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Effects of Rapeseed Oil (*Rapus indicus*) Supplementation on Omega-3 Fatty Acid Concentration and Carcass Characteristics in Broiler Chicken

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ABSTRACT

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Dietary fatty acid composition in broiler influences carcass quality by altering fat deposition and fatty acid profile. Thus, the study was carried out to evaluate the effect of incorporation of rapeseed oil in broiler ration on omega-3 fatty acid concentration of carcass and its traits in broiler chicken. A total of 160 day-old straight run broilers (Vencobb 400) were randomly divided into four treatment groups (G1, G2, G3 and G4) having four replicates of ten chicks each. The basal diets (G1) were prepared to meet BIS (2007) nutrient requirements with palm oil at 1.5, 3, and 4.5 per cent in pre-starter, starter and finisher diets, respectively. The experimental diets were broiler rations prepared with rapeseed oil replacing 25, 50 and 100 per cent of palm oil in G2, G3 and G4 diets, respectively. The diets were fed *ad libitum* till 6 weeks of age. Six birds from each group were randomly selected and slaughtered on 42nd day to study omega-3 fatty acid concentration of carcass and its characteristics. The crude fat content of breast and thigh muscle was significantly ($P < 0.05$) reduced in the group fed rapeseed oil included diets. However, carcass yield, processing yield and meat to bone ratio of cut up parts was not significantly affected. The colour and pH of breast and thigh muscles were similar among the treatment groups. Omega- 3 fatty acid concentration was significantly ($P < 0.01$) increased in both breast and thigh muscle of G4 group broilers compared to G1 group. Thus, rapeseed oil inclusion in diet significantly increased omega-3 fatty acid concentration and significantly reduced crude fat concentration breast and thigh muscles with no effect on the carcass yield and its quality when included in the diet replacing palm oil at different proportion.

Keywords: Broiler chickens, Carcass characteristics, Omega-3 fatty acid, Rapeseed oil

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INTRODUCTION

In India, poultry industry had registered growth rate of 16.8 per cent and poultry meat production increased by 7.8 per cent according to 20th census (DAHD, 2020). The poultry nutritionists invariably incorporate various sources of oil (palm oil, rice bran oil) in broiler ration as energy source. However, dietary fatty acid composition influences carcass quality by altering fat deposition and fatty acid profile (Abdulla *et al.,* 2015). Awareness among consumers about including polyunsaturated fatty acids (PUFA) in the diet to prevent diseases like coronary heart disease, hypertension and diabetes etc. has been increased (Bhalerao *et al.,* 2014) and polyunsaturated fatty acids rich diet has been shown to have beneficial effects on human health (Katan *et al.,* 1995). Improved fatty acid profile of chicken meat with higher n-3 fatty acids (FA) content could be possible by incorporating n-3 FA rich vegetable oils without affecting the carcass quality. Apart from that, color of the meat also plays a major role in consumers preferences, and it is influenced by sex, age, muscle pigments, meat pH, pre slaughtering condition and processing (Sabow *et al.,* 2016; Salwani *et al.,* 2016). Rapeseed oil (*Brassica napus* var.) has been known as a good source of alpha linolenic acid (ALA, C18:3 n-3), which can be readily converted to n-3 long chain polyunsaturated fatty acids (LC-PUFA) in poultry and can be included in vegetable oil blends along with sunflower oil, rice bran oil and palm oil to improve omega -3- fatty acid content of broiler ration (Valavan *et al.,* 2006). The proposed study is to ascertain the carcass characterization by inclusion of polyunsaturated fatty acids rich rapeseed oil replacing saturated fatty acid rich palm oil at different proportions in broiler ration.

MATERIALS AND METHODS

Experimental details and data

The feeding experiment was conducted in Instructional Livestock Farm Complex, College of Veterinary and Animal Sciences, Kerala Veterinary and Animal Science University, Wayanad, Kerala from the period of January to February 2019. Experimental study was approved by Institutional animal ethical committee under 1271/GO/Re/S/09/CPCSEA- IAEC/COVAS/PKD/10/2019. One hundred sixty, day-old straight run Vencobb 400 broiler chicks were purchased from local hatchery and were separated into four groups (G1, G2, G3 and G4) with four replicates of ten chicks each. The experimental diets were prepared as per BIS (2007) recommendations. The basal diets were prepared with vegetable oil (palm oil) included at the rate of 1.5, 3.0, and 4.5 per cent in pre-starter, starter and finisher diet, respectively. The treatment diets were prepared with rapeseed oil replacing 25, 50 and 100 per cent of palm oil in G2, G3 and G4 diets, respectively. The feed was prepared at the feed mill facilities in Instructional Livestock Farm Complex (ILFC). Feed and water were supplied *ad libitum* up to 42nd day of age.

Slaughter study

At the end of the experiment (42nd day) six birds from each treatment group were randomly selected and weighed. The birds were euthanized by cervical dislocation and slaughtered. The carcass weight was calculated by removing the feathers, blood, head, feet, and organs, except the lungs and kidneys. The yield of carcass, cut up parts, edible organ and inedible offal's, were calculated based on pre-slaughter live weight basis (Choo *et al*., 2014) and breast, thigh and drumstick portions were deboned and weighed separately. The cut-up part of collected breast and thigh muscle samples were weighed and stored in deep freezer at -20° C for fatty acid analysis.

Chemical composition of carcass

The breast and thigh muscle samples from different treatment groups were collected as per procedure mentioned in FSSAI (2017). The fresh meat was chopped at meat chopper at 3 mm size and mixed thoroughly for chemical composition (AOAC, 2016) analysis.

Hunter Lab colour (L a* b*) values*

Colour values of the breast and thigh muscle samples were determined objectively as per Page *et al*. (2001) using Hunter Lab Mini Scan XE plus Spectrophotometer (Hunter Lab, Virginia, USA) with diffuse illumination. The instrument was set to measure Hunter L* a* and b* using illuminant 45/0 and 10° standard observer with an aperture size of 2.54 cm. It was calibrated using black and white calibration tiles before starting of the measurement and colorimeter score recorded with 'L' of black equals zero and 'L' of white equals 100, 'a' of lower numbers equals more green (less red), higher numbers equals more red (less green) and 'b' of lower numbers equals more blue (less yellow), higher numbers equals yellow (less blue). The colour coordinates L* (lightness), a* (redness) and b *(yellowness) of the samples were measured thrice and mean values were taken.

pH

The pH of breast and thigh muscles at 24 h post-slaughter was measured by using a digital pH meter as per the method described by AOAC (2016). Ten grams of sample was blended with 50 ml distilled water for one min using a tissue homogenizer (Kinematica, Switzerland) at the speed of 4000 rpm. The pH of the homogenate was recorded by immersing the combined glass electrode of a digital pH meter (EUTECH instruments pH 510, Singapore).

Fatty acid analysis

The wet sample of breast and thigh muscle fatty acid methyl ester (FAME) was synthesized by using direct method of FAME synthesis proposed by O'Fallon *et al*. (2007). Methyl ester composition of fatty acids was analysed by gas chromatography (GCMS-QP 2010 Ultra, Shimadzu, Japan) using a flame ionization detector. A

capillary column (100 m length x 0.25 mm internal diameter, 0.20 ìm; Rt-2560 Restek®) was used for analysis. The carrier gas used was high purity helium (99.99 per cent) with a total flow rate of 106.7 ml/min and a column flow rate of 1 mL/ min. The sample volume was 1 μL with a split ratio of 1:100. Oven temperature program was initially set at 100 ºC which was held for 4 minutes, then ramped at 3 ºC/min to 190 ºC and held for 5.0 min, then ramped at 2 ºC/min to 230 ºC and held for 20 min. The total run time was 79 min. The injection port, and the flame ionization detector temperatures were 225ºC, and 245ºC, respectively. Linolenic acid methyl ester isomer mix, Methyl all-*cis*-5,8,11,14,17-Eicosapentaenoic acid and *cis*-4,7,10,13,16,19-Docosahexaenoic acid (Sigma-Aldrich, India) were used as reference for quantification. Fatty acids were quantified as g fatty acid per 100 g of muscle.

Statistical Analysis

The data obtained in this study were analyzed statistically by one way ANOVA as per the methods described by Snedecor and Cochran (1994) using the SPSS version 21.0 ® software.

RESULTS AND DISCUSSION

Carcass yield and processing yield

The carcass yield and processing yield were presented in Table 1. Dietary supplementation of rapeseed oil in place of palm oil at different concentration has not affected the carcass yield and its cut up parts yield. Meat to bone ratio of cut parts was not significantly affected. In accordance with our experimental results, Ebdi and Nobakht (2017) reported that canola oil had no significant effects on carcass, breast, thigh and abdominal fat yield on addition in the diet. Similarly, Wang *et al*. (2013) reported that combination of linseed and palm oil at 5 per cent in broiler ration has not affected carcass yield which is comparable to our findings. Researchers Jankowski *et al*. (2012); Kitessa and Young, (2008) concluded in their research that rapeseed oil had no effect on carcass yield and processing yield. However, giblets weight and yield were significantly affected in G2 and G3 group birds where significantly higher giblet weight ($P < 0.01$) was recorded compared to G1 and G4 groups. Comparable to our findings, Wongsuthavas *et al*. (2007) reported that soya bean oil affected the liver weight of the birds. Similarly, Shahryar *et al*. (2011) reported that canola oil and poultry fat included at 3 per cent level significantly reduced edible organ weight in broilers. Khatun *et al*. (2018); Lopezferrer *et al*. (1999) and Nguyen *et al*. (2003) reported that different fat sources like palm oil, rapeseed oil, sunflower oil had affected thigh muscle, breast muscle and abdominal fat yield.

Carcass chemical composition

The chemical composition of breast and thigh muscles of experimental birds of G1, G2, G3 and G4 groups are presented in Table 2. The dietary inclusion of

Table 1. Effect of rapeseed oil on carcass yield and processing yield

Attributes	Groups				SEM	P value
	G1	G2	G3	G4		
Live weight (g)	2112.00	2122.50	2251.50	2109.50	32.43	0.074
Yield (per cent live weight)						
Carcass	72.97	73.85	73.14	70.63	0.607	0.279
Breast	20.81	20.78	21.09	20.74	0.261	0.971
Thigh	9.85	10.02	10.41	10.32	0.183	0.721
Drumstick	9.83	9.23	10.37	9.35	0.246	0.364
Drumettes	3.31	3.93	4.07	3.56	0.121	0.089
Wings	3.28	4.01	3.64	3.41	0.115	0.110
Neck	5.18	5.92	5.22	5.45	0.117	0.078
Back	10.72	10.90	9.35	9.28	0.332	0.159
Skin	6.50	6.68	6.06	6.88	0.204	0.575
Abdominal fat	1.33	1.42	1.55	1.17	0.060	0.156
Edible organs (per cent live weight)						
Heart	0.49	0.54	0.50	0.53	0.018	0.691
Liver	2.12^{b}	2.62^{a}	2.32^{b}	2.10^{b}	0.068	0.005
Gizzard	1.38	1.63	1.39	1.40	0.043	0.096
Giblets	3.99^{b}	4.80^{a}	4.21^{b}	4.03^{b}	0.100	0.002
Meat: Bone						
Breast	6.26	5.59	6.48	6.28	0.213	0.518
Thigh	5.40	4.60	5.15	4.71	0.140	0.136
Drumstick	3.71	3.59	4.02	3.55	0.106	0.433

^{abc}Mean values with different superscripts within a row differ significantly

Table 2. Chemical composition (%) of breast and thigh muscle

Attributes	Groups				SEM	P value
	G1	G2	G3	G4		
Breast muscle						
Moisture	75.42	74.44	75.08	74.96	0.145	0.098
Crude protein	20.02	20.63	20.50	20.68	0.112	0.139
Crude fat	1.68^{a}	1.40^{b}	1.35^{b}	1.36^{b}	0.039	0.000
Thigh muscle						
Moisture	75.42	74.43	75.08	74.96	0.145	0.097
Crude protein	18.84	18.65	18.74	18.77	0.063	0.819
Crude fat	2.58^{a}	2.23^{b}	2.11^{b}	2.17^{b}	0.056	0.001

^{abc}Mean values with different superscripts within a row differ significantly

rapeseed oil decreased ($P<0.001$) crude fat content of breast and thigh muscles compared to palm oil alone fed group. However, other parameters like moisture, crude protein, and total ash were not affected by the dietary fat source. The reason for the difference in body fat accumulation could be attributed to various metabolic uses of the absorbed dietary PUFA levels, n-6/n-3 ratio and decreased rate of fatty acid synthesis (Shahid *et al.,* 2019). Similar to our findings, Bostami *et al.* (2017) and Ghasemi *et al.* (2015) also reported that crude fat content in breast muscle of canola oil fed group was less than sunflower oil fed group ($P< 0.05$) when included at 5 per cent in the broiler ration. Kavouridou *et al.* (2008) concluded in their research that body fat content of the birds consuming linseed oil was lower ($P<0.001$) than the body fat of the birds fed the soya bean oil and palm oil which is similar to our findings. Bharath *et al.* (2014) also reported lower intramuscular fat in both breast and thigh muscles when sunflower oil was replaced by linseed oil and fish oil.

Carcass colour and pH

Colour is an important meat quality trait as it affects consumer acceptability of meat (Adeyemi *et al.,* 2015). Dietary oil had no significant ($P>0.05$) influence on L*(lightness), a*(redness) and b*(yellowness) value of breast and thigh muscle (Table 3). These results are similar to the findings of Khatun *et al.* (2018) on broilers fed with palm oil, sunflower oil and their combination at 6 per cent in broiler ration. Jankowski *et al.* (2012) reported that meat colour parameters in turkey did not change with the dietary supplementation of soyabean oil, rapeseed oil and linseed oil. However, this observation contradicts the findings of Qi *et al.* (2010) who reported that dietary supplementation of different oils influenced the colour of broiler meat.

Omega-3 fatty acid concentration in breast and thigh muscle

The n-3 FA concentration in breast and thigh muscles was affected by dietary fatty acid profile (Table 4). Alpha linolenic acid (ALA) concentration increased significantly ($P<0.01$) in breast and thigh muscle in G4 group. Whereas concentration of ALA recorded in G3 group breast and thigh muscles were similar to G4. The eicosapentaenoic acid (EPA) concentration in breast muscle (0.031 g/100 g of muscle) and thigh muscle (0.026 g/100 g of muscle) of G4 was significantly higher than G1 and G2. While comparing to G3 group. EPA concentration was similar to G4 in thigh muscle and lower than G4 in breast muscle. Docosahexaenoic acid (DHA) content in thigh muscle of G4 (0.029 g/100 g of muscle) group was significantly higher ($P<0.01$) than in G1, G2 and G3 groups. Thus omega-3 fatty acid content in carcass was positively related to its content in the diet when palm oil was replaced by omega-3 fatty acid rich rapeseed oil. The dietary fatty acids will be deposited without any modifications in the carcass (Nieto and Ros, 2012). The fatty acid profile of muscle tissue reflects the dietary fatty acid profile (Abdulla *et al.*, 2015). Poudel *et al.* (2016) reported a similar effect on concentration of EPA and DHA in breast muscle when rapeseed oil was incorporated at 30 g per kg diet. Similarly, Skøivan

et al. (2018) who used palm oil and rapeseed oil at 6 per cent in broiler diet reported that Linolenic (18: 3 n3) content was more in rapeseed oil fed group than palm oil group. Valavan *et al*. (2016) reported that dietary incorporation of rapeseed oil at 3 per cent level recorded a significantly higher level of total n-3 FA and eicosapentaenoic acid (EPA) content in breast muscle of broilers. According to Stanacev *et al*. (2014), there was a significant ($P<0.05$) increase of total n-3 FA in the chicken breast meat when fed with rapeseed oil (4 and 6%).

Table 3. Colour and pH of breast and thigh muscle

Attributes	Groups				SEM	P value
	G1	G2	G3	G4		
Breast muscle						
pH	5.52	5.55	5.51	5.43	0.029	0.544
L*	54.55	55.47	58.29	55.45	0.735	0.322
a*	5.01	5.14	4.69	4.71	0.214	0.876
b*	14.65	15.60	14.98	16.21	0.612	0.845
Thigh muscle						
pH	5.56	5.56	5.43	5.55	0.034	0.499
L*	46.38	49.44	48.03	49.34	0.692	0.392
a*	7.51	6.30	6.24	6.62	0.230	0.179
b*	14.26	14.98	14.63	14.58	0.342	0.926

L*(lightness), a*(redness) and b *(yellowness)

Table 4. Omega-3 fatty acid concentration in breast and thigh muscle (g/100 g muscle)

Attributes	Groups				SEM	P value
	G1	G2	G3	G4		
Breast muscle (g/100 g muscle)						
Alpha-Linolenic acid (C18:3)	0.178^{b}	0.192^{b}	0.264^{ab}	0.349^{a}	0.025	0.024
Eicosapentaenoic acid (C20:5)	0.014^{b}	0.018^{b}	0.025^{a}	0.031^{b}	0.002	0.003
Docosahexaenoic acid (C22:6)	BDL	BDL	0.020	0.028	0.004	-
Thigh muscle (g/100 g muscle)						
Alpha-Linolenic acid (C18:3)	0.155^{b}	0.217^{b}	0.294^{ab}	0.412^{a}	0.035	0.022
Eicosapentaenoic acid (C20:5)	0.009^{c}	0.013^{c}	0.019^{b}	0.026^{a}	0.002	0.000
Docosahexaenoic acid (C22:6)	0.011^{c}	0.014^{bc}	0.017^{b}	0.029^{a}	0.002	0.000

^{abc}Mean values with different superscripts within a row differ significantly
BDL-Below detection limit

CONCLUSION

The results of the present study revealed that incorporation of rapeseed oil in broiler ration increased deposition of n-3 FA content in the broiler carcass with no

adverse effect on carcass yield and quality. However, rapeseed oil inclusion had significantly reduced crude fat concentration in the breast and thigh muscle, which is a desirable character for consumer's preference. Thus, based on the results obtained from this study and considering more availability and comparable cost of rapeseed oil, it is suggested that rapeseed oil could be included in broiler pre-starter, starter and finisher diet at 1.5, 3.0 and 4.5%, respectively as an energy source to increase n-3 FA concentration.

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