MANIPULATION OF BROILER MEAT FATTY ACID COMPOSITION USING QUERCETIN

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Abstract - Flavonoids have been reported to decrease the serum lipid and alter the lipid metabolism in various laboratory animals. Among flavonoids, quercetin is widely found in the animal feed ingredients and showed the potential of altering the fatty acid composition in animal fed by quercetin. Thus, this research aimed to evaluate the potential of quercetin and the suitable levels of it, in manipulating the fatty acid composition of broiler meat, to produce healthier chicken meat. Different levels of quercetin including 0, 100 and 200 mg/kg of diet used in this study. Chickens were slaughtered after 42 days feeding. The major fatty acids of *pectoralis majors* muscle in broiler chickens were oleic (C18:1n-9, 33.0-35.2%), palmitic (C16:0, 26.1-27.9%), linoleic (C18:2n-6, 14.0-14.6%) and stearic (C18:0, 11.8–13.7%) respectively. The content of palmitic, oleic and linoleic acids significantly ($p<0.05$) decreased by inclusion of 200 mg/kg quercetin in the diet. In addition, a significant decrease ($P<0.05$) in the relative proportion of monounsaturated fatty acids (MUFA), n-6 polyunsaturated fatty acids (PUFA), n-6: n-3 fatty acid ratios (FAR) were also observed. It is concluded that the supplementation of quercetin at 200 mg/kg in the broiler diet would affect the meat fatty acid composition of the pectoralis major muscle in broilers.

Key Words – Flavonoid, Fatty acids, Broiler chickens, Quercetin

I. INTRODUCTION

Quercetin, is a flavonol-type and plant-derived flavonoid found in fruits, vegetables, leaves and grains. The antioxidant activity of quercetin has been well-characterized [1]. The quercetin is present in the lower concentration in the normal diet and addition of quercetin in the diet contributes to increase the quercetin level of plasma. Studies in different animals have shown that the highest accumulation of the flavonoid and its metabolites are in the liver, lungs and kidney [2]. Flavonoids have been reported to decrease the serum lipids through their antiatherogenic action, modify the eicosanoid biosynthesis, protect low-density lipoprotein (LDL) from oxidation and to prevent platelet aggregation [3]. In addition, several studies have also revealed that the supplementation of quercetin to the diet decreased serum free fatty acids (FFA), triglyceride (TG) levels and the fatty acids composition of different tissues in mice and rabbits [4]. Thus, this experiment aimed to evaluate the potential of quercetin in manipulating the fatty acid composition of broiler meat.

II. MATERIALS AND METHODS

Birds, housing and experimental design

An experiment was conducted with 150 male broiler chicks (Cobb 500) for 42 days. Upon arrival of on-day-old chicks, they were weighed, wing-tagged and randomly assigned into 3 treatments with 10 replicates and 5 birds in each replicate. Each replicate was placed in a 70 cm × 60 cm battery cage with a wire mesh floor. Each cage was equipped with a feeder, a water cup and an individual floor waste tray to collect excreta. The dietary treatments were consisted of basal diet (control), basal diet with 100 mg/kg quercetin and basal diet with 200 mg/kg quercetin. The basal diet was corn and soybean meal-based starter (mash form; 22.5% CP and 3100 kcal of metabolizable energy (ME) /kg and finisher (mash form; 20% CP and 3200 kcal of ME/kg) diets from d 1 to 22 and from 22 d onwards, respectively. The basal diet was formulated to meet the nutritive requirements. Feed and water were provided ad libitum and the chickens were under 20 h of fluorescent lighting. At the end of experiment 10

birds randomly with the mean body weight of 2.3 kg were selected from each treatment and slaughtered. Afterwards, meat samples from the left breast muscle (*Pectoralis major*) were taken and kept at -80 ^{o}C for fatty acid analysis. All procedures involving animals were approved by the Universiti Putra Malaysia Ethics Committee.

Determination of fatty acid composition

The total fatty acids were extracted from meat based on the method of Folch *et al*. [5] modified by Rajion *et al*. [6], using chloroform: methanol 2:1 (v/v) containing butylated hydroxytoluene to prevent oxidation during sample preparation. Transmethylation of the extracted fatty acids to their fatty acid methyl esters (FAME) were carried out using KOH in methanol and 14 % methanolic boron trifluoride (BF_3) (Sigma Chemical Co. St. Louis, Missouri, USA) according to methods by AOAC [7]. The FAME were separated by gas chromatography (Agilent 7890A), using a Supelco SP 2330 capillary column of 30m x 0.25mm ID x 0.2 µm film thickness (Supelco, Inc., Bellefonte, PA, USA). The carrier gas was hydrogen at a flow rate of 1.2 ml/min. The split ratio was 1: 20 after injection of 1 µl of the FAME. The injector temperature was programmed at 250°C and the detector temperature was 300 °C. The column temperature program initiated runs at 100°C, for 2 min, warmed to 170 °C at 10 °C /min, held for 2 min, warmed to 200°C at 7.5 °C /min, and then held for 20 min to facilitate optimal separation. The peaks of samples were identified and concentrations calculated based on the retention time and peak area of known standards (Sigma Chemical Co., St. Louis, Missouri, USA). The fatty acid concentrations are expressed as g/100g of total identified fatty acids measured in each sample.

Statistical analyses

Data were analysed using the general linear models (GLM) procedure of SAS [8] in a completely randomized design (CRD) and the means were compared with Duncan's Multiple Range test.

III. RESULTS AND DISCUSSION

The composition of fatty acids (g/100g of total fat) of broiler meat is presented in Table 1. The major fatty acids of *pectoralis major* muscle in broiler were oleic (C18:1n-9, 33.0-35.2%), palmitic (C16:0, 26.1-27.9%), linoleic (C18:2n-6, 14.0-14.6%) and stearic (C18:0, 11.8–13.7%) respectively. The inclusion of quercetin in the diet affected some of the fatty acids composition. The content of palmitic, oleic and linoleic acids significantly ($p<0.05$) decreased by inclusion of 200 mg/kg quercetin in the broiler diet. The quercetin seems to decrease these fatty acids in a dose dependent manner.

Table 1. Effect of quercetin on fatty acids composition of broiler meat

Fatty acids	T1	T2	T3	SEM
C12:0	1	1.3	1.6	0.20
C14:0	1.4	1.4	1.5	0.09
C16:0	27.9^{a}	26.7^{ab}	26.1^{c}	0.35
C16:1	2.5	2.6	2.6	0.14
C17:0	2.1	2.2	2.5	0.21
C17:1	1.1	1.9	1.7	0.22
C18:0	11.8	13	13.7	0.93
C18:1n-9	35.2^{a}	33.3^{b}	33^{b}	0.83
C18:2n-6	15.1^{a}	14.1^{ab}	13.2^{b}	0.57
C18:3n-3	1.1	1.2	1.5	0.12
C20:4n-6	1.7	2.3	2.2	0.25

T1: Basal diet; T2: Basal diet + 100 mg/kg quercetin; T3: Basal diet+200 mg/kg quercetin
Means within the same row with different superscripts are significantly different ($p < 0.05$); SEM, standard error of mean

This result was in agreement with Hoek-van den Hil *et al*. [4] who reported the significant reduction in palmitic acid, oleic acid and linoleic acid in the plasma of quercetin-fed mice. Another research conducted by Gnoni *et al*. [3] using primary cells indicated significant reduction in palmitic acid concentration in rat hepatocytes treated by 25 µM of quercetin upon 30 min incubation.

Table 2 represent the data on partial sums (g/100g of total fatty acid) of intramuscular fatty acid of broiler meat fed with and without quercetion. A significant decrease ($p<0.05$) in the relative proportion of MUFA, n-6 PUFA, n-6: n-3 fatty acid ratio (FAR) were observed. This

reduction in some fatty acids was probably due to the effects of quercetion on catabolism of fatty acids. This result was in line with the result of Boer *et al*. [9] who reported that, the inclusion of 1% quercetin in the rat diet, affected the fatty acid catabolism pathway and reduced the free fatty acids in the lung tissue.

Table 2. Effect of quercetin on fatty acids composition of broiler meat

Fatty acids	T1	T2	T3	SEM
SFA[1]	44.2	44.6	45.4	1.04
MUFA[2]	38.8[a]	37.8[ab]	37.3[b]	0.51
n-3PUFA[3]	1.1	1.2	1.5	0.12
n-6PUFA[4]	16.8[a]	16.4[ab]	15.4[b]	0.41
n-6:n-3 FAR	23.7[a]	16.5[ab]	9.9[b]	1.75
Total PUFA[5]	17.3	17.5	17.5	0.63
PUFA: SFA	0.4	0.4	0.4	0.02

T1: Basal diet; T2: Basal diet + 100 mg/kg quercetin; T3: Basal diet+200 mg/kg quercetin
Means within the same row with different superscripts are significantly different ($p < 0.05$); SEM, standard error of mean.
[1]SFA= C12:0+C14:0+C16:0+C17:0+C18:0.
[2] MUFA = sum of C16:1+C17:1+C18:1n-9
[3] n-3PUFA= C18:3n-3
[4] n-6PUFA= C18:2n-6 + C20:4n-6
[5] Total PUFA= n-3PUFA+ n-6PUFA

Gnoni *et al*. [3] suggested that the quercetin was found to decrease the *de novo* fatty acid and triacylglycerol (TAG) synthesis in the rat hepatocytes. The changes induced by quercetion in the intramuscular fatty acid of broiler observed in this study showed almost the same pattern in the reduction of fatty acids and augurs well with the previous reports.

IV. CONCLUSION

In conclusion, supplementation of quercetin at 200 mg/kg of diet in broiler diet affected the lipid metabolism as indicated by changes in the fatty acid composition of *pectoralis major* muscle.

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REFERENCES

1. Alia, M., Mateos, R., Ramos, S., Lecumberri, E., Bravo, L. & Goya, L. (2006). Influence of quercetin and rutin on growth and antioxidant defense system of a human hepatoma cell line (HepG2). European Journal of Nutrition 45: 19-28.

2. Boots, A. W., Haenen, G. R. & Bast, A. (2008). Health effects of quercetin: from antioxidant to nutraceutical. European Journal of Pharmacology 585: 325-337.

3. Gnoni, G. V., Paglialonga, G. & Siculella, L. (2009). Quercetin inhibits fatty acid and triacylglycerol synthesis in rat-liver cells. European Journal of Clinical Investigation 39: 761-768.

4. Hoek-van den Hil, E. F., Keijer, J., Bunschoten, A., Vervoort, J. J. M., Stankova, B., Bekkenkamp, M., Herreman, L., Venema, D., Hollman, P. C. H., Tvrzicka, E., Rietjens, I. M. C. M. & Van Schothorst, E. M. (2013). Quercetin Induces Hepatic Lipid Omega-Oxidation and Lowers Serum Lipid Levels in Mice. PLoS ONE 8: 51588.

5. Folch, J., Lees, M. & Stanley, G. (1957). A simple method for the isolation and purification of total lipides from animal tissues. Journal of Biological Chemistry 226: 497-509.

6. Rajion, M. A., McLean, J. G. & Cahill, R. N. (1985) Essential fatty acids in the fetal and newborn lamb. Australian Journal of Biological Sciences 38(1): 33-40.
7. AOAC, (2000) Official Methods of Analysis, 17th ed. Association of Official Analytical Chemists, Washington, DC.
8. SAS. (2003). SAS, Statistical Analysis Institute (Version 9.1.3); SAS Institute Inc.: Cary, NC, USA.
9. Boer, V. C. J., Schothorst, E. M., Dihal, A. A., Woude, H., Arts, I. C. W., Rietjens, I. M. C. M., Hollman, P. C. H. & Keijer, J. (2006). Chronic quercetin exposure affects fatty acid catabolism in rat lung. Cellular and Molecular Life Sciences. 63: 2847-2858.