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EFFECT OF FEEDS CONTAINING DIFFERENT FATS ON CERTAIN CARCASS PARAMETERS OF JAPANESE QUAIL

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ABSTRACT

The aim of this study was to determine the effect of different dietary fat on carcass traits in Japanese quail (*Coturnix coturnix japonica*). A total of 168, 7 weeks old Japanese quail (48 males and 120 females) were used in this study. They were evenly distributed into 4 treatment groups with 3 replicates per group containing 4 males and 10 females each. The birds fed a basal diet with different fats (Sunflower, flax, corn, and fish oils) at 3% level for 13 weeks. On the last day of experiment, 12 birds were randomly selected from each treatment group (6 males and 6 females) and slaughtered to determine carcass characters included in this study which were carcass weight, dressing percentage with or without giblets and the relative weights of heart, liver, gizzard, thighs, wings, breast, back, neck and abdominal fat. Our results indicated that supplementing diet of quail with fish oil and flax oil resulted in significant improvement concerning body weight, carcass weight, dressing percentage with or without giblets and relative weights of heart, liver, gizzard, thigh, and breast and significant decrease ($p < 0.05$) as regards relative weights of wings, back and neck compared to treatments of sunflower oil and corn oil. However, T4 (Fish oil) surpasses other treatment groups (T1, T2, and T3) with relation to all carcass parameters involved in this experiment. Overall, the results reveal that adding fish and flax oils to the diet of Japanese quail have a significant effect on carcass efficiency. Therefore, fish and flax oils could be used as a good tool for improving carcass yield of quails.

Keywords: Japanese quail, fat sources, quail diets, carcass traits.

INTRODUCTION

Saturate fatty acids and Trans fatty acids cause negative effects on human health, but polyunsaturated fatty acids (PUFA) have positive effects on human health. Regarding coronary heart disease (Bhatnagar and Durring, 2003; Meyer *et al*., 2003). Therefore the consumption of unsaturated oils in diets is recommended both to decrease high cholesterol intake and to increase the ratio of polyunsaturated to saturated fatty acids to prevent the development of atherosclerosis (Culter, 1991). Polyunsaturated fatty acids are subject to free- radical reactions leading to lipid peroxidation which is known to play a significant role in the development of cancer, aging, diabetes mellitus, and atherosclerosis (Mayes, 1995). Over the past 20 years many studies and clinical experiments indicated that omega-3 PUFA, particularly Eicosapentaenoic (EPA) and Decosahexaenoic (DHA) acids exert beneficial effects on human health. Omega-3 (PUFA) is essential for normal growth and development and plays an important role in the prevention and treatment of coronary heart disease, hypertension, inflammatory, autoimmune disorders and cancer (El - Yamany *et al*., 2008). The lipid composition of broiler meat can be modified by adding Linoleic (LA) and Linolenic (LNA) acid, vegetable oils (Lopez - Ferrer *et al*., 1999a) and fish oils (Scaife *et al*., 1994; Lopez - Ferrer *et al*., 1999b). When chicken meat is enriched with PUFA, particularly with n-3 long chain fatty acids ($C \geq 20$), all vegetable fat sources seem to be less effective than marine fats. This effect results from the content of n-3 fatty acids, because marine oils are composed of Eicosapentaenoic acid ($_{C20:5\ n-3}$, EPA) and Docosahexaenoic acid ($_{C22:6\ n-3}$, DHA), in a variable but generally high proportion, whereas vegetable contain LNA, whose conversion to longer - chain derivatives and deposition in peripheral tissues is not sufficient to give nutritionally valuable modified products (Caston and Lesson, 1990; Cherian and Sim, 1991). The supplementation of broiler diets with small quantities of fats and oils is a long standing practice for increasing growth and the utilization of feed and energy and entirely improving the performance (Chekani - Azar *et al*., 2007). In the recent studies, the performance and difference parts of fowl carcass has been investigated through supplementing diets with marine origins, i.e., fish oil (Farrell, 1995; Lopez - Ferrer, 2001) and animals origins, i.e., poultry fat (Zollistsch *et al*., 1997). Results from these experiments revealed that digestibility of fat added, were increased (improve of performance) and abdominal fat decreased as the degree of unsaturation increase. The marine oils (fish oil and certain marine algae) contain the long chain (C_{20} and longer) omega- 3 fatty acids as being an important factor in the diet is for promote of health in man and animals than other origins (Bezard *et al*., 1994; Cherian *et al*., 1996). Thus, this experiment was conducted to evaluate the effect of two type origins (Omega-3 fatty acid origin, i.e., flax oil and fish oil and omega-6 fatty acid origin, i.e., sunflower oil and corn oil) on certain carcass traits of Japanese quail.

MATERIALS AND METHODS

Birds and treatments

A total of 168, 7 weeks old Japanese quail (48 males and 120 females) were used in this experiment. Following one week of adaptation period on experimental conditions and treatment diets the birds were weighed to provide an equal live weight in all groups at the beginning of the study. Birds were evenly distributed into 4 treatment groups with 3 replicates per group which containing 4 males and 10 females each. For 13 weeks (including adaptation period) the quail were fed diets containing 3% oils from sunflower (T1), flax (T2), corn (T3), or fish (T4). The quail were allowed free access to food and water. The birds were housed in wire cages with 7 birds (2 males and 5 females) for each cage. Ingredients and chemical composition of diet were shown in Table-1. However, the fatty acid composition of oils used in this experiment is presented in Table-2. A regime of 17 h constant lighting and continuous ventilation were provided and all birds were kept under uniform management conditions throughout the experimental period.

Carcass traits

On the last day of experiment, 12 birds were randomly selected from each treatment groups (6 males and 6 females) and withdrawn from feed overnight to facilitate gut clearance, after that, birds were weighed to obtain live body weight. After recording the weights of birds, they were slaughtered, defeathered, processed (removal of head and feet), and eviscerated (removal of gastrointestinal tract). Carcasses were stored at 4°C for about 16 h. Afterward, the weights of carcasses were recorded, the carcasses were dissected to determine the percentage of carcass morphology by measuring the weights of heart, liver, gizzard, thighs, wings, breast, back, neck and abdominal fat and then the dressing percentage with and without giblets were calculated.

Statistical analysis

Data generated from experiment was carried out in a complete randomized design (Steel and Torrie, 1980). These data were subjected to ANOVA according to GLM procedure of SAS software (SAS, 2000). The significant differences among means were determined by using Duncan's multiple range tests. Differences among treatment means were compared at $p < 0.05$.

Table-1. Ingredients and chemical composition of the diet fed to Japanese quail.

	Sunflower oil (T1)	**Flax oil (T2)**	**Corn oil (T3)**	**Fish oil (T4)**
Ingredients (%)				
Yellow corn	12	12	8.5	10
Wheat	47.7	47.7	51.5	50
Soybean meal	20	20	19.7	19.7
Protein concentrate*	10	10	10	10
Lime stone	7	7	7	7
Oil	3	3	3	3
Sodium chloride	0.3	0.3	0.3	0.3
Calculated content**				
Crude protein (%)	21.05	21.05	21.1	21.05
Metabolizable energy (k cal / kg)	2888	2879	2881	2885
Total calcium (%)	3.6	3.6	3.6	3.6
Available phosphorus (%)	0.30	0.30	0.30	0.30
Methionine (%)	0.35	0.35	0.34	0.34
Lysine (%)	1	1	0.99	0.99
Cystine (%)	0.27	0.27	0.27	0.27

* Golden protein concentrate provided per kg: : 2500 ME / kg; 40% crude protein; 9% crude fat; 4.5% crude fiber; 9% calcium; 2.3% available phosphorus; 2.3% lysine; 1.25 methionine; 1.8% methionine + cystine; 100000 IU vit A; 10 mg vit B1; 100 mg vit B12; 20 mg vit K_3; 50 mg copper; 700 mg manganese; 2 mg selenium; 200 mg vit E; 0.5 mg biotin; 5 mg folic acid; 200 mg niacin; 80 mg pantothenic acid; 10 mg iodine; 25000IU vit D3; 500 mg iron; 10 mg cobalt; 600 mg zinc; 10 mg vit B6.
** Calculated composition was according to NRC (1994).

Table-2. Fatty acid composition (%) of oils included in the diets of Japanese quails.

Numeric name	Common name	TI	T2	T3	T4
C12:0	Lauric acid	-	-	-	0.090
C14:0	Myristic acid	0.06	0.12	0.06	5.41
C15:0	None	0.02	0.08	0.03	0.47
C16:0	Palmitic acid	6.25	6.0	11.01	14.05
C17:0	Margaric acid	0.03	0.11	0.09	1.73
C18:0	Stearic acid	3.58	2.5	1.91	2.87
C20:0	Arachidic acid	0.238	0.5	0.36	0.15
C21:0	None	0.008	0.01	0.01	0.04
C22:0	Behenic acid	0.587	0.23	0.15	0.02
C23:0	None	0.028	0.02	0.02	0.06
C24:0	Lignoceric acid	0.203	0.08	0.16	0.15
C14:1	Myristoleic acid	-	-	-	0.03
C15:1	None	0.01	0.01	-	0.19
C16:1	Palmitoleic acid	0.09	0.4	0.13	8.25
C17:1	None	0.04	0.03	0.04	0.36
C18:1 n9	Oleic acid	23.0	19.0	24.0	21.94
C20:1 n9	Gadoleic acid	0.255	0.28	0.36	11.22
C22:1 n9	Erucic acid	0.007	0.01	0.01	7.65
C24:1 n9	Nervonic acid	0.005	0.02	0.12	2.30
C18:3 n3	Alpha linolenic acid	0.108	57.29	1.26	0.50
C20:3 n3	None	0.025	0.05	0.03	0.05
C20:5 n3	Eicosapentenoic acid (EPA)	0.118	0.63	0.09	10
C22:6 n3	Docosahexaenoic acid (DHA)	0.012	0.0	0.02	10.73
C18:2 n6	Linoleic acid	65	12.18	60	1.02
C18:3 n6	Gamma linolenic acid	0.016	0.02	0.06	0.13
C20:2 n6	11, 14 - Eicosadienoic acid	0.155	0.08	0.06	0.19
C22:2 n6	13, 16 - Docosadienoic acid	0.155	0.003	0.001	0.38
Total of saturated fatty acids		11.0	9.65	13.8	25.04
Total of mono unsaturated fatty acids		23.40	19.75	24.66	51.94
Total of polyunsaturated fatty acids		65.58	70.55	61.52	23.0
Total of omega - 3 fatty acids		0.26	58.27	1.4	21.28
Total of omega - 6 fatty acids		65.32	12.28	60.12	1.72
Total of omega - 6 / total omega - 3 fatty acids ratio		251.23	0.21	42.94	0.08

T1: Sunflower oil; T2: Flax oil; T3: Corn oil; T4: Fish oil.

RESULTS

The effect of different fat sources added in quail diets on carcass traits are shown in Table-3. The body weight, carcass weight, dressing percentage with and without giblets were significantly higher ($p < 0.05$) in quail fed a diet containing fish oil followed by the results of flax oil, whereas the worst results for these traits were recorded when birds fed a diet containing sunflower oil and corn oil. The relative weight of heart, liver, thigh, and breast were found to be significantly ($p < 0.05$) different as a result of feeding different fats. The diet containing fish oil had the highest means for these traits, followed by the means of flax oil treatment, compared sunflower oil and corn oil treatments with the lowest means. The relative weight of gizzard was found to be statistically different ($p < 0.05$). The means of this characteristic were highest in quail fed diets containing fish oil and flax oil, while those fed diets containing sunflower oil and corn oil were the lowest. The relative weight of wing and back (Table-3) demonstrated that sunflower oil and corn oil diets provided the highest values for these two traits, whereas flax oil and fish oil diets had the lowest values for these traits. Significant differences ($p< 0.05$) in relative weight of neck were observed between the dietary treatment groups. Quail given corn oil diet had the highest value of his trait, followed by the values of sunflower oil diet and then the values of flax oil diet, while the fish oil diet had the lowest values with respect to this trait. There were significant differences ($p < 0.05$) concerning abdominal fat between dietary fat groups. Birds fed sunflower oil had significantly highest values in relation to the this trait, followed by the results of corn oil and flax oil treatments, whereas the lowest abdominal fat means were obtained when quail fed diet containing fish oil.

Table-3. Effect of different sources of fat on carcass traits of Japanese quail.

Traits	Treatments			
	T1	T2	T3	T4
Body weight (g)	160.84 ± 5.34 c	171.58 ± 9.26 b	157.50 ± 5.43 d	181.61 ± 5.95
Carcass weight (g)	100.32 ± 3.07 c	112.86 ± 5.96 b	98.37 ± 3.90 d	127.12 ± 4.54 a
Dressing percentage without giblets	62.37 ± 6.18 c	65.77 ± 8.87 b	62.45 ± 5.51 c	69.99 ± 7.32 a
Dressing percentage with giblets	67.78 ± 5.29 c	71.54 ± 6.15 b	67.65 ± 7.29 c	75.62 ± 6.28 a
Heart (%)	1.17 ± 0.11 c	1.20 ± 0.14 b	1.11 0.21 d	1.25 ± 0.12 a
Liver (%)	3.85 ± 0.22 c	4.96 ± 0.47 b	3.72 ± 0.28 c	5.21 ± 0.21 a
Gizzard (%)	3.69 ± 0.16 b	3.73 ± 0.24 a	3.35 ± 0.24 c	3.77 ± 0.28 a
Thigh (%)	23.15 ± 1.03 c	25.13 ± 1.12 b	23.03 ± 2.09 c	27.52 ± 1.57 a
Wings (%)	10.98 ± 1.11 a	9.11 ± 0.98 b	10.30 ± 1.26 a	8.03 ± 1.35 c
Breast (%)	34.56 ± 4.65 c	36.44 ± 5.51 b	34.19 ± 6.50 c	38.61 ± 5.62 a
Back (%)	24.23 ± 5.01 a	22.90 ± 4.41 b	24.27 ± 4.28 a	20.11 ± 3.17 c
Neck (%)	5.66 ± 0.95 b	5.23 ± 1.89 c	6.93 ± 0.78 a	4.97 ± 1.81 d
Abdominal fat (%)	1.42 ± 0.13 a	1.19 ± 0.25 B	1.28 ± 0.18 b	0.76 ± 0.24 c

T1: Sunflower oil; T2: Flax oil; T3: Corn oil; T4: Fish oil [a, b, c] Values within rows followed by different letters differ significantly ($P < 0.05$)

DISCUSSIONS

As shown from Table-3 supplementing quail ration with fish oil and flax oil (Major sources of omega-3 fatty acids) resulted in significant improvement regarding body weight, carcass weight, dressing percentage with or without giblets, main cuts of carcass (thigh and breast) and giblets (heart, liver, gizzard) and significant decrease in secondary cuts of carcass (wing,

Back, neck) and abdominal fat as compared with the diet supplemented with sunflower oil and corn oil (sources of omega-6 fatty acids). The positive results obtained in this study when ration of quail supplemented with fish oil (T4) and flax oil (T2) compared to sunflower oil (T1) and corn oil (T3) as concerns carcass characteristics included in this study may be explained by that fish oil and flax oil contain high levels of omega-3 fatty acids and low ratio of omega-6 to omega-3 fatty acids. Dalton (2000) indicated that the decrease in the ratio of omega-6 to omega-3 fatty acids in Japanese quail diet resulted in significant improvement in productive performance of these birds. Important nutritionally - essential n-3 fatty acids are alpha - Linolenic acid (ALA), Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA), all of which are polyunsaturated. Thus accumulation of long - chain n-3 fatty acids in tissue is more effective when they are obtained directly from food or when competing amounts of n-6 analogs do not greatly exceed the amount of n-3 (Midilli *et al*., 2009; Culver, 2001). EPA and DHA are made by micro algae that live in sea water. These are then consumed by fish and accumulate to high levels in their internal organs. Fish oil stimulate blood circulation, increase the breakdown of fibrin, a compound involved in clot and scar formation and additionally has been shown to reduce blood pressure, reduce blood cholesterol and triglycerides levels, regular intake, reduces the risk of secondary and primary heart attack, treatment of rheumatoid arthritis and cardiac arrhythias, helpful in depression and anxiety, reduce the risk of ischemic and thrombotic stroke (Sanders *et al*., 1997; Davidson *et al*., 2007). Pinchasove and Nir (1992) reported that n-3 long chain PUFA content (1 - 4%) in the diet reduces fat accretion in chickens. Omega-3 fatty acids present in fish oil mainly EPA and DHA reduced fat deposition by reducing the circulating very low density lipoprotein (VLDL) levels in the blood and effectiveness to decrease of fat accretion in arteries, tissues, and carcass. El - Yamany *et al*., (2008) found that adding flax oil to quail diet resulted in significant improvement in dressing percentage and significant decrease in abdominal fat percentage. Crespo and Esteve - Garcia (2000) suggested that reduction of abdominal fat in broilers fed flax oil seems to be a consequence of higher lipid oxidation despite the higher synthesis of endogenous fatty acids. Tikk *et al*., (2010) reported that 4% of fish oil and flax oil content of feed increased the omega-3 fatty acid content of leg meat from 2.6% to 7.8%, of breast meat from 2.3 to 5.7% and of abdominal fat from 3.0 to 10.2%. However, the Figures indicated omega-3 fatty acid as percentage of total lipids. The benefits of n-3 fatty acid enrichment of eggs and chicken meat have enhanced the studies on the effect of dietary fatty acid composition on fatty acid deposition in animal tissues (Huyghebaert, 1995). The aim sources of n-3 long - chain PUFA are marine (Hargis and Van Elswyk, 1993). Vegetable sources, such as flax oil and rapeseed oil, may clearly increase the n-3 fatty acid in the form of LNA, the precursor of the whole n-3 family. Lopez - Ferrer *et al*., (2001) indicated that chicken modify their lipid profile shortly after one week of replacement of the dietary fat sources. However, the correlation between the nature and magnitude of the change in deposition of each fatty acid in chicken meat and its amount in the diet is unclear. A linear response to increasing amount of EPA and DHA in the diet would ensure high levels of such fatty acids in meat.

CONCLUSIONS

In conclusion it seems that inclusion of fish oil and flax oil in quail diet could be produce better performance and carcass efficiency. It may be due to fat substitution from n-6 type (Linoleic acid, LA) to (Alpha Linolenic acid, LNA) and specially long chain n-3 PUFA type such as EPA and DHA had significant effects on performance improvement and lower abdominal fat in Japanese quail.

REFERENCES

Bezard J., J. P. Blond A. Bernard and P. Clouet. 1994. The metabolism and availability of essential fatty acids in animal and human tissues. Reprod. Nutr. Dev. 34: 539-568.

Bhatnagar D. and P. N. Durrington. 2003. Omega-3 fatty acids: their role in the prevention and treatment of atherosclerosis related risk factors and complications. Int. J. Clin. Pract. 57: 305-314.

Caston L. and S. Lesson. 1990. Research note: Dietary fat and egg composition. Poultry Sc. 69: 1617-1620.

Chekani - Azar N. Maheri - Sis H. A. Shahriar and A. A. Ahmadzaneh. 2007. Effects of different substitution levels of fish oil and poultry fat on performance and parts of carcass on male broiler chicks. J. Anim. Veter. Adv. 6: 1405-1408.

Cherrian G. and J. Sim. 1991. Effect of feeding full fat flax and canola seeds to laying hens on the fatty acid composition of eggs, embryos and newly hatched chicks. Poult. Sci. 71: 516-521.

Crespo N. and E. Esteve - Garcia. 2000. Nutrient and fatty acid deposition in broilers fed different dietary fatty acid profiles. Poult. Sci. 81: 1533-1542.

Culver J. N. 2001. Evaluation of tom fertility as affected by dietary fatty acid composition. M. Sc. Thesis, Faculty of the Virginia Polytechnic Institute and State University, USA.

Culter R. G. 1991. Antioxidants and aging. Am. J. Clin. Nutr. 56: 373-379.

Dalton M. N. 2000. Effects of dietary fats on reproductive performance, egg quality, fatty acid composition of tissues in Japanese quail (*Coturnix coturnix japonica*). M. Sc. Thesis, Faculty of the Virginia Polytechnic Institute and State University, USA.

Davidson M. H., E. A. Stein, E. H. Bays, K. C. Maki, R. T. Doyle, R. A. Shalwitz, C. M. Ballantyne and H. N. Ginsberg. 2007. Efficacy and tolerability of adding prescription omega-3 fatty acids 4g/d to Simvastatin 40 mg/d in hypertriglycridemic patients: An 8 - week, randomized, double - blind, placebo - controlled study. Clin. Thrapeutics (Elsevier). 29: 1354-1367.

El - Yamany A. T., H. M. H. El - Allawy, L. D. Abd El - Samee and A. A. El - Ghamry. 2008. Evaluation of using different levels and sources of oil in growing Japanese quail diets. Amer. Euras. J. Agric. Envir. Sci. 3: 577-582.

Farrell D. J. 1995. The enrichment of poultry products with the omega (n)-3 polyunsaturated fatty acids. A selected review. Proc. Aus. Poult. Sci. Symp. 7: 16-21.

Hargis P. S. and M. E. Van Elswyk. 1993. Manipulating the fatty acid composition of poultry meat and eggs for the health conscious consumer. World's Poult. Sci. J. 49: 251-264.

Huyghebaert G. 1995. Incorporation of polyunsaturated fatty acids in egg yolk fat at varying dietary fat levels and composition. Arch. Geflugelk. 59: 145-152.

Lopez - Ferrer S., M. D. Baucells, A. C. Barroeta and M. A. Grashorn. 2001. N-3 enrichment of chicken meat. 1. Use of very long - chain fatty acids in chicken diets and their influence on meat quality: fish oil. Poult. Sci. 80: 741-752.

Lopez - Ferrer S., M. D. Baucells, A. C. Barroeta and M. A. Grashorn. 1999 a. Influence of vegetable oil sources on quality parameters of broiler meat. Arch. Geflug. 63: 29-35.

Lopez - Ferrer S., M. D. Baucells, A. C. Barroeta and M. A. Grashorn. 1999 b. N-3 enrichment of chicken meat using fish oil: alternative substitution with rapeseed and linseed oils. Poult. Sci., 78: 356-365.

Mayes P. A. 1995. Lipids of Physiological Significance and Metabolism of Unsaturated Fatty Acids and Eicosenoic, In Harper's Biochemistry, 22nd Edition Librarie du Liban, Beirut. pp. 137-221.

Meyer B. J., N. J. Mann, J. L. Lewis, G. C. Milligan, A. J. Sinclair and P. R. Howe. 2003. Dietary intakes and food sources of omega-6 and omega-3 polyunsaturated fatty acids. Lipids. 38: 391-398.

Midilli M., I. Bayram, H. Erol. I. S. Cetingul, S. Cakir, E. Calikoglu and M. Kiralan. 2009. The effects of dietary poppy seed oil and sunflower oil on performance, reproduction and egg quality parameters and fatty acid profile of egg yolk in the Japanese quail. J. Anim. Vet. Adv. 8: 379-384.

Pinchasov Y. and I. Nir. 1992. Effect of polyunsaturated acid concentration on performance, fat deposition and carcass fatty acid composition in broiler chickens. Poult. Sci. 71: 1504-1512.

Sanders T. A. B., F. R. Oakley, G. J. Miller, K. A. Mitropoulos, D. Crook and M. F. Oliver. 1997. Influence of n-6 versus n-3 polyunsaturated fatty acids in diets low in saturated fatty acids on plasma lipoproteins and hemostatic factors. Arter. Thromb. Vasc. Biol. 17: 3449-3460.

ASA. 2000. SAS / STAT User's Guide, Version 6.12. SAS. Inst. Inc., Cary, Nc.

Scaife J. R. M., I. I. Galbraith, W. Michie and V. Campbell. 1994. Effect of different dietary supplemental fats and oils on the tissue fatty acid composition and growth of female broilers. Br. Poult. Sci. 35: 107-118.

Steel R. G. D. and J. H. Torrie. 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2nd Ed. McGraw - Hill Book Co., NY.

Tikk H., M. Piirsalu and V. Tikk. 2010. Increasing omega-3 fatty acids in quail meat. Vloom@emu.Ee;matti. piirsalu@agri.Ee.

Zollistch W., W. Knaus, F. Aichnger and F. Lettner. 1997. Effects of different dietary fat sources on performance and carcass characteristics of broilers. Anim. Feed. Sci. Technol. 66: 63-73.