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Improving Performance, Meat Quality and Muscle Fiber Microstructure of Native Indonesian Muscovy Duck Through Feed Protein and Metabolizable Energy

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Abstract: Tenderness is determined by the growth and size of muscle fibers, which can be arranged through the feed. The current study was designed to investigate protein and metabolic energy level on performance including meat quality and muscle fiber size of male muscovy ducks. Five protein levels and metabolic energy of feed treatments (13% and 2300 kcal/kg, 15% and 2500 kcal/kg, 17% and 2700 kcal/kg, 19% and 2900 kcal/kg, 21% and 3100 kcal/kg) and 100 male duck of muscovy ducks were administered in this research. Protein and metabolic energy level significantly affected ($p < 0.01$) carcass weight, feed conversion ratio, abdominal fat percentage, physical meat quality and muscle fiber diameter. Feed with 21% protein and 3100 kcal/kg metabolic energy resulted in good performance (1342.60±2243.62 carcass weight, 4.00±0.64 feed conversion and 68.86±5.59% carcass percentage), physical meat quality and large muscle fiber diameter of 50.59 μm , but comparatively high abdominal fat level of 5.60±0.71.

Key words: Muscovy duck, muscle fiber, tenderness

INTRODUCTION

Muscovy duck is a fast growing and suitable meat fowl source. Although very common as meat duck, Muscovy lay 100-125 eggs annually and is less preferable meat due partly to its smelly, tough and dark meat. Native Indonesian Muscovy are mostly found in Java in traditional system, so they are yet showing maximum performance and meat quality (CIVAS and FAO, 2006). In France, Muscovy ducks are under intensive system and have contributed 45% of duck meat supply (Zanusso *et al.*, 2003). However, there has not been a fixed feeding guideline for Muscovy sustainability especially the need of protein and metabolic energy. According to Bintang (2000), feed containing 12.47% protein and 2515 kcal/kg ME was sufficient to meet Muscovy primary needs because 10-week-old Muscovy weighs only 849 g with 8.06 feed conversion ratio and at the 12-week-old weighs 995 g with 8.50 feed conversion ratio. From Muscovy fed with 12% protein and 2619 kcal/kg ME diet was gained 64.78 and 61.43% carcass in male and female, respectively, while 15% protein and 2608 kcal/kg ME diet produced 65.48% and 61.65% carcass in male and female, respectively (Bintang, 2001).

Magdalena *et al.* (2010) stated that protein and metabolic energy ratio influenced growth, abdominal fat, body fat, muscle fiber diameter and eventually meat tenderness of broiler. Baeza *et al.* (2000) and (2002) showed lipid content of muscle could also be manipulated by feeding levels, with feed restriction often decreasing intramuscular fat content and overfeeding

inducing an increase. Increase in lipid content of breast muscle of mule and Muscovy ducks is between 6-8 and 12-13 weeks of age. Baeza *et al.* (2002) stated that at 12 weeks old, breast meat of selected Muscovy duck weighed differently from that of control as much as 39%. Age is the main influence of muscle development. This was supported by Chartrin *et al.* (2005) that 14 weeks old Muscovy duck had muscle weight 89% heavier than that of Pekin duck observed in breadth and length of muscle fiber. Muscle fiber length can reach 12 cm with 10-150 μm diameter. Muscle fiber diameter is determined by some factors like species, state of nutrition, age, sex and activity (Subowo, 2002; Purba, 2010). White muscle fiber or αW in male and female Muscovy duck is 28.1 μm and 27.4 μm , respectively and red fiber or αR is 15.1 and 14.2 μm , respectively (Bernacki *et al.*, 2008). This condition calls for protein and metabolic energy level to obtain high performance and meat quality of Muscovy duck both in physics and microstructure.

MATERIALS AND METHODS

This research was conducted in Experimental farm of Animal Science Faculty Jenderal Soedirman University, Laboratory of Pathology Faculty of Animal Medicine GadjahMada University and Biology Research Centre LIPI Indonesia. Research treatments were protein content and energy feeds in which feed in R1 contained 13% protein and 2300 kcal/kg ME, R2 contained 15% protein and 2500 kcal/kg ME, R3 contained 17% protein and ME 2700 kcal/kg, R4 contained 19% protein and

2900 kcal/kg ME and R5 contained 21% protein and 3100 kcal/kg ME. Each treatment consisted of four heads which was repeated five times. A total of 100 male day old Muscovy ducks were randomly distributed to 25-compartment cage applying Completely Randomized Design. Muscovy ducks were kept in cement floored cage at ambient temperature 33°C in prior period then decreased each week up to 28°C at the eighth week. Feed and water were given *ad libitum*. Treatment feeds were referred to National Research Council (1994) as shown in Table 1. The observed performances were final weight, feed conversion ratio, carcass percentage, abdominal fat level and physical meat quality, while muscle fiber observed was muscle fiber size.

RESULTS AND DISCUSSION

Muscovy duck performance

Carcass weight: The highest carcass weight of 9-week-old Muscovy ducks was 342.60±224.62 g in R5. It was still inferior to that by Omojola (2007) and Solomon *et al.* (2006) producing 2000 and 2470 g Muscovy ducks. Protein and metabolic energy level significantly affected ($p<0.01$) carcass weight. Table 2 shows that the higher protein and metabolic energy level, the higher carcass weight gained, while feed with low protein and metabolic energy level was not sufficient for early growth phase of Muscovy ducks. Brahmaniyo *et al.* (2003) reported that male Muscovy ducks grow fast until 9 weeks old and need feed with high balanced protein and energy. Fan *et al.* (2008) stated that meat duck was highly responsive to high metabolic energy feed. On the contrary, Iskandar *et al.* (2001) showed that treatment feed with 2750 kcal ME/kg and 180 g/kg protein produced carcass weight not significantly different from that of 3000 kcal ME/kg and 200 g/kg protein and 3250 kcal ME/kg and 220 g/kg protein. Atmomarsono (1999), Tanwiriah (2006), Miclosanu and Roibu (2001) and Bintang (2000) reported that higher protein level would speed up Muscovy's feather growth, leading to faster adaptability and eventually higher weight gain.

Feed conversion: Feed conversion average of 9-week-old Muscovy fed with different level of protein and metabolic energy diet ranged from 4.00±0.64 to 5.26±0.38, (Table 2). Feed conversion in this research was higher than that of Bhuiyan *et al.* (2005), Tanwiriah *et al.* (2011) and Huang *et al.* (2012), reporting male Muscovy feed conversion was 2.64, from 2.53-4.43 and 3.09. Protein and metabolic energy treatment significantly affected ($p<0.01$) feed conversion which is strongly related to feed consumption and body weight gain and it could be used to measure feed efficiency and fowl productivity (Lacy and Vest, 2004). R1 was not different from R2 because of relatively similar feed consumption (5108.16 and 5128 g) and relatively similar body weight gain (919.8 and 1062.6 g) in

Table 1: Materials and Compositions of Treatment Feed

	R1	R2	R3	R4	R5
Percentage					
Corn	0.00	30.00	30.00	30.00	30.00
SBM	0.00	7.00	7.00	7.00	7.00
Rice bran	98.30	58.60	53.70	46.00	38.20
PMM	0.00	2.70	7.10	12.00	17.00
Oil	0.00	0.00	0.50	3.30	6.10
L-lysine HCl	0.10	0.10	0.10	0.10	0.10
DL-Methionine	0.30	0.30	0.30	0.30	0.30
Topmix	0.20	0.20	0.20	0.20	0.20
NaCl	0.10	0.10	0.10	0.10	0.10
CaCO ₃	1.00	1.00	1.00	1.00	1.00
Amount	100.00	100.00	100.00	100.00	100.00
Protein (%)	13.00	15.00	17.00	19.00	21.00
ME (kcal/kg)	2300.00	2500.00	2700.00	2900.00	3100.00
Fat (%)	4.92	4.48	4.80	5.06	5.32
Crude fiber (%)	11.21	7.87	7.38	6.57	5.76
Ca (%)	0.77	0.83	0.86	0.88	0.94
P _{av} (%)	0.56	0.40	0.48	0.39	0.56
Lysine (%)	0.76	0.90	0.96	1.00	1.11
Methionine (%)	0.53	0.55	0.58	0.61	0.64

Muscovy for nine weeks, respectively. Feed consumption in R4 was however relatively high, scoring 5271 g but with only 1088 g body weight gain. R3 and R5 showed relatively similar body weight gain (1139 and 1288 g), respectively and feed consumption of 5205 and 5256 g, respectively. Factors influencing feed consumption are environment, age, sex and nutrient content. This was in accordance with Iskandar *et al.* (2001) that ducks fed with 2750 kcal/kg ME and 18% crude protein diet showed higher feed consumption than those with 3000 kcal/kg and 20% protein diet, scoring 96,61 g and 85.84 g, respectively; however, feed efficiency was relatively similar. Fan *et al.* (2008) stated that for 2 to 6 week old ducks to gain weight required 18% protein and 3008-3030 kcal/kg ME diet.

Carcass percentage: The average carcass percentage in this research was 63.04±5.64 to 68.86±5.59 (Table 2). According to Bhuiyan *et al.* (2005) 9-week-old Muscovy duck had 68.10 carcass percentage, while Kleczek (2006) stated that carcass percentage of male and female Muscovy was 74.65-76.54 and 75.35-75.85, respectively. Protein and metabolic energy level did not significantly affect ($p>0.05$) carcass percentage because protein and metabolic energy affect not only body weight gain but also other non-carcass organs. This is in line with Soeparno (2005) and Yadnya (2004) that carcass weight and carcass percentage are significantly affected by slaughter weight and non-carcass weight (weight of blood, feather, leg and innards). Raji *et al.* (2009) also stated that there was highly significant positive correlation ($p<0.01$) between body weight and body measurements and innards. Suparyanto (2006) and Sklan *et al.* (2003) stated that high slaughter weight did not always result in high carcass weight and carcass percentage because higher living body weight required bigger organs to have well-balanced metabolism.

Table 2: Carcass weight, Feed Conversion Ratio, Carcass Percentage and abdominal fat percentage of 9-week-old Muscovy ducks consuming feed with different levels of protein and metabolic energy

Treatment ¹	Carcass weight g ²	Feed conversion ³	Carcass (%)	Abdominal fat (%) ²
R1	976.00±69.39 ^a	5.26±0.38 ^a	63.04±5.64	1.29±1.35 ^a
R2	1119.60±76.98 ^a	4.60±0.33 ^{ab}	63.77±7.30	4.24±0.78 ^{bc}
R3	1192.00±62.59 ^b	4.38±0.23 ^b	65.10±4.43	2.84±0.53 ^c
R4	1140.60±57.20 ^{ab}	4.63±0.24 ^{ab}	63.95±1.90	4.73±0.34 ^b
R5	1342.60±224.62 ^b	4.00±0.64 ^b	68.86±5.59	5.60±0.71 ^b

Table 3: pH level, water holding capacity (WHC), cooking loss and meat tenderness of 9-week-old Muscovy duck fed with different protein and metabolic energy level diets

Treatment ¹	pH ² (%)	WHC ²	Cooking Loss (%)	Tenderness (kg/cm ²)
R1	6.07±0.07 ^a	35.51±2.85 ^a	40.14±0.96 ^b	5.88±0.06 ^a
R2	5.89±0.04 ^b	37.00±1.83 ^a	38.88±1.029 ^b	5.60±0.28 ^{ab}
R3	5.95±0.09 ^{bc}	38.67±2.05 ^b	38.06±1.58 ^b	5.63±0.21 ^{ab}
R4	5.80±0.06 ^{bd}	39.72±4.82 ^b	32.96±1.37 ^a	5.71±0.45 ^a
R5	5.87±0.04 ^b	42.33±2.43 ^b	31.38±0.95 ^a	5.20±0.14 ^{bc}

Table 4: Muscle fiber diameter (µm) of 9-week-old Muscovy duck fed with different protein and metabolic energy level diet using scanning electron microscope (SEM)

Treatment	Repeat				Average	Sd
	1	2	3	4		
R1	11.367	14.016	11.115	13.155	12.41	1.69
R2	17.228	12.039	14.208	12.633	14.03	3.75
R3	17.514	16.638	17.205	13.824	16.30	1.40
R4	31.551	35.098	33.183	26.365	31.55	2.32
R5	57.594	56.550	43.153	45.067	50.59	7.54

Abdominal fat percentage: Yuniza (2002) stated that abdominal fat, one of body fats inside abdominal cavity, will increase due to sufficient feed and ageing. Miclosanu and Roibu (2001) reported that at the 56th day, Muscovy ducks fed with medium metabolic energy diet (2750 kcal/kg) and high metabolic energy diet (3050 kcal/kg) had 0.81±0.45 and 0.94±0.27 abdominal fat percentage, respectively, which in this research was 1.29±1.35-5.60±0.71 (Table 2). Protein and metabolic energy significantly affected ($p < 0.01$) abdominal fat percentage. Energy consumption of R4 and R5 was higher than that of R1, R2 and R3. Soeparno (2005) stated that the energy excess would be stored as body fat and abdominal fat. Fan *et al.* (2008) supported that consuming high energy feed did not significantly affect carcass but significantly increased abdominal fat in which feed energy lower than 2700 kcal/kg could not induce abdominal fat. Kleczek *et al.* (2006) stated that positive correlation existed between body weight and fat in Muscovy ($r = 0.373$ to 0.59).

Meat physical quality

pH: The average of meat pH in this research was above isoelectronic point (5.01-5.01), thus 5.80±0.06-6.03±0.13 (Table 3), relatively similar to that of Wawro *et al.* (2004) that meat pH of male Muscovy was 5.8±0.07. It is in accordance with Dransfield and Sosnicki (1999) that after cattle died, anaerobic metabolism would lower pH from 7.2 (muscle) to 5.8 (meat) along with rigor mortis, while Alvarado and Sams (2000) reported that

duck meat pH was higher, ranging from 6,0 to 6,59. Feed protein and metabolic energy significantly affected ($p < 0.01$) meat pH of 9-week-old Muscovy ducks because Muscovy fed with high protein and metabolic energy diet were assumed to have highly glycolytic meat; accordingly glycolysis occurred faster and pH obtained was lower. In line with Setiawan (2010) that even small amount of protein-carbohydrate bond could affect insulin hormone level and eventually glycogen synthesis. Table 3 shows protein and metabolic energy level increase causes meat pH decrease. pH change depends on glycogen supply in muscle, the higher muscle glycogen the more lactic acid so final pH value was lower. In contrast, ducks fed with low protein and metabolic energy diet had lower muscle glycogen and slower postmortem glycolysis so final pH value was higher as reported by Soeparno (2005) and Nurwantoro and Mulyani (2003).

Water holding capacity (WHC): Water holding capacity is the ability of meat protein to bound water inside meat, therefore water holding capacity describes damage level of meat protein. WHC average in this research was 35.51±2.85-42.33±2.43 (%). Protein and metabolic energy significantly affected ($p < 0.01$) water holding capacity of 9-week-old Muscovy. Muscovy WHC value increased along with the consumed protein and metabolic energy diet because the higher meat protein level the higher water holding capacity. Abustam's (2005) reported that WHC was also affected by pH, in

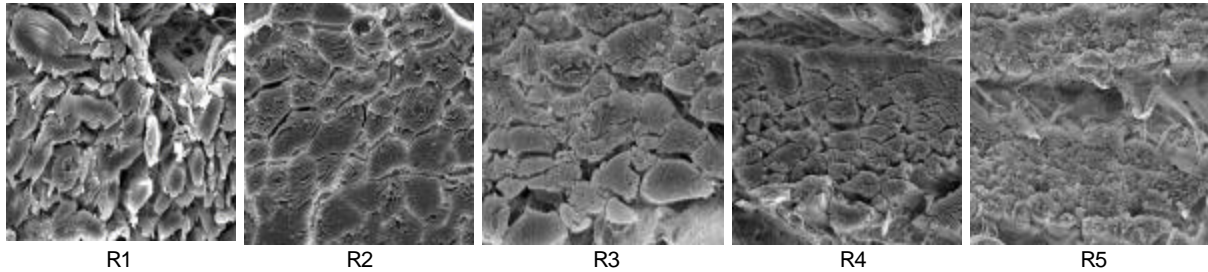


Fig. 1: Muscle fiber of 9 week old Muscovys breast meat fed with different protein and metabolic energy analyzed using SEM

which electrons were released in pH lower than meat isoelectric point, causing proton excess met with resistance from myofilament and gave more rooms for water molecules in meat; accordingly, meat WHC increased. Lawrie (2006) stated that almost all water content in meat is stored in myofibril and room between thick filament and thin filament. Interfilament mostly determines WHC of myofibril protein. The higher final pH value, the lower water holding capacity is. Faster pH decrease will increase actomyosin to contract because more denatured sarcoplasmic protein would extract the juice from meat protein.

Cooking loss: Muscovy fed with different protein and metabolic energy level had meat cooking loss ranging from 31.38 ± 0.95 to $40.14 \pm 0.96\%$ (Table 3). It was relatively similar to that of Alvarado and Sams (2000) scoring 31.26 to 37.97% and of Ali *et al.* (2007) namely $34.48 \pm 1.48\%$. Protein and metabolic energy level significantly affected ($p < 0.01$) cooking loss of 9-week-old Muscovy ducks. Widaningsih (2011) and Soeparno (2005) stated that meat composition was affected by feed nutrient content particularly protein and energy. Increase in feed protein and energy would increase meat protein and fat, so that less meat juice was lost when cooking and cooking loss was closely related to pH and water holding capacity.

Tenderness: Muscovy meat tenderness was between 5.20 ± 0.14 and 5.88 ± 0.06 kg/cm² (Table 3). While Omojola (2007) reported lower meat tenderness on male Muscovy of 3.28 ± 0.27 kg/cm² and Baeza reported 4.56 ± 0.48 - 5.14 ± 0.45 kg/cm². The higher protein and metabolic energy level, the more tender the meat produced because Muscovy ducks undergo normal growth and maximum muscle cells growth is followed by fat cells growth, making meat of Muscovy R4 and R5 fattier. This is in line with Tambunan (2009) that factors influencing meat tenderness is correlated with meat composition itself, among which are fat cells in between meat fiber and collagen. According to Soeparno (2005), tenderness was also affected by meat collagen because collagen could accumulate greatly. Chartrin *et al.* (2003)

stated that fat content in Muscovy meat was 2.26-7, 57% and Larzul *et al.* (2002) showed high collagen in Muscovy breast meat of 4.82 mg/g meat. Collagen in breast meat of Muscovy R1, R2, R3, R4 and R5 was 2.36, 1.98, 1.53, 2.16 and 1.28 mg/g meat, respectively. On the other hand, Larzul *et al.* (2002) reported high collagen in Muscovy breast muscle of 4.30-4.82 mg/g muscle, while Matitaputty and Suryana (2010) showed 1.75 mg/g muscle collagen in Pekin duck and 1.27 mg/g muscle in broiler.

Muscle fiber: The average of muscle fiber diameter in Muscovy ranged from 12.41 ± 1.69 to 50.59 ± 7.54 μ m as shown in Table 4. Research by Sudjatinah (1998) showed diameter of 28.00 to 32.16 μ m, while Sari (2003) reported Mule duck/Mandalung (Muscovy and Anas crossbred) had 13.47 ± 3.26 muscle fiber diameter at 8 week old, 15.24 ± 2.99 at 10 week old and 18.08 ± 5.01 μ m at 12 week old. Protein and metabolic energy level significantly affected ($p < 0.01$) muscle fiber diameter which is the result of hypertrophy process. Soeparno (2005) reported that prenatal muscle growth was marked as muscle fiber hyperplasia period and postnatal muscle growth was particularly due to hypertrophy. Mozdziak *et al.* (2002) and Rehfeldt *et al.* (2004) mentioned that muscle fiber diameter of fasting fowls was smaller than those of feed sufficiency. Feed intake limitation either quantitatively or qualitatively would lower muscle fiber diameter. Choi and Kim (2008) stated that muscle fiber diameter depended on some factors as species, sex and nutrition. According to Kisiel and Ksiazkiewicz (2004) and Biesiada-Drzazga *et al.* (2000) slow growing duck or dwarf duck has small muscle fiber diameter but fast growing duck or big bodied duck has large fiber diameter. Muscle fiber diameter is related to tender or tough meat, muscle fiber size in cross sectional area will increase along with ageing, large muscle fiber diameter appears rougher and more elastic than small diameter (Dransfield and Sosnicki, 1999).

Conclusion: Feed containing 21% protein and 3100 kcal/kg metabolic energy resulted in optimum performance (carcass weight, feed conversion ratio and

carcass percentage) and meat quality and high fat abdominal and large muscle fiber diameter. Meat pH was however relatively similar to that of Muscovy ducks fed with lower protein and energy metabolic diet.

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