MUSCLE FIBER DIAMETER AND FAT TISSUE SCORE IN QUAIL (Coturnix-coturnix japonica L.) MEAT AS AFFECTED BY DIETARY TURMERIC (Curcuma longa) POWDER AND SWANGI FISH (Priacanthus tayenus) MEAL

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ABSTRACT

The objectives of this study were evaluate the dietary turmeric powder and swangi fish meal on size of muscle fiber diameter and fat tissue score of major pectorales and semimembranosus of quail meat. Research was conducted based on 2x3 of factorial completely randomized design, in which the first factor was 2 types of diet, i.e. RA : standard diet; RB : 85% standard diet + 15% swangi fish meal, and the second factor was 3 levels of period time of turmeric powder addition, i.e. P0 : without turmeric powder; P1 : turmeric powder 54 mg/quail/day was given since quail age 210 days old; P2 : turmeric powder 54 mg/quail/day was given since quail age 14 days old. Difference of means between treatment groups were analyzed by Duncan’s Multiple Range Test in 95% significance level. The results showed that combined treatment of turmeric powder with RA (P0 : 2.33 µm; P1 : 3.06 µm; P2 : 2.98 µm) and RB (P0 = 2.22 µm; P1 = 3.12 µm; P2 = 2.92 µm) increased (P<0.05) muscle fiber diameter on major pectorales significantly. Muscle fiber diameter on semimembranosus were increased (P<0.05) by combined treatment of turmeric powder with RA (P0 : 2.83 µm; P1 : 3.50 µm; P2 : 3.24 µm) and RB (P0 = 2.85 µm; P1 = 3.28 µm; P2 = 3.33 µm). In conclusion, combined treatment of RA (standard diet) and RB (diet with Swangi fish meal) increased (P<0.05) the size of muscle fiber diameter in major pectorales and semimembranosus.

Keywords : muscle fiber, fat tissue, swangi fish meal, turmeric powder
INTRODUCTION

Quail meat may contribute the fulfillment of meat production at present time although quail meat production is not as big as other poultry meat (Genchev et al., 2008). Besides having high productivity of eggs, quails can produce high nutrition meat. Quail meat can be used as an alternative choice because it contains high level protein. Birds are generally culled when their productivity has declined (Ioniţă et al., 2010).

Quail meat quality is not only determined by the protein content in the meat, but also it could be determined by meat tenderness. Consumers generally like tender meat (Dransfield et al., 1984; Genchev et al., 2008). Muscle fiber diameter and fat tissue are important factors affect the tenderness of meat (Crouse et al., 1991; Nishimura et al., 1999). The big diameter of the muscle fibers and low score of fat tissue produce tough meat, while the small diameter of muscle fibers and a high score of fat tissue produce tender meat (Chartrin et al., 2006; Seideman et al., 1987).

Some factors, such as activity and nutrition levels, may affect the size of muscle fibers diameter and fat tissue of meats (Cribb and Hayes, 2006; Migdal et al., 2004; Petersen et al., 1998). Muscles having a high activity level usually have a big muscle fibers diameter. It is due to the high activity that can increase muscle contractions which cause muscle hypertrophy and causes the enlargement of the muscle fibers diameter. High activity in muscle also causes low score of fat tissue, because fat has been depleted to support the exercise activity. Fat tissue is basically energy reserves that may be used at any time when muscle need more energy caused by high activity (Horowitz, 2003; Romijin et al., 1993; Seideman et al., 1987).

Dietary may affect the tenderness of meat. The muscle fiber diameter and fat tissue of meats may be influenced by nutrient levels, beside the exercise activity factors (Bruns et al., 2005; Migdal et al., 2004). High protein content in the diet may be a precursor to develop muscle fibers, whereas high carbohydrate and fat content in the diet could be a source of energy for muscle activity (Praseno, 2001; Baty et al., 2007).

Providing feed additive in diet may improve the quality of poultry meat, because diet could affect muscle fiber and fat tissue of meats (Stahl et al., 2005). Chemical compound in turmeric powder and swangi fish meal may play a role in quail metabolism, so that it may influenced the tenderness of quail meat.

Swangi fish meal contains essential amino acids (Kittiphatthananawon et al., 2005). Lysine and methionine that contained in swangi fish meal have an important role in endogenous synthesis of carnitine in the body. Carnitine is an essential factor in long-chain fatty acid oxidation. It acts as a carrier of fatty acyl groups from the cytoplasm to the mitochondrion. Deficiency of carnitine may reduced the ability of body to transport long-chain fatty acids into mitochondria (Feller and Rudman, 1988; Hoppel, 1982).

Turmeric powder contains 3-4% curcumin that can increase protein metabolism in the body (Chattopadhyay et al., 2004; Rahmat and Kusnadi, 2008; Raju et al., 2012). Curcumin in turmeric powder also play a role in fat metabolism. Akram et al. (2010) stated that turmeric could stimulate bile production, and increase the bodies ability to digest fats. The study on the role of turmeric powder and swangi fish meal as feed additives is important to provide information about its dose and the proper period time of turmeric powder to optimize metabolism and improve quail meat product.

This study was conducted to clarify the effect of turmeric powder and Swangi fish meal supplementation on metabolism and meat tenderness in female quail.

MATERIALS AND METHODS

Experimental Diet and Quail Management

Materials used in this study were 90 females quail (Coturnix-coturnix japonica L), turmeric (Curcuma longa), turmeric powder, swangi fish (Priacanthus tayenus) meal, standard diet, alcohol (70%, 80%, 90%, 96%, absolute), toluol, glycerin, paraffin, cananda balsam, 0.9% NaCl, aquadest, husk, drinking water, desinfectants (composition Cetylpyridium 1%, Cetyltrimethyl Ammonium Chloride Bromide and Benzalkonium Chloride 2%), anti-stress vitamin (vitamin A, D3, E, K, B1, B2, B6, B12, C, nicotic acid, calcium-D-pantohenate, electrolytes such as sodium, potassium, calcium, and magnesium), and liquid sugar. Study were cage (collective and battery), the feed box, drinking places, measuring cups, scales, surgical instruments, 25 watt bulbs, hygrometer, cage cleaning tools, microscopes, and microtomes.

Quail Acclimatization and Grouping

There were two kinds of cages used during...
the study, those were collective and battery cages. Acclimatization process for quail adaptation is done in collective cages for 2 weeks, and was continued at battery cage for 1 week. After completing the period of acclimatization, 90 quails were distributed into 30 boxes battery cage system. One box battery cage contained 3 quails. Quails were divided into 6 groups, so each treatment group consisted of 15 quails.

**Diet Types**

Two types of diets were used in this study, i.e. standard diet (RA) and high protein diet (RB). Standard diet used in this study was the commercial consisted of corn, bran, soybean, coconut, peanut, meat flour, bone flour, leaves powder, wheat, canola, vitamins, calcium, phosphorus, and minerals. High-protein diet (RB) consisted of 85% standard diet and 15% swangi fish meal. The nutrient composition of standard diet (RA) and high protein diet (RB) are presented in Table 1.

**Muscle and Fat Tissue Measurements**

Variables assessed in this study were muscle fibers diameter and fat tissue score of quail meats. Meat samples were taken from the *major pectorales* and *seminembranosus* of quail meats. In this study, the muscle tissue samples were taken about 1 cm x 1 cm. Fixation process for quail meat samples (*major pectorales* and *seminembranosus*) was done using bouin solution (a compound fixative used in histology), and then muscle histology preparat was made with paraffin method. After making histological preparation, staining process was done using Hematoxylin-eosin (HE) (Suntoro, 1983).

Observations were conducted on the histological structure of muscle tissue component (muscle fiber and fat tissue) in 5 different visual fields by using 10x10 magnification light microscopy. Muscle fiber diameter was measured by using 40x10 magnification light microscopy (Suwiti, 2008).

The other histological structures of meat and fat tissue were analyzed using quantitative analysis or by scoring. When fat tissue was not formed, the 0 point was given. When a few fatty tissues (only found a number of fat tissues in 1 visual field from histological sample was found, the 1 point was given. When it was found much fat tissues (a number of fat tissues were found in 2 different visual field or more from histological sample), the 2 point was given (Suwiti, 2008).

**Data Analysis**

Research was conducted based on 2x3 of factorial completely randomized design, in which the first factor was 2 types of diet (RA : standard diet; RB : 85% standard diet + 15% Swangi fish meal), and the second factor was 3 levels of period time of turmeric powder addition (P0 :

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>RA</th>
<th>RB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content (%)</td>
<td>11.66</td>
<td>12.18</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>22.76</td>
<td>25.19</td>
</tr>
<tr>
<td>Crude fat (%)</td>
<td>4.38</td>
<td>4.92</td>
</tr>
<tr>
<td>Crude fiber (%)</td>
<td>5.70</td>
<td>4.15</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>3.68</td>
<td>4.40</td>
</tr>
<tr>
<td>Phosphor (%)</td>
<td>0.73</td>
<td>0.82</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>6.79</td>
<td>7.05</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>54.41</td>
<td>41.29</td>
</tr>
<tr>
<td>Cholesterol (g/100g)</td>
<td>0.82</td>
<td>0.68</td>
</tr>
<tr>
<td>Energy metabolism (Kcal/kg)</td>
<td>2890</td>
<td>2920</td>
</tr>
<tr>
<td>Amino acids:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Lysine (ppm)</td>
<td>16000</td>
<td>16598</td>
</tr>
<tr>
<td>· Methionine (ppm)</td>
<td>672</td>
<td>1048</td>
</tr>
</tbody>
</table>
Table 2. Muscle Fiber Diameter (MFD) and Fat Tissue Score (FTS) of Major Pectorales and Semimembranosus at Different Treatment Turmeric Powder and Type Diets

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Type of Diets</th>
<th>Treatment Turmeric Powder</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P0</td>
<td>P1</td>
</tr>
<tr>
<td>MFD (µm)</td>
<td>a. Major Pectorales</td>
<td>RA</td>
<td>2.33±0.29&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RB</td>
<td>2.22±0.22&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>2.27±0.26</td>
</tr>
<tr>
<td></td>
<td>b. Semimembranosus</td>
<td>RA</td>
<td>2.83±0.10&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RB</td>
<td>2.85±0.21&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>2.84±0.16</td>
</tr>
<tr>
<td>FTS</td>
<td>a. Major Pectorales</td>
<td>RA</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RB</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>b. Semimembranosus</td>
<td>RA</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RB</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>1.13</td>
</tr>
</tbody>
</table>

Table 2 shows that supplementation of turmeric powder in combination with RA (standard diet) and RB (diet with Swangi fish meal) resulted in significantly increased (P<0.05) on the size of muscle fiber diameter in major pectorales and semimembranosus of quail meats. In the layer phase, quails require 20% of feed protein. Feeds that are not completely digested by the bodies are passed through the gastrointestinal tract and excreted into the litter. The result was lost of nutrient (Hassan et al., 2011; NRC, 1994).

RESULTS AND DISCUSSION

Muscle Fiber Diameter

Standard diet (RA) and diet with swangi fish meal (RB) without turmeric powder did not show significant effect on the size of muscle fiber diameter of major pectorales (RAP0 : 2.33 µm; RBPO : 2.22 µm) and semimembranosus (RAP0 : 2.83 µm; RBPO : 2.85 µm) (Table 2). Crude protein content of two diet (RA : 22.76%, RB : 25.19%) did not affect size of diameter muscular fiber of major pectorales and semimembranosus of quail meats. Without the addition of Turmeric powder, the muscle fiber diameter of major pectorales and semimembranosus was significantly increased (P<0.05) since the quails were 60 days old (Table 2). The collected data were analyzed by analysis of variance. Duncan’s Multiple Range Test was performed for mean comparison with 95% significance levels.

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(tripsin, chymotrypsin) that increases protein metabolism. It also increases mucin secretion, acting as gastro-protectant against irritants, and has some good effects on the intestine (Chattopadhyay et al., 2004; Platel and Srinivasan, 2000; Rathaur et al., 2012).

Increasing protein metabolism in the body is not only increase protein deposition, but also increase deposition of myofibril. The more number of myofibril resulted in the larger the size of muscle fiber diameter. Myofibril protein is a major part in the meat tissue that has functioned in muscle contraction. It consists of myosin (60-70% of total protein myofibrils), actin (20-25% of total protein myofibrils), and regulatory proteins (tropomyosin, troponin). Increasing a number of myofibrils enlarge (hypertrophy) muscle fiber diameter. Several factors, such as activity, growth, and nutrition, can influence the size of muscle fiber diameter (Cribb and Hayes, 2006; Gunawan, 2011).

Figure 1. The Interaction between Diet Quail with Turmeric Powder on Muscle Fiber Diameter of Major Pectorales (A) and Semimembranosus (B). The symbols represent RA : standard diet ( ); RB : 85% standard diet + 15% swangi fish meal (¾). P0 : not given turmeric powder; P1 : turmeric powder 54 mg / quail / day was given when quail age 210 days old; P2 : turmeric powder 54 mg / quail / day was given when quail age 14 days old.
The size of muscle fiber diameter between *semimembranosus* and *major pectorales* muscle fibers are shown in Table 2. Diameter size of *semimembranosus* muscle fibers was larger than those of *major pectorales* muscle fibers because *semimembranosus* muscle is more active than *major pectorales* muscle. Baar and Esser (1999) stated that high resistance exercise training was correlated well with hypertrophy. Training rats twice a week for 6 weeks resulted in 13.9% and 14.4% hypertrophy in the extensor digitorum longus and tibialis anterior muscles, respectively. Rennie and Tipton (2000) stated that muscle hypertrophy resulted from exercise activity is caused by an increase in muscle protein synthesis in the resting and recovering of muscle. Suwiti (2008) stated that muscle fiber diameter will undergo physiological atrophy and reduction in the size of muscle fiber diameter if it is never used.

Large size from the muscle fiber diameter of *semimembranosus* in this study demonstrated that curcumin (a compound from turmeric powder) and exercise activity are even more potent to build muscle and protecting against muscle atrophy, and it made *semimembranosus* tougher than *major pectorales*. Chen *et al.* (2007) reported a positive relationship between muscle fiber diameter and meat tenderness. Chen (2011) also found highly correlated between muscle fiber diameter and shear force (tenderness) (r : 0.833). Seideman *et al.* (1987) stated that the increasing number of myofibrils per unit area which caused larger muscle fibers tougher than small muscle fibers.

**Fat Tissue**

Fat tissue (intramuscular fat) of quail meat is presented in Table 2, and they were found in a few amounts. Nishimura *et al.* (1999) stated that intramuscular fat was deposited mainly between bundles of muscle fibers, within the perimysium (Figure 2).

Table 2 shows that the different period times of turmeric powder addition in the diet of quail did not significantly affect the fat tissue of *major pectorales* muscle (P0 : 1.38; P1 : 1.13; P2 : 0.88) and *semimembranosus* (P0 : 1.13; P1 : 0.63; P2 : 0.50) in quail meat. Turmeric powder 54 mg/quail/day that was added in the diet of quail was not effectively reduce fat metabolism. Good nutrition may increase intramuscular fat. In the layer phase, quails need more energy consumption. Hight level of energy consumption will be followed by a high fat deposition although curcumin could be expected to reduce fat content (Akram *et al.*, 2010; Souza *et al.*, 2003; Widodo, 2002).

Table 2 showed that there was not significant effect between standard diet and diet which were added swangi fish meal in the fat tissue of *major pectorales* (RA : 1.25; RB : 1.00) and *semimembranosus* (RA : 0.83; RB : 0.67) of quail.
meats. Energy metabolism and fat contained in the two levels of quail diet (Table 1) were not much different, the fat tissue of quail meat (major pectorales and semimembranosus) were not significantly different. Trayhurn and Beattie (2001) stated that the fat tissue stores increase in periods of positive energy balance and declines when energy expenditure is higher than that of intake.

The average score of fat tissue in semimembranosus was lower than those of major pectorales (Table 2), because semimembranosus muscle was more active than major pectorales. More activities from semimembranosus muscle make it having a few number of fat tissues. Solichedi et al. (2003) stated that lipid content in femoral muscle is lower than those in pectoral muscle because femoral muscle is more active than pectoral muscle. 

Horowitz (2003) stated that exercise activity could improve the coordination on fatty acid mobilization, uptake and oxidation, and therefore reduce the potential for lipid accumulation in muscle.

Low score from the fat tissue of semimembranosus muscle in this study demonstrated that exercise activity is even more potent to decrease the deposited fat in muscle, and it caused semimembranosus tougher than major pectorales. DeVol et al. (1988) reported a positive relationship between fat content and meat tenderness \( r = 0.32 \). Chartrin et al. (2006) also reported a positive relationship between fat content and meat tenderness \( r = 0.43 \). Nishimura et al., 1999) stated that a large amount of deposited fat in muscle can contribute to tenderization of meat by disorganizing the structure of intramuscular connective tissue. It bring about aawakening of the intramuscular connective tissue, and contributing to tenderization of meat.

**CONCLUSIONS**

Turmeric powder supplementation which combined with RA (standard diet) and RB (diet with Swangi fish meal) increased the size of muscle fiber diameter in major pectorales and semimembranosus.

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