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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ABSTRAK

Tujuan penelitian ini adalah untuk mengevaluasi pengaruh penggunaan tepung kunyit dan ikan swangi terhadap ukuran diameter serat otot dan jaringan lemak *major pectorales* dan *semimembranosus* pada daging puyuh. Penelitian menggunakan rancangan acak lengkap pola faktorial 2x3, yaitu faktor pertama adalah jenis ransum terdiri RA : ransum standar dan RB : 85% ransum standar + 15% tepung ikan swangi, dan faktor kedua adalah periode pemberian tepung kunyit terdiri dari 3 level yaitu P0 : tanpa diberi tepung kunyit; P1 : diberi tepung kunyit 54 mg/ekor/hari sejak berumur 210 hari; P2 : diberi tepung kunyit 54 mg/ekor/hari sejak berumur 14 hari. Perbedaan bermakna antar kelompok perlakuan dianalisis menggunakan uji Duncan's Multile Range Test pada taraf signifikasi 95%. Hasil penelitian menunjukkan bahwa combinasi perlakuan tepung kunyit dengan RA (P0 : 2,33 µm; P1 : 3,06 µm; P2 : 2,98 µm) maupun dengan RB (P0 : 2,22 µm; P1 : 3,12 µm; P2 : 2,92 µm) meningkatkan secara nyata ($P<0.05$) diameter serat otot pada *major pectorales.* Kombinasi tepung kunyit dengan RA dan dengan RB juga meningkatkan secara nyata ($P<0.05$) diameter serat otot pada *semimembranosus.* Kesimpulan penelitian ini adalah suplementasi tepung kunyit pada ransum RA dan RB meningkatkan secara nyata ($P<0.05$) ukuran dari diameter serat otot pada *major pectorales* dan *semimembranosus.*

Kata Kunci : serat otot, jaringan lemak, tepung ikan swangi, tepung kunyit

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 tumeric 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 tumeric 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). Beside 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 have declined (Ioniță *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 (Kittiphattanabawon *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. Defeciency of carnitin 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 tumeric 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, canada 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 priod of accimatization, 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 *semimembranosus* 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 *semimembranosus*) 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 1. Nutrient Composition of Standard Diet (RA) and High Protein Diet (RB)

Nutrien	RA	RB
Water content (%)	11.66	12.18
Crude protein (%)	22.76	25.19
Crude fat (%)	4.38	4.92
Crude fiber (%)	5.70	4.15
Calcium (%)	3.68	4.40
Phosphor (%)	0.73	0.82
Ash (%)	6.79	7.05
Carbohydrate (%)	54.41	41.29
Cholesterol (g/100g)	0.82	0.68
Energy metabolism (Kcal/kg)	2890	2920
Amino acids:		
· Lysine (ppm)	16000	16598
· Methionine (ppm)	672	1048

Table 2. Muscle Fiber Diameter (MFD) and Fat Tissue Score (FTS) of *Major Pectorales* and *Semimembranosus* at Different Treatment Turmeric Powder and Type Diets

Parameters	Type of Diets	Treatment Turmeric Powder			Average
		P0	P1	P2	
MFD (μm)					
a. *Major Pectorales*	RA	2.33±0.29[a]	3.06±0.28[b]	2.98± 0.08[b]	2.79±0.22
	RB	2.22±0.22[a]	3.12±0.36[b]	2.92± 0.13[b]	2.75±0.24
Average		2.27±0.26	3.09±0.32	2.95± 0.11	
b. *Semimembranosus*	RA	2.83±0.10[a]	3.50±0.12[b]	3.24± 0.35[b]	3.19±0.29
	RB	2.85±0.21[a]	3.28±0.23[b]	3.33± 0.46[b]	3.15±0.30
Average		2.84±0.16	3.39±0.18	3.28± 0.41	
FTS					
a. *Major Pectorales*	RA	1.50	1.00	1.25	1.25
	RB	1.25	1.25	0.50	1.00
Average		1.38	1.13	0.88	
b. *Semimembranosus*	RA	1.25	0.75	0.50	0.83
	RB	1.00	0.50	0.50	0.67
Average		1.13	0.63	0.50	

a, b :The different superscripts at the same row indicate significant different (P<0.05). No differ between the same column. RA : standard diet; RB : 85% standard diet + 15% swangi fish meal. 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.

without turmeric powder; P1 : turmeric powder 54 mg/quail/day was given since quail age was 210 days old; P2 : turmeric powder 54 mg/quail/day was given since quail age was 14 days old).

The collected data were analyzed by analysis of variance. Duncan's Multiple Range Test was performed for mean comparison with 95% significance levels.

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 ; RBP0 : 2.22 μm) and *semimembranosus* (RAP0 : 2.83 μm; RBP0 : 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. 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).

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*. This phenomenon is caused by absorption and protein metabolism in the gastrointestinal tract and liver of bodies which could be enhanced by supplementing turmeric powder. Curcumin (a compound from turmeric powder) protects hepatocytes cell activity (hepatoprotective) and increases the secretion of pancreatic enzymes

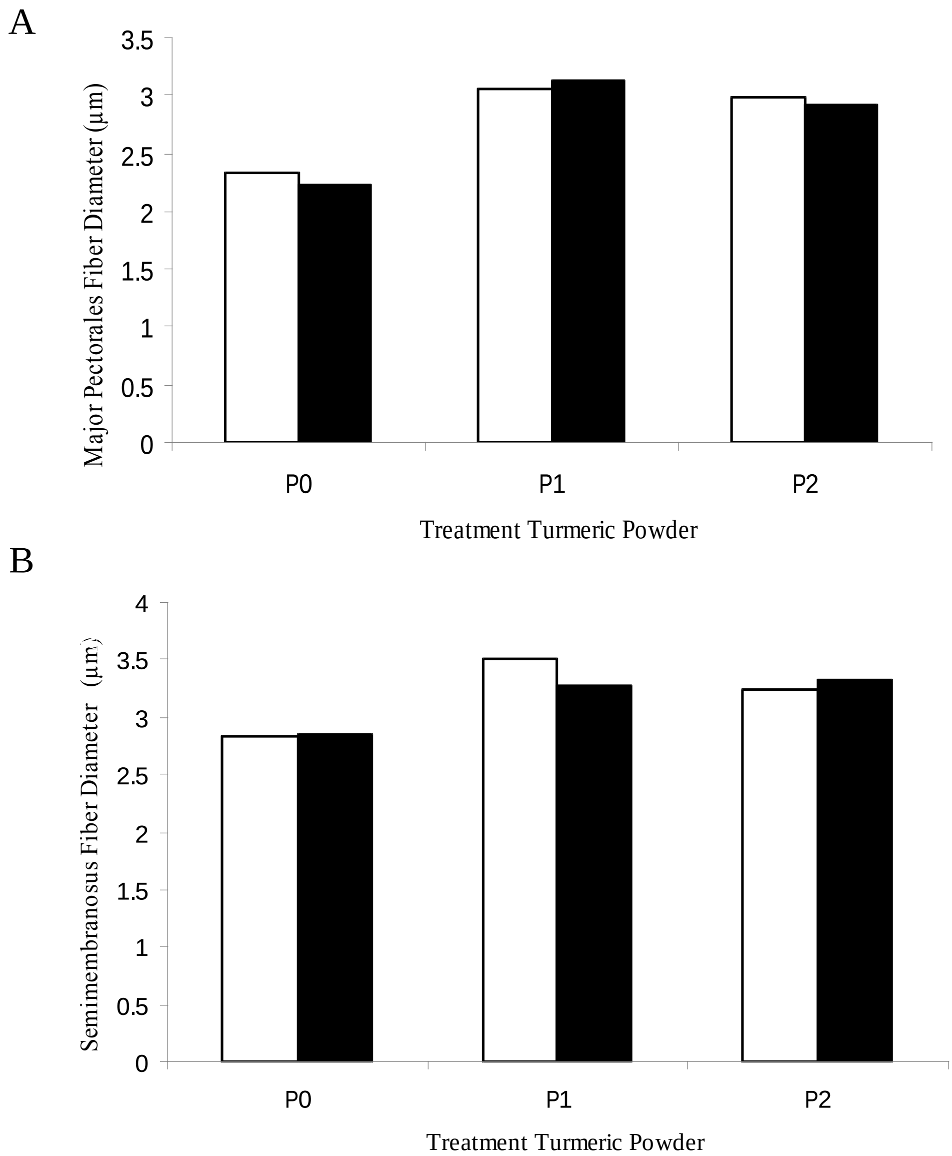

Figure 1. The Interaction between Diet Quail with Turmeric Powder on Muscle Fiber Diameter of *Major Pectorales* (A) and *Semimembranosus* (B). The symbols represent RA : standard diet (□); RB : 85% standard diet + 15% swangi fish meal (¾). P0 : not given turmeric powder; P1 : turmeric powder 54 mg / 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.

(tripsin, chymotrypsin) that increases protein metabolism. It also increase 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,

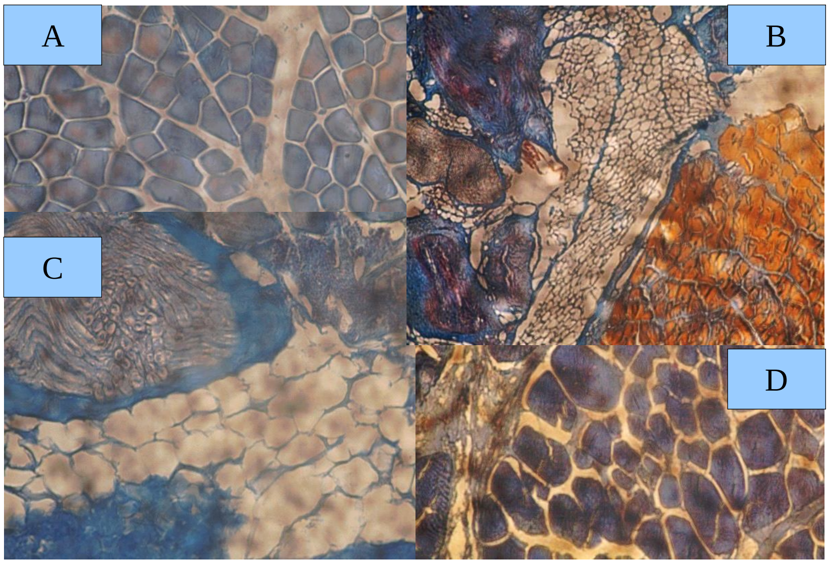

Figure 2. Histological Structure of Quail Meat : A. Cross-Section Muscular Fiber (HE:10x10); B. Fat Tissue (HE:4x10); C. Blood Vessel (HE : 10X10); D. Connective Tissue (HE:10x10).

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2001; Loenneke, 2012; Schoenfeld, 2010).

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 aweakening of the intramuscular connective tissue, and contributing to tenderization of meat.

CONCLUCIONS

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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