANGES IN DIETARY PROTEIN AND OIL LEVELS ON PRODUCTION PARAMETERS OF FEMALE BROILER CHICKENS

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ABSTRACT

Two experiments, as factorial arrangement of treatments in a complete randomized design, were conducted to evaluate weight gain (WG), feed conversion (FC), and carcass characteristics of female broilers fed diets varying in crude protein (CP) and metabolisable energy (ME) levels with graded oil supplementation. In experiment 1, the CP level was 190 and 220 g/kg in the starter diets and reduced by 25 g/kg for each grower diet with ME of 12.1 and 12.6 MJ /kg and oil level of 0 and 40 g/kg. In the second experiment, the level of CP was 190, 210, and 230 g/kg in the starter diets and reduced by 30g/kg in each corresponding grower diet with an oil level of 0, 20, and 40 g /kg. The 190 g/kg dietary CP reduced WG of birds at market age in both experiments but increased the FC value only in trial 2 ($P < 0.05$). In addition, it reduced protein and moisture contents but increased fat level in ready to cook (RTC) carcasses ($P<0.05$). In experiment 2, however, birds fed the 210 g CP/kg diet had WG and FC at market age, and yield of abdominal fat, pectoralis major muscle and drum, in addition to RTC carcass moisture comparable to those fed the highest dietary CP level. Dietary oil supplementation at 40 g/kg improved ($P<0.05$) bird WG and FC in both trials. In conclusion, diets containing 40 g oil/kg with 210 – 180 g CP/kg (starter and grower, respectively) can be safely fed to broiler females.

Keywords: protein, oil, female broilers, performance, carcass composition

INTRODUCTION

Commercial poultry meat producers raise as-hatched or separately sexed broiler chickens fed nutrient balanced and least cost rations with cereal grain and sometimes added fat as the major source of metabolisable energy (ME). Ideally, protein, carbohydrate, and lipid components of feed ingredients in nutritionally balanced diet supply the bird needed ME where carbohydrate and lipid calories fuel the utilization of protein and amino acid for tissue maintenance and growth. That nutrient-energy distribution in rations was confirmed by Pesti and Smith (1984) who in their review of 47 related experiments illustrated that broiler growth and feed efficiency were linearly increased in response to increasing protein level from 150 to 250 g/kg in diets containing 12 MJ ME/kg and constant level of added fat whereas an increase in added fat level, up to 50 g/kg, led to an increase in weight gain and feed efficiency only at protein levels less than 220 g/kg. It is generally accepted that increasing dietary protein level results in reduced abdominal fat pad (ABF) and carcass fat where Rosebrough *et al.* (1999) proved that the level of dietary protein modifies the metabolic utilization of dietary fat by the bird. In fact ABF yield was decreased whereas breast yield was increased when protein level was increased from 160 to 240 g/kg (Smith *et al.,* 1998).

As a common practice, commercial poultry meat producers and feed mills add fat such as soybean or sunflower oil at levels up to 50 g/kg in order to meet the energy needs of the modern fast growing bird. The bird assimilation of dietary fat may lead to changes in abdomen and carcass fat composition (Keren-Zvi *et al.,* 1990) where the female chicken has the genetic capacity to deposit more fat than male (Bartov *et al.* 1974). In their work on selected male broilers raised from 7 to 56 day of age, Keren-Zvi *et al.* (1990) reported a reduction in body and adipose tissue fat and an improvement in feed intake and conversion in response to an increase in soybean oil level, especially in a diet with no added oil. Consequently, those researchers and Dvorin *et al.* (1998) documented that vegetable oils with appreciable amount of polyunsaturated fatty acids tend to decrease lipogenesis. On the other hand, there was an increase in body weight and body fat and ABF yields when the level of animal fat was increased from 40 to 100 g/kg in female broiler grower-finisher diet (Deaton *et al.,* 1981). It seems that the quantity, source, and fatty acid profile of fat (Wiseman *et al.,* 1986), diet nutrient-energy and ingredient composition and physical texture, and bird gender, age, and strain (Keren-Zvi *et al.,* 1990) are nutritional and inheritance factors that dictate the overall bird response to dietary oil supplementation.

Bartov and Plavnik (1998) considered a practical diet with 12.6 MJ/kg to be moderate in ME whereas a diet containing 13.0 MJ/kg to be high in energy. According to breeder nutrient recommendation, each commercial broiler strain has its protein and ME requirement that is dependent on its inherent growth rate and feed intake and conversion capacity where these requirements may even differ from those of NRC (1994). Thus commercial broiler vegetable based rations (Berres *et al.,* 2010), contains variable levels of protein and ME depending on strain and market restrictions and needs. But conventional vegetable derived feed ingredients such as soybean by-products and corn are becoming scares and sometimes unavailable because of occurring adverse climatic conditions and alternative energy uses leading to their unpredictable prices. That volatile market situation, especially in economies of developing nations, usually forces poultry producers to marginalize diet ME, protein, or supplemental oil content in least cost balanced rations in an attempt to save on cost of production while meeting market consumer demand (Gonzalez-A & Pesti, 1993; Farrell, 2005). In addition, fat deposited in the bird viscera or abdomen at market age is considered as a waste by poultry producers and food processers (Griffiths *et al.,* 1977), concomitantly, meat fat is a health concern, especially when it comes to maintaining a healthy cardiovascular system (Sizer & Whitney, 2011). Beside sunflower oil, the oil of soybean seed is a lipid energy source that is frequently included in broiler rations of the Mediterranean basin and its extra caloric effect on bird performance has been reported in several studies (Wiseman *et al.*, 1986; Nitsan *et al.*, 1997). Therefore, the objective of the current study is to evaluate performance, ABF yield, cut-up parts yield, and carcass composition of a female broiler chicken in response to changes in protein and ME levels in a moderate ME (12.6 MJ/kg) practical diet with or without vegetable oil.

MATERIALS AND METHODS

Birds and management

Regulations and guidelines of the American University of Beirut Institutional Animal Care and Use Committee were applied in caring and managing for the experimental animals. In the first Experiment, 1440 day-old Arbor Acres feather sexed female broiler chicks were distributed among 32 floor pens with 45 birds per pen in an environmentally controlled poultry house. Each pen was equipped with infrared lamp heater, pan feeders, and automatic bell-shaped drinkers throughout this trial that lasted for 7 weeks. In Experiment 2, three hundred and sixty day-old Avian 43 feather sexed female broiler chicks were reared in 45 electrically heated and raised wire floors Petersime battery brooder cages with 8 birds per cage from hatch to 21 day of age. Afterwards, birds were weighed and kept in grower cages until 42 day of age. The Petersime brooders and grower cages were placed in a closed poultry house with elevated side windows. All day-old female broiler chicks were obtained from a local hatchery (Tanmia Agricultural Development Co. Sal, Beirut, Lebanon). In both experiments bird average initial body weight per cage were similar among all replicates.

Diets and experimental design

In Experiment 1, ME, protein, and supplemental oil levels were varied in corn-soybean meal diets to prepare starter rations containing, per kg diet, 190 and 220 g CP, 12.1 and 12.6 MJ ME, and 0 and 40 g soybean oil, respectively (Table 1). The level of protein in the grower diets was reduced by 25 g CP/kg diet to obtain rations containing 165 and 195 g CP/kg and fed from 21 to 49 day of age (Table 2). The rations were distributed in a 2x2x2 factorial arrangement of treatments in a complete randomized design (CRD) and each experimental diet was randomly allocated among 4 floor pens with 45 birds per pen.

In Experiment 2, corn-soybean meal diets containing 190, 210, and 230 g CP/kg diet and 0, 20, and 40 g soybean oil/kg diet with 12.6 MJ ME/kg were prepared (Table 3). Similar to Experiment 1, the protein level in the grower diets, fed from 21 to 42 day of age, was lowered by 30 g CP/kg diet, so that protein content in the finisher rations was 160, 180, and 200 g/kg (Table 4). The experimental diets were distributed in a 3x3 factorial arrangement of treatments in CRD where each experimental treatment was randomly allocated among five cages with 8 birds per cage.

In both trials, the minimum specification of essential amino acids in the experimental diets was adjusted in proportion to change in dietary protein level and, except for ME in all diets and protein in most diets, all other nutrients met or exceeded NRC (1994) broiler chicken nutrient requirements. Also all birds were subjected to 24 hour light and mash feed and water were offered *ad libitum*.

TABLE 1

Composition (g/kg as Fed) of a Corn-Soybean Meal Diet Varying in Metabolisable Energy (ME, MJ/kg)), Crude Protein (CP, g/kg), and Soybean Oil Levels Fed to Female Broiler Chicks from Hatch to 21 Day of Age, Experiment 1

	0 g/kg soybean oil				40 g/kg soybean oil			
	12.1 (MJ/kg)		12.6 (MJ/kg)		12.1 (MJ/kg)		12.6 (MJ/kg)	
	CP (g/kg)		CP (g/kg)		CP (g/kg)		CP (g/kg)	
Ingredient	190	220	190	220	190	220	190	220
Corn	651	600	684	633	531	480	564	513
Soybean meal (48)	156	227	150	221	176	247	171	241
Soybean meal (44)	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
Fish meal	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Soybean oil	0.00	0.00	0.00	0.00	40.0	40.0	40.0	40.0
Limestone	13.5	13.4	14.3	13.7	13.2	13.1	13.3	13.2
Dicalcium phosphate	14.3	13.8	13.6	13.7	14.6	14.1	14.6	14.0
Salt	3.6	3.5	3.5	3.5	3.6	3.6	3.6	3.6
DL-methionine	1.2	1.5	1.2	1.4	1.3	1.6	1.3	1.5
Sand[A]	52.4	32.8	25.4	5.7	112	92.6	84.2	65.7
Premix[B]	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Amprol	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Calculated composition								
ME (MJ/kg)	12.1	12.1	12.6	12.6	12.1	12.1	12.6	12.6
CP	190	220	190	220	190	220	190	220
Crude fat	31.1	30.0	32.3	31.1	66.9	65.7	68.1	66.9
Methionine	4.7	5.4	4.7	5.4	4.7	5.4	4.7	5.4
Methionine + Cystine	7.4	8.5	7.4	8.5	7.4	8.5	7.4	8.5
Lysine	10.2	12.2	10.1	12.1	10.6	12.6	10.5	12.5

[A]Merck KgaA, 64271, Darmstadt, Germany.

[B]Amount of vitamin and trace mineral premix supplied per kg diet: calcium carbonate, 1.32 g (calcium, 0.5 g); vitamin A (retinyl acetate), 186,000 IU; vitamin D_3 (cholecalcifeol), 3,720 ICU; vitamin E (DL-α-tocopheryl acetate), 33,000 IU; vitamin K (menadione sodium bisulfide), 5.4 mg; vitamin B_1, 2.7 mg; vitamin B_2, 12.6 mg; vitamin B_6, 6.6 mg; vitamin B_{12}, 1.65 mg; niacin, 53.1 mg; folic acid, 1.65 mg; pantothenic acid (calcium-D-pantothenate), 15.9 mg; D-biotin, 6.6 mg; choline, 300 mg; vitamin C, 100 mg; butylated hydroxytoluene, 150 mg; manganese, 108 mg; iron, 102 mg; zinc, 77.4 mg; copper, 16.1 mg, cobalt, 0.16 mg; iodine, 0.60 mg; selenium, 0.46 mg.

TABLE 2

Composition (g/kg as Fed) of a Corn-Soybean Meal Diet Varying in Metabolisable Energy (ME, MJ/kg), Crude Protein (CP, g/kg), and Soybean Oil Levels Fed to Female Broiler Chicks from 21 to 49 Day of Age, Experiment 1

	0 g/kg soybean oil				40 g/kg soybean oil			
	12.1 (MJ/kg)		12.6 (MJ/kg)		12.1 (MJ/kg)		12.6 (MJ/kg)	
	CP (g/kg)		CP (g/kg)		CP (g/kg)		CP (g/kg)	
Ingredient	165	195	165	195	165	195	165	195
Corn	686	636	720	669	567	516	600	549
Soybean meal (48)	124	194	118	189	144	215	138	209
Soybean meal (44)	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Fish meal	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Soybean oil	0.00	0.00	0.00	0.00	40.0	40.0	40.0	40.0
Limestone	14.4	14.3	14.5	14.4	14.2	14.1	14.3	14.1
Dicalcium phosphate	11.5	11.0	11.5	10.9	11.8	11.3	11.8	11.2
Salt	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
DL-methionine	0.4	0.7	0.4	0.7	0.5	0.8	0.5	0.8
Sand[A]	57.9	38.2	29.8	10.2	117	97.0	89.6	70.1
Premix[B]	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Amprol	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
			Calculated composition					
ME (MJ/kg)	12.1	12.1	12.6	12.6	12.1	12.1	12.6	12.6
CP	165	195	165	195	165	195	165	195
Crude fat	29.3	28.2	30.5	29.3	65.1	63.9	66.3	65.1
Methionine	3.4	4.1	3.4	4.1	3.4	4.1	3.4	4.1
Methionine + Cystine	5.9	7.0	5.9	7.0	5.9	7.0	5.9	7.0
Lysine	8.5	10.5	8.4	10.4	8.8	10.9	8.7	10.8

[A]Merck KgaA, 64271, Darmstadt, Germany.

[B]Amount of vitamin and trace mineral premix supplied per kg diet: calcium carbonate, 1.32 g (calcium, 0.5 g); vitamin A (retinyl acetate), 186,000 IU; vitamin D_3 (cholecalcifeol), 3,720 ICU; vitamin E (DL-α-tocopheryl acetate), 33,000 IU; vitamin K (menadione sodium bisulfide), 5.4 mg; vitamin B_1, 2.7 mg; vitamin B_2, 12.6 mg; vitamin B_6, 6.6 mg; vitamin B_{12}, 1.65 mg; niacin, 53.1 mg; folic acid, 1.65 mg; pantothenic acid (calcium-D-pantothenate), 15.9 mg; D-biotin, 6.6 mg; choline, 300 mg; vitamin C, 100 mg; butylated hydroxytoluene, 150 mg; manganese, 108 mg; iron, 102 mg; zinc, 77.4 mg; copper, 16.1 mg, cobalt, 0.16 mg; iodine, 0.60 mg; selenium, 0.46 mg.

TABLE 3

Composition (g/kg as Fed) of a Corn-Soybean Meal Diet Varying in Protein (CP, g /kg) and Soybean Oil Levels Fed to Female Broilers from Hatch to 21 Day of Age, Experiment 2

	0 g/kg soybean oil			20 g/kg soybean oil			40 g/kg soybean oil		
	CP (g/kg)			CP (g/kg)			CP (g/kg)		
Ingredient	190	210	230	190	210	230	190	210	230
Corn	686	653	619	627	593	559	567	533	499
Soybean meal (48)	149	197	244	159	207	254	169	217	264
Soybean meal (44)	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2
Fish meal	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Soybean oil	0.00	0.00	0.00	20.0	20.0	20.0	40.0	40.0	40.0
Limestone	12.5	12.6	12.7	12.3	12.5	12.6	12.2	12.3	12.4
Dicalcium phosphate	13.5	13.0	12.5	13.7	13.2	12.7	13.9	13.4	12.9
Salt	3.0	3.1	3.1	3.1	3.1	3.2	3.1	3.2	3.2
DL-methionine	1.8	1.7	1.7	1.8	1.8	1.7	1.9	1.8	1.8
Sand[A]	28.0	13.4	0.8	56.9	43.4	30.6	86.7	73.1	60.5
Premix[B]	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Amprol	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Calculated composition									
ME[C] (MJ/kg)	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6
CP	190	210	230	190	210	230	190	210	230
Crude fat	31.9	31.0	30.0	49.8	48.9	47.9	67.6	66.7	65.8
Methionine	5.3	5.5	5.7	5.3	5.5	5.7	5.3	5.5	5.7
Methionine + Cystine	8.0	8.5	9.0	8.0	8.5	9.0	8.0	8.5	9.0
Lysine	10.0	11.4	12.8	10.2	11.6	13.0	10.4	11.8	13.1

[A]Merck KgaA, 64271, Darmstadt, Germany.

[B]Amount of vitamin and trace mineral premix supplied per kg diet: calcium carbonate, 1.32 g (calcium, 0.5 g); vitamin A (retinyl acetate), 186,000 IU; vitamin D_3 (cholecalcifeol), 3,720 ICU; vitamin E (DL-α-tocopheryl acetate), 33,000 IU; vitamin K (menadione sodium bisulfide), 5.4 mg; vitamin B_1, 2.7 mg; vitamin B_2, 12.6 mg; vitamin B_6, 6.6 mg; vitamin B_{12}, 1.65 mg; niacin, 53.1 mg; folic acid, 1.65 mg; pantothenic acid (calcium-D-pantothenate), 15.9 mg; D-biotin, 6.6 mg; choline, 300 mg; vitamin C, 100 mg; butylated hydroxytoluene, 150 mg; manganese, 108 mg; iron, 102 mg; zinc, 77.4 mg; copper, 16.1 mg, cobalt, 0.16 mg; iodine, 0.60 mg; selenium, 0.46 mg.

[C]Metabolisable energy.

TABLE 4

Composition (g/kg as Fed) of a Corn-Soybean Meal Diet Varying in Protein (CP, g/kg) and Soybean Oil Levels Fed to Female Broilers from 21 to 42 Day of Age, Experiment 2

	0 g/kg soybean oil CP (g/kg)			20 g/kg soybean oil CP (g/kg)			40 g/kg soybean oil CP (g/kg)		
Ingredient	160	180	200	160	180	200	160	180	200
Corn	740	707	674	680	647	613	621	586	552
Soybean meal (48)	97.0	144	190	108	155	202	118	166	214
Soybean meal (44)	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7
Fish meal	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3
Soybean oil	0.00	0.00	0.00	20.0	20.0	20.0	40.0	40.0	40.0
Limestone	13.5	13.6	13.7	13.4	13.5	13.6	13.3	13.4	13.4
Dicalcium phosphate	14.8	14.4	14.0	15.0	14.6	14.1	15.1	14.7	14.2
Salt	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
DL-methionine	0.6	0.7	0.7	0.7	0.8	0.8	0.7	0.8	0.9
Sand[A]	41.3	27.5	14.8	70.1	56.3	43.7	99.1	86.3	72.7
Premix[B]	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Amprol	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Calculated composition									
ME[C] (MJ/kg)	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6
Crude protein	160	180	200	160	180	200	160	180	200
Crude fat	30.7	29.8	28.9	48.6	47.7	46.7	66.4	65.5	64.5
Methionine	3.5	3.9	4.2	3.5	3.9	4.2	3.5	3.9	4.2
Methionine + Cystine	6.3	6.9	7.5	6.3	6.9	7.5	6.2	6.9	7.5
Lysine	8.0	9.3	10.6	8.2	9.5	10.8	8.3	9.7	11.0

[A]Merck KgaA, 64271, Darmstadt, Germany.

[B]Amount of vitamin and trace mineral premix supplied per kg diet: calcium carbonate, 1.32 g (calcium, 0.5 g); vitamin A (retinyl acetate), 186,000 IU; vitamin D_3 (cholecalcifeol), 3,720 ICU; vitamin E (DL-α-tocopheryl acetate), 33,000 IU; vitamin K (menadione sodium bisulfide), 5.4 mg; vitamin B_1, 2.7 mg; vitamin B_2, 12.6 mg; vitamin B_6, 6.6 mg; vitamin B_{12},1.65 mg; niacin, 53.1 mg; folic acid, 1.65 mg; pantothenic acid (calcium-D-pantothenate), 15.9 mg; D-biotin, 6.6 mg; choline, 300 mg; vitamin C, 100 mg; butylated hydroxytoluene, 150 mg; manganese, 108 mg; iron, 102 mg; zinc, 77.4 mg; copper, 16.1 mg, cobalt, 0.16 mg; iodine, 0.60 mg; selenium, 0.46 mg.

[C]Metabolisable energy.

Measurements and chemical analyses

In both trials, initial, 21 day, and final body and feed weights for each cage or pen were measured and daily record of mortality was kept. At termination, three birds from Experiment 1 and four birds from Experiment 2 were selected from each pen so that their body weight was similar to the pen average bird weight. Birds were then individually identified and slaughtered at the American University of Beirut processing plant, where viscera, abdominal fat pad (ABF), giblet, preen glands, shanks, and head were manually removed and ready-to-cook (RTC) carcass and ABF weights were recorded. The RTC carcasses were stored at -22 C to be further dissected after thawing for 18 hr at room temperature. Left pectoralis major muscle (PMJ), thigh, and drum without skin were dissected and weighed. The entire other half of the RTC carcass was ground and homogenized in a Hobart[1] meat grinder and a 100 g representative sample was collected and analyzed for moisture, CP, and crude fat composition (AOAC, 1990).

Statistical analysis

Following the general linear model of SAS (1992), in Experiment 1, the data were analyzed as three-way ANOVA with dietary protein, ME, and oil levels as main variables and their interactions. Similarly in Experiment 2, the data were analyzed as two-way ANOVA with dietary protein and oil levels as independent variables and their interactions. Treatment means were separated following Duncan's Multiple Range test when the probability of treatment effect was lower than 5%.

RESULTS AND DISCUSSION

Except for weight gain response to changes in ME and soybean oil level of ready to market birds, all interaction terms in the first experiment were not significantly different. That significant interaction was represented in an increase in weight gain from 2177 to 2323 g when the ME level of the 40 g/kg oil diet was increased from 12.1 to 12.6 MJ/kg; this very same energy increase in the no added oil diet, however, resulted in a reduction of weight gain from 2047 to 1919 g. Although all diets were nutritionally balanced and met the requirement of the chicken, it seems that the higher amount of complex carbohydrate in the 12.6 MJ/kg diet with no added oil could have contributed to less utilization of protein and amino acid, thus less weight gain. Alternatively, Tables 5 and 7 show the effect of the main factors on the criteria measured in Experiment 1. Lowering the ME level from 12.6 to 12.1 MJ/kg in a practical diet had no effect on broiler performance, ABF, cut-up parts yield, and carcass composition. In contrast similar changes in diet ME by Masey O'Neill *et al.* (2012) only decreased efficiency of feed conversion in male broilers fed a diet with or without added fat. Female broilers raised in floor pens gained less weight and utilized feed less efficiently ($P < 0.01$) when CP was decreased from 220 to 190 g/kg diet during the starter period. This reduction in weight gain was maintained at market age, but feed conversion was comparable. Carcass yield and the yields of ABF, PMJ, thigh, and drum of birds consuming the 190 or 220 g CP diets were comparable. These carcass yield results are in agreement with those reported by Smith *et al.* (1998). Although there was no significant increase in the yield of abdominal fat as a result of lowering the dietary protein level, it was apparent in Table 7 that the birds fed the 190g CP diet accumulated more fat in their RTC carcasses but less moisture and protein than those fed a diet containing 220g CP ($P < 0.01$). As shown in Table 5,

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[1] Model: 84145, Serial Number: 56-071-642 GD.

growth rate and feed conversion of female broilers raised in floor pens from hatch to market age (49 day) were improved ($P < 0.05$) as a result of supplementing the diet with 40g oil/kg. This dietary added oil, however, had no effect on ABF, RTC and cut-up-parts yields, and carcass chemical composition of female broilers (Tables 5 and 7).

There was no significant interaction between CP and oil level in the second experiment, consequently, the effect of the main factors on the averages of the different criteria measured are presented in Tables 6 and 7. Reducing the level of dietary protein from 230 to 190 g/kg reduced weight gain and increased feed conversion of female broilers from hatch to 21 or 42 day of age ($P < 0.05$). The performance of birds fed the 210 g CP diet was similar to the 230 CP diet fed birds, but better ($P < 0.05$) than those fed the lowest CP diet, except for the 21 day old bird feed conversion that was intermediate. Graded reduction in dietary CP level from 260 to 170 g/kg, similarly, reduced weight gain and increased feed conversion when a practical diet was fed to female broilers from 21 to 42 day of age (Sterling *et al.*, 2002). As in Experiment 1, carcass and thigh yields of the 42 day old female broilers were not affected by decreasing protein level from 230 to 190 g/kg diet. Earlier findings showed inconsistent response in female broilers carcass yield to reducing CP by up to 90 g/kg, where carcass yield was either unchanged as for the results obtained in Experiment 1 and those reported by Smith *et al.* (1998) or it was reduced (Sterling *et al.*, 2002). Contrary to the findings of the first experiment, reducing dietary CP from 230 or 210 to 190g in the present trial, decreased PMJ and drum relative weights, but increased that of ABF ($P < 0.01$). Moreover, ABF, PMJ, and drum yields of female broilers fed the diet containing 210 g CP were similar to those fed the highest CP diet. Similarly, breast yield was reduced whereas that of ABF was increased when CP was reduced in a female broiler diet from 240 to 160 g/kg in a work conducted by Smith *et al.* (1998). Also the ABF yield was increased and pectoralis minor muscle decreased when protein was decreased from 260 to 177 g/kg in a diet fed to female broiler chickens from 21 to 42 day of age with no effect on PMJ muscle and drum (leg quarter) yields (Sterling *et al.* 2002). In comparison with the other two treatments (Table 7), the lowest CP diet, similar to the results obtained in the first experiment, reduced carcass moisture and protein contents whereas it increased carcass fat ($P < 0.01$). Finally, the RTC carcass had more fat and less protein ($P < 0.01$) when dietary CP level was decreased from 230 to 210 g CP/kg. The current findings on changes in carcass moisture, protein, and fat in response to variation in dietary protein level were comparable to those of Twining *et al.* (1978) who reported an increase in carcass moisture and protein with a concomitant decrease in fat. In addition, Bartov *et al.* (1974) showed that skin fat accumulated at the expense of its moisture. Finally, the current outcomes on carcass composition are in agreement with those of Pesti and Fletcher (1983).

Weight gain and feed conversion of female broilers raised from hatch to 21 day of age was not changed when 20 g soybean oil was added to a diet with no exogenous oil. At this age, only weight gain was improved ($P < 0.01$), however, when oil was increased to 40 g/kg diet (Table 4). Similarly, the supplementation of 30 to 90 g corn oil/kg diet increased weight gain of 28 day old male broiler chicks (Griffiths *et al.* 1977). However, Keren-Zvi *et al.* (1990) found that the addition of 46 g soybean oil/kg diet with a dietary ME of 12.3 MJ/kg did not affect body weight but improved feed conversion of 56 day old male broiler chickens. At market age and similar to the findings of Experiment 1, the live performance of broiler female fed the highest oil level (Table 6), in terms of weight gain and feed conversion, was better ($P < 0.05$) than that of birds fed the no added oil diet but this improvement, unlike the first trial, was accompanied by a reduction in thigh and drum yields ($P < 0.05$). Birds fed the 20 g oil diet from hatch to 42 day of age had a weight gain lower than those fed the 40g oil, but higher than birds fed the no exogenous oil diet ($P < 0.01$). On the other hand, the birds fed the 20g oil diet had intermediate cumulative feed conversion value. Deaton *et al.* (1981) reported a similar increase in female broiler body weight, but with no change in feed conversion when animal fat level was increased by 60 g/kg in a high energy grower-finisher diet already containing 40 g/kg fat. It has been documented that an increase in growth, feed conversion, diet metabolisable energy, and net energy body deposition occur together or separately in diets supplemented with a limited amount of lipid that has an added net energy value in comparison with other nutrients (Griffith *et al.,* 1977; Pesti & Smith, 1984; Nitsan *et al.,* 1997). Although the magnitude of bird performance differed between the two present experiments, their response to changes in dietary oil and protein levels were consistent. Smith *et al.* (1998) reported a reduction in performance of fast growing (Ross x Ross 208) and slow growing (Peterson x Arbor-Acres) female broilers when dietary protein level was reduced from 240 to 160 g/kg, but the magnitude of reduction in the fast growing strain was higher than that of the slow growing one.

Similar to the findings of Experiment 1, the amount of added oil in the second trial, irrespective of its level, had no effect on either the yield of RTC carcass, ABF and PMJ or on the chemical composition of the RTC carcasses (Tables 6 and 7). Significant results were obtained, however, for thigh and drum yields. Thigh yield of birds consuming the 20 and 40g oil diets was comparable but lower ($P < 0.05$) than that of birds fed the no added oil diet. Drum yield was reduced only by feeding 40g of dietary added oil ($P<0.05$). The apparent discrepancy in the cut-up part yield results, observed in the current paper (Table 5 and 6), could be explained by the fact that the birds in the first experiment were grown to 49 day as opposed to 42 in the second trial. Differences in age at slaughter, genotype, and setup of rearing facility (Sizemore and Seigel 1993) could lead to inconsistency in cut-up parts yield response as a consequence of nutritional changes. The findings of Kerin-Zvi *et al.* (1990) and Moran (1996) with respect to breast muscle response to either poultry fat or soybean oil supplementation were similar to current results on the same organ. In the work of Moran (1996) there was no change in pectoralis major and minor muscles, thigh, and drum yields of 50 day old male broilers when poultry fat was added in a practical diet and in which calorie to protein ratio was kept constant. In contrast, Kerin-Zvi *et al.* (1990) reported a decrease in ABF relative weight in response to increasing soybean oil level to 46 or 90 g/kg in a practical diet containing either 0 or 50 g/kg soybean oil and moderate or high in ME, respectively, when using a male broiler strain selected for high ABF deposition. But there was no change in ABF yield of the low ABF selected bird when fed a similar diet. Deaton *et al.* (1981) on the other hand showed an increase in ABF and body fat yields in response to increased dietary fat supplementation. That inconsistent response in body lipid deposition to dietary fat supplementation was related to gender and strain fat deposition capacity (Wiseman *et al.* 1986), type of fat affecting digestibility (Keren-Zvi *et al.,* 1990) and metabolism (Dvorin *et al.,* 1998), or ME of basal diet (Nitsan *et al.,* 1997). Current and earlier research work clearly indicated that carcass fat and protein composition are not affected by supplemental fat level of both male and female broilers fed similar but moderate ME diets (Bartov *et al.,* 1974; Griffith *et al.,* 1977; Keren-Zvi *et al.,* 1990; Barbour *et al.,* 2006). The estimated international corn and soybean meal 48 prices are 400 and 700 US $/ton, respectively (Barbour *et al.,* 2008), while the economic value of soybean oil in a least cost balanced ration is US $ 891 per ton (Leeson & Summers, 1997). According to current results there is a 171 g increase in estimated average weight gain and reduction of 0.085 g feed per g weight gain per female broiler bird due to 40 g/kg soybean oil supplementation in rations fed from hatch to 42 day of age. Those dietary manipulations could lead to acceptable returns in developing poultry markets (Farrell, 2005). Compared with the 230 g CP/kg starter diet recommended by NRC (1994), a moderate decrease of 20 g of CP /kg diet does not seem to reduce performance, ABF, RTC, and cut-up part yields.

TABLE 5

Weight Gain (WG), Feed Conversion (FC), Ready to Cook (RTC) Carcass, Abdominal Fat Pad (ABF), and Cut-up Parts Yield of Arbor-Acres Female Broiler Chickens Raised in Floor Pens and Fed Corn-Soybean Meal Diets Containing Varying Levels of Crude Protein (CP), Metabolisable Energy (ME) and Soybean Oil from Hatch to 49 Day of Age, Experiment 1

Performance values are least square mean of 4 floor pens per treatment with 45 birds per pen. RTC carcass and cut-up part yield values are least square mean of 12 birds per treatment

	0-21 day		0-49 day		Yield (g/kg BW)				
	WG (g)	FC (g:g)	WG (g)	FC (g:g)	RTC-carcass	ABF	PMJ[A]	Thigh	Drum
CP[B] (g/kg)									
190	422[b]	1.745[a]	2093[b]	2.355	673	18.8	52.3	42.1	40.8
220	453[a]	1.599[b]	2144[a]	2.289	678	17.4	53.4	42.4	41.8
ME (Kcal/Kg)									
12.1	440	1.699	2116	2.328	677	17.7	53.3	42.4	41.6
12.6	435	1.645	2121	2.317	674	18.4	52.4	42.1	41.0
Oil level (g/kg)									
0.0	413[b]	1.717[a]	1983[b]	2.382[a]	677	18.0	52.8	42.5	41.4
40.0	462[a]	1.627[b]	2254[a]	2.262[b]	674	18.2	52.9	42.0	41.2
s.e.m[C]	9.16	0.0470	38.03	0.07	5.8	1.5	1.4	0.6	0.9
				P>F					
CP	0.0001	0.0002	0.0750	0.1948	0.1952	0.1767	0.2934	0.4352	0.1260
ME	0.4885	0.1181	0.8425	0.8256	0.4840	0.5081	0.3953	0.5728	0.3606
Oil	0.0001	0.0121	0.0001	0.0237	0.4672	0.8622	0.9312	0.3596	0.7350
CP x ME	0.3827	0.1785	0.1400	0.7927	0.9002	0.1050	0.7831	0.0746	0.8993
CP x Oil	0.6006	0.1449	0.9144	0.4342	0.1387	0.7978	0.4447	0.1638	0.2385
ME x Oil	0.5377	0.3102	0.0001	0.4802	0.9227	0.8502	0.7576	0.9248	0.8316
CP x ME x Oil	0.6948	0.7768	0.5957	0.8484	0.9174	0.2085	0.3975	0.3717	0.5315

[A]Pectoralis major muscle.

[B]Grower diet fed from 21 to 49 day contained 165 and 195 g protein/kg.

[C]Pooled standard error of the means.

[ab]Means within a column in each comparison group with no common superscripts differ significantly ($P<0.05$)

TABLE 6

Weight Gain (WG), Feed Conversion (FC), Ready to Cook (RTC) Carcass, Abdominal Fat Pad (ABF), and Cut-up Parts Yield of Avian 43 Female Broiler Chickens Raised in Battery Cages and Fed Corn-Soybean Meal Diets Containing Varying Levels of Crude Protein (CP) and Soybean Oil from Hatch to 42 Day of Age, Experiment 2

Performance values are least square mean of 5 cages per treatment with 8 birds per cage. RTC carcass and cut-up part yield values are least square mean of 20 birds per treatment.

	0-21 day		0-42 day		Yield (g/kg BW)				
	WG (g)	FC (g:g)	WG (g)	FC (g:g)	RTC-carcass	ABF	PMJ[A]	Thigh	Drum
CP[B] (g/kg)									
190	578[b]	1.591[a]	1637[b]	2.101[a]	700	30.1[a]	43.2[b]	42.3	45.2[b]
210	609[a]	1.535[ab]	1706[a]	2.031[b]	706	23.4[b]	46.1[a]	42.2	46.6[a]
230	619[a]	1.492[b]	1718[a]	2.011[b]	705	22.2[b]	46.9[a]	42.2	47.0[a]
Oil (g/kg)									
0.0	583[b]	1.569	1606[c]	2.091[a]	704	25.0	44.7	43.3[a]	47.2[a]
20.0	597[b]	1.534	1678[b]	2.045[ab]	704	24.9	44.9	41.7[b]	46.4[a]
40.0	626[a]	1.515	1777[a]	2.006[b]	702	25.8	46.6	41.7[b]	45.2[b]
s.e.m[C]	16.7	0.046	31.5	0.041	4.0	1.3	1.2	0.7	0.7
					P > F				
CP	0.0130	0.0400	0.0068	0.0270	0.1608	0.0001	0.0008	0.9973	0.0175
Oil	0.0108	0.3412	0.0001	0.0540	0.8529	0.6582	0.1072	0.0183	0.0088
CP x Oil	0.1108	0.2120	0.5257	0.1729	0.2728	0.3273	0.1369	0.3496	0.6779

[A]Pectoralis major muscle.

[B]Grower diet fed from 21 to 42 day contained 160, 180, and 200 g protein/kg.

[C]Pooled standard error of the mean.

[ab]Means within a column in each comparison group with no common superscripts differ significantly ($P<0.05$).

TABLE 7

The RTC Carcass Moisture, Crude Fat, and Crude Protein (CP) of 49 Day-Old Female Arbor-Acres Broiler Chickens Raised in Floor Pens and Fed Corn-Soybean Meal Diets Containing Varying Levels of Crude Protein (CP), Metabolizable Energy (ME) and Soybean Oil in Experiment 1 and 42 Day-Old Female Avian 43 Broiler Chickens Raised in Battery Cages and Fed Corn-Soybean Mmeal Diets Containing Varying Levels of Crude Protein (CP) and Soybean Oil in Experiment 2

In Experiment 1 the RTC carcass composition values are least square mean of 12 birds per treatment whereas the RTC carcass composition values are least square mean of 20 birds per treatment in Experiment 2

	Moisture		Crude Fat (g/kg RTC carcass)		CP	
	Experiment 1	Experiment 2	Experiment 1	Experiment 2	Experiment 1	Experiment 2
CP (g/kg)						
190	638[b]	639[b]	149[a]	162[a]	166[b]	158[c]
210		650[a]		146[b]		163[b]
220	656[a]		128[b]		172[a]	
230		655[a]		134[c]		166[a]
ME (Kcal/Kg)						
12.1	651		135		169	
12.6	643		142		170	
Oil level (g/kg)						
0.0	649	651	141	144	170	163
20.0		645		147		162
40.0	646	648	136	149	168	161
s.e.m[A]	8.5	4.0	7.5	3.6	2.9	1.4
			P > F			
CP	0.0055	0.0001	0.0006	0.0001	0.0079	0.0001
ME	0.1832		0.1695		0.6253	
Oil	0.5717	0.1683	0.3426	0.2197	0.3323	0.1794
CP x ME	0.2674		0.4516		0.6468	
CP x Oil	0.8265	0.4311	0.5159	0.5103	0.5288	0.6831
ME x Oil	0.4731		0.6537		0.5853	
CP x ME x Oil	0.4470		0.0942		0.5222	

[A]Pooled standard error of the mean.

[a-c]Means within a column in each comparison group with no common superscripts differ significantly ($P<0.05$).

It resulted in a moderate increase, however, of RTC carcass fat which could be a consumer health concern. It is important to mention that the current study has contributed additional information to the literature on performance and carcass characteristics of female broilers in response to lipid supplementation that benefits the regional developing poultry industry. In conclusion, a reduction of 40 g CP/kg diet below the NRC (1994) protein requirement in moderate ME diet is not recommended since it resulted in a decrease in performance and carcass moisture and protein content with a concomitant increase in ABF yield and carcass fat of female broilers. Alternatively, the reduction of 20 g protein/kg below NRC (1994) recommended requirement level could be considered in the formulation of female broiler rations. In addition, the supplementation of vegetable oil up to 40 g/kg in a diet with no added lipid could be suggested. Although soybean oil supplementation is an added cost, some acceptable financial returns might be achieved depending on the market value of feedstuffs and bird response.

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