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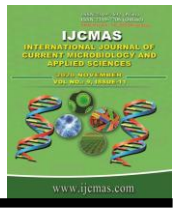

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Enrichment of Omega-3 Fatty Acids on Breast and Thigh Meat of Post-hatch Japanese Quail as Influenced by PUFA Rich Oil Sources in Feed

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A B S T R A C T

A study was conducted to assess the fatty acids composition on post-hatch performance of Japanese quail meat as influenced by supplementing PUFA rich oil sources like fish oil and linseed oil, independently and simultaneously at 2 and 4 per cent levels. The biological experiment was started with a total of five hundred and twenty five day old straight-run Japanese quail chicks up to 5 weeks of age. At the end of five weeks growth study, six birds from each treatment group were drawn randomly and subjected to humane method of slaughter. Breast and thigh meat samples collected and stored during slaughtering process were utilized to study the fatty acid composition of Japanese quail meat. The results revealed that breast and thigh meat obtained from the post-hatch Japanese quail fed with different n-3 PUFA rich oil sources had significantly ($P<0.01$) lower values of Myristic, Palmitic and Stearic acids when compared to birds received basal diet alone. The statistical analysis showed that the increase in Oleic, Linoleic, Linolenic acids, Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA), Total n-3 PUFAs, Total n-6 PUFAs and Total n-3/n-6 fatty acids ratio in breast and thigh meat of post-hatch Japanese quail fed n-3 PUFA rich lipid sources was highly significant ($P<0.01$). Based on the results of this study, it is concluded that the Japanese quail meat concentrations of Oleic acid, Linoleic acid, Linolenic acid, EPA, DHA, Total n-3 PUFAs, Total n-6 PUFAs and Total n-3 / n-6 fatty acids ratio showed significant ($P<0.01$) increase with a significant ($p<0.01$) decrease in Palmitic and Stearic acids content especially in case of Japanese quail fed diets enriched with fish oil and linseed oil at higher levels.

Introduction

Consumers are increasingly interested in functional foods. One category of functional foods of great interest is *Designer foods* that contain Omega-3 fatty acids (n-3 PUFA). Research studies revealed that the fatty acid composition of lipids of avian muscle tissues can be modified to match human nutritional guidelines better by appropriately manipulating the fatty acid composition of the diet (Leskanich and Noble, 1997). Omega-3 fatty acid poses interesting challenges to the food industries to convert recent knowledge into a means of producing healthier foods. In general, birds including mammals are unable to synthesize the essential omega−3 fatty acid (Alpha-Linolenic acid-ALA) and can be

obtained it only through diet. Keeping this in view, research work was carried out to assess the fatty acid composition on post hatch performance of Japanese quail meat as influenced by incorporation of Omega-3 Polyunsaturated fatty acid (PUFA) rich oil sources in ration.

Materials and Methods

The biological experiment was carried out by using five hundred and twenty five, day old straight-run Japanese quail chicks reared up to 5 weeks of age. The birds were wing banded, weighed individually and randomly allotted into seven treatment groups as T_1 (Control: without oils), T_2 (2% Fish oil), T_3 (2% Linseed oil), T_4 (4% Fish oil), T_5 (4% Linseed oil), T_6: 2% oil (1% Fish oil + 1% Linseed oil) and T_7: 4% oil (2% Fish oil + 2% Linseed oil) with three replicates having 25 chicks in each replicate.

The birds were reared under cage system of management with standard management practices throughout the experimental period. The birds were fed with experimental diet *ad libitum* and had free access to wholesome drinking water throughout the experimental period. All the experimental diets were formulated as per the standards prescribed by Shrivastav and Panda (1999) on isocaloric and isonitrogenous basis.

At the end of five weeks growth study period, six birds from each treatment group were drawn randomly and subjected to humane method (Mechanical method) of slaughter. Breast and thigh meat samples collected and stored during slaughtering process were utilized to study the fatty acid composition of quail meat.

Samples of thigh and breast muscles from each treatment were used to extract the lipids and transmethylation was done using one-step methylation procedure as described by Sukhija and Palmquist (1988). The data collected were subjected to statistical analyses as per Snedecor and Cochran (1989). Angular transformation is applied to percentages before statistical analysis wherever needed. The non-parametric values were subjected to Kruskal-Wallis non-parametric test (Sokal and Rohlf, 1995).

Results and Discussion

Fatty acids composition of meat

The mean fatty acids composition such as Myristic, Palmitic, Stearic, Oleic, Linoleic, Linolenic, Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA), total n-3, total n-6, n-3 /n-6 fatty acid ratio of breast and thigh meat on post-hatch performance of Japanese quail at fifth week of age as influenced by supplementing various n-3 PUFA rich oil sources independently and simultaneously in feed are presented in Tables 1 and 2, respectively.

The breast and thigh meat obtained from the post-hatch Japanese quail received different n-3 PUFA rich oil sources had significantly ($P<0.01$) lower values of Myristic, Palmitic and Stearic acids when compared to birds received basal diet alone.

The statistical analysis showed that the increase in Oleic, Linoleic, Linolenic acids, EPA, DHA, total n-3 PUFAs, total n-6 PUFAs and total n-3/n-6 fatty acids ratio in breast and thigh meat of post-hatch Japanese quail fed n-3 PUFA rich lipid sources was highly significant ($P<0.01$).

Myristic acid

Breast

From the table, it was observed that the breast meat from the birds in group T_1 (Control)

recorded significantly higher Myristic acid (1.76 per cent) when compared to breast meat from the birds fed with 2 per cent fish oil (T_2) (0.56 per cent) which was considered lowest among the treatment groups. The statistical analysis revealed significant ($P<0.05$) difference due to oil supplementation on breast meat Myristic acid content.

Thigh

The study showed that the thigh meat harvested from the birds in control group (T_1) had higher Myristic acid (1.52 per cent) when compared to the thigh meat harvested from the birds fed with 4 per cent linseed oil (T_5) (0.55 per cent) which was considered lowest value among the treatment groups. There exists highly significant ($P<0.01$) difference due to dietary treatment on Myristic acid content of thigh meat.

Palmitic acid

Breast

The study showed that the breast meat obtained from the birds in control group (T_1) had higher Palmitic acid (31.20 per cent) when compared to breast meat obtained from the birds in 4 per cent fish oil group (T_4) (21.00 per cent) which had the lowest value among the treatment groups. On statistical perusal, the dietary treatments exhibited highly significant ($P<0.01$) difference on Palmitic acid content of breast meat.

Thigh

From the table, it was observed that the thigh meat from the birds in group T_1 (control) recorded significantly higher Palmitic acid (31.30 per cent) when compared to thigh meat from the birds grouped under 4 per cent linseed oil (T_5) (20.30 per cent) which was lowest among the other treatment groups. The statistical analysis revealed highly significant ($P<0.01$) difference due to PUFA rich oil supplementation in Japanese quail feed on thigh meat Palmitic acid content.

Stearic acid

Breast

Among the treatment groups, the breast meat received from the birds in control group (T_1) had higher Stearic acid value (19.60 per cent) when compared to breast meat received from the birds supplemented with 4 per cent fish oil (T_4) (9.5 per cent) which was considered as a lower value. The statistical analysis indicated highly significant ($P<0.01$) difference due to dietary treatments on breast meat Stearic acid content.

Thigh

The results of this study showed that thigh meat harvested from the birds in control group (T_1) had higher Stearic acid content (18.50 per cent) when compared to thigh meat harvested from the birds in 4 per cent linseed oil supplemented group (T_5) (10.60 per cent) which was lower than other treatment groups. Highly significant ($P<0.01$) difference was noted due to dietary treatments on thigh meat Stearic acid content.

Oleic acid

Breast

The breast meat obtained from the birds in T_3 (2 per cent linseed oil) group had the higher Oleic acid (36.00 per cent) when compared to the breast meat obtained from the birds in control group (30.60 per cent) which was lower among other treated groups. The statistical analysis revealed highly significant ($P< 0.01$) difference due to dietary treatments on breast meat Oleic acid content.

Thigh

Among the treatment groups, the thigh meat obtained from the birds fed diets with 4 per cent linseed oil (T_5) had the higher Oleic acid content (39.60 per cent) when compared to the thigh meat obtained from the birds in control group (T_1) (32.70 per cent) which was considered as a lower value than other treated groups.

The statistical analysis indicated highly significant ($P<0.01$) difference due to dietary treatments on thigh meat Oleic acid content.

Linoleic acid

Breast

The present study showed that the breast meat from the birds fed diets with 2 per cent linseed oil (T_3) recorded the higher Linoleic acid (20.60 per cent) content when compared to the breast meat from the birds in control (T_1) group (14.60 per cent) which was lower than the other treated groups.

There exists highly significant ($P<0.01$) difference due to dietary treatments on breast meat Linoleic acid content.

Thigh

From the table, it was inferred that the thigh meat obtained from the birds in 4 per cent linseed oil group (T_5) had higher Linoleic acid content (20.70 per cent) than the thigh meat from the birds in group T_1 (control) (14.10 per cent) which was lowest among the n-3 PUFA rich oil supplemented groups.

The statistical analysis revealed highly significant ($P< 0.01$) difference due to dietary treatments on thigh meat Linoleic acid content.

Linolenic acid

Breast

The results of the study indicated that the breast meat obtained from the birds in 4 per cent linseed oil group (T_5) had higher Linolenic acid content (7.20 per cent) than the breast meat obtained from the birds in control group T_1 (0.81 per cent) which was lowest among the n-3 PUFA rich lipid supplemented groups. There exists highly significant ($P< 0.01$) difference due to dietary treatments on breast meat Linolenic acid content of Japanese quail.

Thigh

The present study showed that the thigh meat harvested from the birds in 4 per cent linseed oil group (T_5) recorded the higher Linolenic acid (5.60 per cent) content when compared to the thigh meat harvested from the birds in control (T_1) group (0.73 per cent) which was lower than the other treated groups. The statistical analysis indicated highly significant ($P<0.01$) difference due to dietary treatments on thigh meat Linolenic acid content. Crespo and Esteve-Garcia (2001) observed that birds fed linseed oil presented the highest values of linolenic acid in all tissues, which is in agreement with the results of this study.

Eicosapentaenoic acid (EPA)

Breast

The results of the study showed that the breast meat from the 4 per cent fish oil supplemented group (T_4) recorded the higher EPA content (5.40 per cent) when compared to the breast meat from the birds in control group (T_1) (0.66 per cent) which was not received the n-3 PUFA lipid source supplementation and has lowest value among other treated groups. The statistical analysis

revealed highly significant (P< 0.01) difference due to dietary treatments on breast meat EPA content.

Thigh

The supplementation of 4 per cent fish oil as n-3 PUFA rich oil sources in feed to birds in group T_4 proved to transfer 4.44 per cent EPA to thigh meat which was higher when compared to thigh meat obtained from the birds in group received basal diet only (control) (0.55 per cent). The statistical analysis indicated highly significant (P<0.01) difference due to dietary treatments on thigh meat EPA content.

Similar to these results, Miller and Robisch (1969) reported that the fish oils at 1.5 and 2.5 per cent level fed to broilers had influenced the fatty acid patterns of the tissue lipids. Chanmugam *et al.,* (1992) observed that levels of EPA were increased (P<0.05) in all the groups fed menhaden fish oil than other groups which is in agreement with the results of this study.

Docosahexaenoic acid (DHA)

Breast

The supplementation of 4 per cent fish oil as n-3 PUFA rich lipid source in feed to birds in group T_4 proved to transfer 9.81 per cent DHA to breast meat which was higher when compared to breast meat obtained from the birds in group received basal diet only (0.73 per cent). The statistical analysis showed highly significant (P<0.01) difference due to dietary treatments on breast meat DHA content.

Thigh

The results of the study revealed that the thigh meat from the birds in 4 per cent fish oil group T_4 recorded highest DHA content (8.31 per cent) when compared to the thigh meat obtained from the birds in (Control) T_1 group (0.62 per cent) which had not received the n - 3 lipid source supplementation and considered as lowest value among other treated groups. The statistical analysis exhibited highly significant (P<0.01) difference due to dietary treatments on thigh meat DHA content.

According to Phetteplace and Watkins (1990), broiler chicken fed diets enriched with menhaden fish oil resulted in increased concentration of EPA and DHA which coincides with the results obtained in this study.

Total n-3 PUFA

Breast

The breast meat obtained from the birds in 4 per cent fish oil group T_4 recorded the higher value of (19.20 per cent) total n-3 PUFAs when compared to breast meat obtained from the birds in group T_1 (control) (2.20 per cent) which was considered lowest among the other treated groups with n-3 PUFA rich oil sources. Highly significant (P<0.01) difference due to dietary treatments was noted on breast meat total n-3 PUFAs content.

Thigh

From the table, it was observed that the mean total n-3 PUFAs of the thigh meat obtained from the birds in 4 per cent fish oil group (T_4) had the higher amount of total n-3 PUFAs content (15.50 per cent) when compared to the thigh meat obtained from the birds in group T_1 (control) (1.90 per cent) which was considered lowest among the treated group of birds. The results showed highly significant (P<0.01) difference due to dietary treatments on thigh meat total n-3 PUFAs.

Table 1 Mean fatty acids composition (%) (±S.E.) in breast muscle of post-hatch Japanese quail as influenced by feeding PUFA rich oil sources in feed

Treatment groups	Myristic acid	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	EPA	DHA	n-3PUFA	n-6 PUFA	n-3/n-6 PUFA ratio
T_1- Control	1.76^{D} ±0.09	31.2^{C}±0.38	19.6^{D} ±0.63	30.6^{A} ±0.61	14.6^{A} ±0.99	0.81^{A}±0.05	0.66^{A}±0.06	0.73^{A}±0.05	2.2^{A}±0.14	14.6^{A}±0.99	**0.15^{A}±0.04**
T_2- 2% Fish oil (FO)	0.56^{A} ±0.08	23.2^{B}±0.62	11.8^{BC} ±0.56	33.3^{BC} ±0.79	16.6^{B} ±0.28	2.5^{B}±0.09	4.7^{DE}±0.42	7.41^{E}±0.14	14.6^{D}±0.43	16.6^{B}±0.28	**0.88^{F}±0.08**
T_3- 2% Linseed oil (LO)	1.23^{C} ±0.19	22.9^{B}±0.26	12.5^{BC} ±0.77	36.0^{D} ±0.36	20.6^{C} ±0.20	4.8^{D}±0.17	0.74^{A}±0.11	1.18^{A}±0.07	6.7^{B}±0.14	20.6^{C}±0.20	**0.32^{B}±0.03**
T_4- 4% Fish oil	0.88^{AB} ±0.04	21.0^{A}±0.33	09.5^{A} ±0.49	32.5^{AB} ±0.66	16.9^{B} ±0.36	2.9^{B}±0.13	5.4^{E}±0.93	9.81^{F}±0.30	19.2^{E}±0.68	16.9^{B}±0.36	**1.14^{G}±0.09**
T_5- 4% Linseed oil	1.08^{BC} ±0.03	21.2^{A}±0.42	11.6^{B} ±0.39	35.3^{CD} ±0.47	20.3^{C} ±0.42	7.2^{E}±0.33	1.5^{AB}±0.11	1.83^{B}±0.04	10.6^{C}±0.24	20.3^{C}±0.42	**0.52^{C}±0.04**
T_6- 2 % (FO +LO)	0.64^{A} ±0.04	23.7^{B}±0.35	13.5^{C} ±0.14	33.7^{BC} ±0.38	16.6^{B} ±0.46	3.8^{C}±0.12	3.0^{BC}±0.07	4.98^{C}±0.08	11.8^{C}±0.22	16.6^{B}±0.46	**0.72^{D}±0.04**
T_7- 4 % (FO +LO)	**0.64^{A} ±0.05**	**24.4^{B}±0.37**	**13.2^{BC} ±0.35**	**32.3^{AB} ±0.32**	**15.7^{AB} ±0.36**	**4.6^{D}±0.29**	**3.2^{CD}±0.03**	**5.95^{D}±0.05**	**13.8^{D}±0.30**	**15.7^{AB}±0.36**	**0.88^{E}±0.09**

Value within each cell is a mean of 6 observations

$^{A-G}$ Mean values not sharing a common superscript column wise differ significantly. (P<0.01)

Table.2 Mean fatty acids composition (%) (±S.E.) in thigh muscle of Post-hatch Japanese quail as influenced by feeding PUFA rich oil sources in feed

Treatment groups	Myristic acid	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	EPA	DHA	n-3 PUFA	n-6 PUFA	n-3/n-6 PUFA ratio
T_1- Control	1.52^{C} ±0.2	31.3^{E} ±0.26	18.5^{D}± 0.29	32.7^{A}± 0.26	14.1^{A}± 0.24	0.73^{A} ±0.03	0.55^{A} ±0.03	0.62^{A} ±0.04	1.9^{A}±0.09	14.1^{A}± 0.24	**0.13^{A}± 0.01**
T_2- 2% Fish oil (FO)	0.82^{AB} ±0.1	23.8^{C} ±0.01	12.6^{B}± 0.46	34.4^{B}± 0.34	15.3^{B}± 0.28	2.41^{B} ±0.05	4.14^{E} ±0.20	6.61^{E} ±0.09	13.2^{E}±0.11	15.3^{B}± 0.28	**0.86^{F}± 0.01**
T_3- 2% Linseed oil (LO)	1.01^{BC} ±0.1	21.8^{B} ±0.05	11.6^{AB}± 0.20	38.7^{C}± 0.65	20.0^{D}± 0.37	4.91^{D} ±0.20	0.78^{A} ±0.08	1.20^{B} ±0.04	6.9^{B}±0.19	20.0^{D}± 0.37	**0.34^{B}± 0.05**
T_4- 4% Fish oil	0.68^{A} ±0.1	22.6^{B} ±0.28	12.2^{B}± 0.57	34.2^{B}± 0.35	14.8^{AB}± 0.09	2.77^{B} ±0.07	4.44^{E} ±0.06	8.31^{F} ±0.20	15.5^{F}±0.16	14.8^{AB} ±0.09	**1.05^{G}± 0.02**
T_5- 4% Linseed oil	0.55^{A} ±0.03	20.3^{A} ±0.26	10.6^{A}± 0.16	39.6^{C}± 0.32	20.7^{D}± 0.18	5.60^{E} ±0.20	1.18^{B} ±0.03	1.47^{B} ±0.03	8.2^{C}±0.18	20.7^{D}± 0.18	**0.40^{C}± 0.05**
T_6- 2 % (FO +LO)	0.62^{A} ±0.06	25.9^{D} ±0.36	14.1^{C}± 0.37	34.2^{AB} ± 0.25	16.5^{C}± 0.18	2.70^{B} ±0.14	1.54^{C} ±0.07	4.42^{C} ±0.09	8.7^{C}±0.13	16.5^{C}± 0.18	**0.53^{D}± 0.01**
T_7- 4 % (FO +LO)	**0.57^{A} ±0.03**	**26.2^{D} ±0.36**	**12.1^{B}± 0.33**	**34.8^{B}± 0.43**	**15.6^{BC}± 0.25**	**3.36^{C} ±0.16**	**2.29^{D} ±0.04**	**5.09^{D} ±0.10**	**10.7^{D}±0.27**	**15.6^{BC} ±0.25**	**0.69^{E}± 0.03**

Value within each cell is a mean of 6 observations

$^{A-G}$ Mean values not sharing a common superscript column wise differ significantly. ($P<0.01$)

Total n - 6 PUFA

Breast

The mean total n-6 fatty acids in the table indicated that the breast meat obtained from the birds in 2 per cent linseed oil group (T_3) had the higher amount of total n-6 PUFA content (20.60 per cent) when compared to the breast meat obtained from the birds in group T_1 (control) (14.60 per cent) which was considered lowest among the treated group of birds. The results showed highly significant ($P<0.01$) difference due to dietary treatments on breast meat total n-6 PUFAs.

Thigh

The thigh meat obtained from the birds in groups fed diets with 4 per cent linseed oil group (T_5) recorded the highest value (20.70 per cent) of n-6 PUFAs when compared to the thigh meat obtained from the birds in T_1 (control) (14.10 per cent) which was considered lowest among the treated groups of birds with n-3 PUFA rich oil sources. Highly significant ($P<0.01$) differences due to dietary treatments were observed on thigh meat total n-6 PUFAs content.

n-3 / n-6 fatty acids ratio

Breast

The breast meat harvested from the birds in 4 per cent fish oil group (T_4) recorded the higher n-3 / n-6 fatty acid ratio (1.14) when compared to the breast meat harvested from the birds in control group (T_1) (0.15) which was considered lowest among the treated groups of birds with n-3 PUFA rich lipid sources. Highly significant ($P< 0.01$) differences due to dietary treatment were observed on breast meat n-3 / n-6 fatty acids ratio.

Thigh

The thigh meat obtained from the birds in 4 per cent fish oil supplemented group (T_4) recorded higher n-3/n-6 ratio (1.05) when compared to thigh meat obtained from the birds in control group (T_1) (0.13) which was considered lowest among the treated group of birds with n-3 PUFA rich lipid sources. The results revealed highly significant ($P<0.01$) difference due to dietary treatments on thigh meat n-3 / n-6 fatty acids ratio. According to Phetteplace and Watkins (1990), broiler chicken fed diets enriched with menhaden oil resulted in decreased n-6: n-3 ratio with increasing levels of menhaden fish oil which coincides with the results obtained in this study.

Chanmugam *et al.,* (1992) reported that birds supplemented with diet rich in linolenic acid content had significantly higher levels of n-3 fatty acids which is in agreement with the results of this study and concluded that to increase the n-3: n-6 ratio in meat, oils with a high content of linolenic acid could be used in poultry feeds. In another study, cockerels fed diet enriched with three per cent tuna orbital oil significantly ($P<0.01$) increased the DHA level which is in accordance with the results of the study.

Based on the research findings, it is concluded that the Japanese quail meat concentrations of Oleic acid, Linoleic acid, Linolenic acid, Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA), total n-3 PUFAs, total n-6 PUFAs and total n-3 / n-6 fatty acids ratio showed significant ($P<0.01$) increase with a significant ($p<0.01$) decrease in Saturated fatty acids content *viz.* Palmitic and Stearic acids content especially in case of Japanese quail fed diets enriched with fish oil and linseed oil at higher levels. Total Omega-3 PUFAs concentration in breast and thigh meat of post-hatch Japanese quail

performance showed an increase in all the treated groups due to incorporation of various n-3 PUFA rich lipid sources in feed.

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