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PERFORMANCE OF THE PHYSICAL MEAT QUALITY ON YOUNG AND MATURE ONGOLE CROSS ACCORDING TO THE KINDS OF MUSCLES

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Abstract

The experiment was conducted to study the effects of kinds of muscles and the age of bull on the performance of physical and nutritional meat quality of male Ongole Cross. The meat samples were *Longissimus dorsi* (LD; short loin meat), *Biceps femoris* (BF; silverside meat), *Triceps brachii* (TB; chuck meat) and *Pectoralis profundus* (PP; brisket point end meat), prepared from the right side carcass of young and mature bull, 5 slices each, based on AMLC method (1993) in Kodya Yogyakarta Abattoir. The meat physical qualities (meat colour, tenderness and collagen contents) and nutritional Quality (protein, fat and cholesterol contents) were analysed at the laboratory of Faculty of Animal Husbandry, Gadjah Mada University. The collected data were analysed using Randomised Completely Design and followed by testing the significant means using Multiple Range Duncan Test. The results indicated that the kinds of muscles had significant effect ($P<0.05$) on tenderness, collagen, protein and cholesterol contents but had no significant effect ($P<0.05$) on colour, fat and cholesterol contents of the meat with TB and LD muscles. Protein contents of meat with BF and PP were significant ($P<0.05$) so do the collagen contents of meat with TB and LD muscles. Tenderness, cholesterol and collagen content on LD muscles were lower than those of BF and TB muscles. Fat content of meat with LD, BF, TB and PP muscles were significant. The meat colour of BF and TB muscles were darker than that of PP and LD. In conclusion, the meat of LD muscle was more tender and attractive than the other muscles. The LD muscle was relatively better than BF, TB and PP muscles. The collagen content of each muscle was: LD 0.74 %, PP 1.07 %, BF 1.2 % and TB 1.37 %. The cholesterol contents of: LD (55.77 mg/100 gram), BF (59.49 mg/100gram), PP (60.12 mg/100gram) and TB (62.05 mg/gram).

Key words: Muscles, Meat, Kinds of muscles, The physical meat quality, The nutritional meat quality

Introduction

The increasing income of the community improves their purchasing power on food consumption, including those derived from animal products. The condition automatically increases the demand of the meat-based protein and provides vast

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opportunities to the provisions of meat, including beef. Among many Indonesian local species, Ongole Cross is one of the most important sources of the Indonesia's meat supply. Most Ongole Cross are raised traditionally by farmers in villages. The meat of Ongole Cross has relatively good palatability, so that it is considered as very favourable for most consumers who always require pure, safe, and healthy, as well as religiously acceptable (for moslem consumers). The Ongole Cross raised traditionally produces high quality meat that is acceptable and utilizable by many people (Soeparno, 1990). The acceptability and utility of meat is determined by the performances of its physical quality, consisting variables such as colour, acidity (pH), Water holding capacity, cooking loss, and tenderness, and collagen content (Soeparno, 1994).

The body of a bull is constructed by various muscles in terms of forms, anatomy, size, location, composition, and function. The main function of muscles is as contraction organ. Muscles change into meat when their functions for contraction stop on account of cutting. Muscles is the main component of meat, hence the quality of meat depends highly on the quality of muscles. The active muscles usually produce meat darker in colour, higher water holding capacity on protein and pH, and lower cooking loss, than the less active ones. They have coarser texture and bigger fibres than the less active muscles that make the meat tenderness are very low. The colour and tenderness are two factors affecting the consumers' decision in selecting meat. The more activity muscles have, the higher energy is required to support the metabolism process within the muscles. The collagen content, as the main element of muscle tissue construction, affects the tenderness or toughness of meat, so that active muscles will result in tougher meat than the less active ones (Soeparno, 1994). The increase of age is identical to the increase of muscles activities. The difference of age and kinds of muscles are predicted to have very big influence the performances of the meat physical quality (Wulf, *et al.*, 1996). To obtain high quality meat suitable with the demand of the consumers, the age and kinds of muscles should be considered (AMLC, 1993). To determine the physical quality of meat, muscles with obvious fibre direction and relatively large proportion within the meat can be used. The muscles of Longissimus *dorsi (LD), Biceps femoris (BF), Triceps brachii (TB),* and *Pectoralis profundus (PP)* are the appropriate samples for the above purpose (Swatland, 1984 and Soeparno, 1994).

The objectives of the study were to find out how far the age and kinds of muscles can affect the physical quality of meat of Ongole Cross and whether or not their age and kinds of muscles have significant interaction with the performance of the meat physical quality. The results of the study was expected to be used as information dealing with the performance of Ongole Cross meat quality based on their age and kinds of muscles as the basis in selecting meats, and as additional knowledge and understanding about the characteristics Ongole Cross physical quality to support further study.

Material and Methods

Time and Place

The study was conducted for 4 months. The slaughter of Ongole Cross was done at Yogyakarta Abattoir and the carcass preparation was conducted at "Lestari" Meat Shop, Yogyakarta. The physical quality was measurement at the laboratory of Technology and Meat Processing of Animal Production Department, Faculty of Animal Husbandry, Gadjahmada University. The physical qualities observed were the meat's colour, acidity (pH), water holding capacity), cooking loss, tenderness, and collagen content.

Materials and Equipment

The main materials of the study were the meats of Ongole Cross raised by farmers traditionally. The meats used were the results of the right side carcass preparation based on AMLC (1993). The samples taken were 4 kinds of muscles consisting of *Longissimus dorsi* (LD; shortloin meat), *Biceps femoris* (BF; silverside meat), *Triceps brachii* (TB; chuck meat) and *Pectoralis profundus* (PP; brisket point end). Other material used was chemical solution required to determine the collagen content.

The equipments used were: weight balance (50 kilograms), analytic balance, spectrometer, oven, water bath, a set of carcass knives.

Experiment and Statistical Analysis Methods

The experiment used the factorial design of Divided Block Design/*Rancangan Petak Terbagi* (RPT) based on Randomised Completely Design (RCD) of Steel and Torrie (1995). The factors of the experiments were the age and kinds of muscles of Ongole cross.

The factor of Ongole Cross age (U) consisted of two groups: (U1) young bull (the permanent incisor had not erupted or the bull was estimated around 1-1.5 years old), and (U2) mature bull (the 3 pairs of permanent incisors had erupted or the bull was estimated around 3-3.5 years old).

The factors of kinds of muscles (T) consisted of 4 groups: (T1) *Longissimus dorsi (LD)*, (T2) *Biceps femoris (BF)*, (T3) Triceps *brachii (TB)*, (T4) *Pectoralis profundus (PP)*.

The data collected were analysed by using Randomised Completely Designed and continued with Multiple Range Duncan Test when the results indicated differences (Steel and Torrie; 1995).

Parameters of the observation

The physical quality comprised: meat colour chard based on AMLC (1991 and 1994), acidity (pH) determined by Bouton and Harris method (1972), meat cooking loss measured based on the method of Bouton, *et al.*, (1971), water holding capacity (WHC) measured with Hamm's method (1972) as quoted by Soeparno (1994), meat tenderness (shear force) measured with the method of Soeparno (1994) and the collagen content was determined with the method of Stagemann-Stalder (CSIRO, 1980).

Results and Discussion

The Characteristics of Meat Physical Quality

The variables of meat physical quality were meat colour chard, acidity (Ph), water holding capacity, cooking loss and tenderness (shear force) of young and adult Ongole Cross. The measurement was applied on meat samples consisting muscles of *Longissimus dorsi (LD), Biceps femoris (BF), Triceps brachii (TB),* and *Pectoralis profundus (PP).* The results showed that only the independent variable of Ongole Cross age had significant influence on the meat tenderness or shear force (P<0.05). While its effects on other values of physical quality was not different significantly (P>0.05). The kinds of muscles had significant influence (P<0.05) on the values of pH, water holding capacity, collagen content, and very significant (P<0.01) on the meat colour chard, cooking loss, and tenderness. There was no interaction (P>0.05) between the age of Ongole Cross and the kinds of muscles on the performance of the meat physical quality (Table 1).

The tenderness of meat taken from young Ongole Cross was higher significantly (P<0.05) than that of meat taken from adult Ongole. Lawrie (1995) stated that different age of bulls produces meat with different tenderness as well. Wullf, *et al.*, (1996) mentioned that the age of cattle has significant correlation with the level of their meat tenderness. In addition, Swatland (1984) also stated that the value of meat

Table 1. Characteristics of meat physical quality of young and adult Ongole Cross determined by measuring those on LD, BF, TB, and PP Muscles.

The Characteristics of Meat Physical Quality	Age of Bull			Kinds of Muscles				
	Young	Adult	Sign.	LD	BF	TB	PP	Sign.
Colour	7.10	7.65	ns	7.00	8.00	7.80	6.70	**
pH (%)	5.46	5.50	ns	5.30	5.48	5.62	5.53	*
Water Holding Capacity (%)	27.96	25.50	ns	30.48	25.20	23.18	28.15	*
Cooking Loss (%)	28.21	33.04	ns	27.23	32.09	33.28	29.91	**
Tenderness (kg/cm ^{2})	3.39	4.15	*	3.20	4.00	4.13	3.75	**
Collagen (%)	0.89	1.30	ns	0.74	1.20	1.37	1.07	*

* Different Significantly (P<0.05) ** Different Very significantly (P<0.01)
ns non-significant (P>0.05)

tenderness increases in accordance with the age of the cattle. Furthermore, different kinds of muscles also produce different kinds of meat physical quality. According to Shackelford, *et al.*, (1995[a]), the physical quality of meat is affected by the kinds of muscles and its location. As the interaction of age and kinds of muscles did not affect the physical quality of meat (P>0.05), it indicated that meat physical quality was mainly influenced by the independent factor of kinds of muscles.

Meat Colour Chard

The average colour chard of young and adult Ongole Cross meat derived from various muscles was 7.38. The colour chard of young Ongole Cross meat was 7.10 and that of the adult was 7.65. While the colour chard of LD, BF, TB, and PP muscles successively were 7.00, 8.00, 7.80, and 6.70 (Table 2).

The meat colour chard ranged from 1-9, from bright-red to dark-brown (AMLC, 1993). Shackle ford, *et al.*, (1995[a]) and Wheller, *et al.*, (1996) stated that myoglobin increased along with the increase of age, because as the age gets older, the deposition of myoglobin on the muscles' red fibres and the number of meat red fibres will increase (Lawrie, 1995). Shackelford, *et al.*, (1995[a]) stated that the activity and value of pH is closely related to the colour of meat. The higher the colour chard is, the darker the meat colour will be. The meat colour favoured by consumers is bright-red from oxyomoglobin pigment with meat colour chard ranged from 4-6. The high colour chard of Ongole Cross is probably affected by *Bos Indicus* blood. According to Lawrie (1995) and Shackelford, *et al.*, (1995a), the meat of Bos Indicus is significantly darker than that of Bos Taurus.

Table 2. The average meat colour chards of various young and adult Ongole Cross meat

Age of Bull (U)	Kinds of Muscles (T)				Average
	LD (T1)	BF (T2)	TB (T3)	PP (T4)	$(U)^{ns}$
Young Bull (U1)	7.00	7.80	7.20	6.40	7.10
Adult Bull (U2)	7.00	8.20	8.40	7.00	7.65
Average (T)	7.00^{ac}	8.00^{b}	7.80^{bc}	6.70^{a}	7.38

[a, b, c] Different letters in the same line shows significant difference (P<0.05)
[ns] Non-significant

The different activities of BF, LD and PP muscles were assumed to have made the meat colour of BF muscles was darker than LD and PP. BF muscles are more active than the other two muscles. Lawrie (1995) stated that the more active the muscles during the cattle was alive, the meats tend to have more red fibres and myoglobin, so that the meat colour of active muscles will be darker than that of the less active.

Acidity Level (pH)

The pH of various kinds of muscles both young and adult Ongole Cross reaches

5.48. The pH value of young male Ongole Cross was 5.46 and the pH of adult male Ongole Cross was 5.50. The pH of LD, BF, PP, and BF muscles were respectively 5.30, 5.48, 5.53, and 5.62 (Table 3).

Table 3. The average ph of various muscles of young and adult male Ongole Cross

Age of Bull (U)	Kinds of Muscles (T)				Average
	LD (T1)	BF (T2)	TB (T3)	PP (T4)	(U)^{ns}
Young Bull (U1)	5.33	5.38	5.65	5.49	5.46
Adult Bull (U2)	5.27	5.58	5.59	5.57	5.50
Average (T)	5.30^{a}	5.48^{ab}	5.62^{b}	5.53^{b}	5.48

$^{a, b}$ Different letters in the same line shows significant difference (P<0.05)
^{ns} Non-significant

When muscles are resting, they are neutral and storing glycogen as the energy source. After the slaughter, various enzymatic reactions will happen through glycolysis process that make the muscles glycogen change into lactate acid in *anaerob* condition so that it will decrease the pH until ultimate level (Lawrie, 1995). When meat pH increases into over 5.8, the water holding capacity also increases and so does the meat tenderness. Muscles with perfect glycolysis process will result in meat with low ultimate pH (Soeparno, 1994). BF muscles of adult male Ongole Cross had pH of 5.99, which was significantly higher than the pH of LD (Soeparno, 1990).

The pH range 5.30-5.62 of male Ongole Cross in this study was still considered as normal for meat. The pH of Fresh meat ranges from 5.4-5.8 (Lawrie, 1995). Meat derived from LD muscles had pH of 5.33, which was significantly lower (P<0.05) than that of BF (5.38) and TB (5.65). This was probably because the activities and glycogen supplies as well as the glycolysis processes within LD were different from those of BF and TB muscles. But they were not any differences between BF and TB muscles. Soeparno (1990) reported that LD of male Ongole Cross had significantly lower pH than BF. Swatland (1984) stated that active muscles, such as BF had lower glycogen stock than less active ones, like LD.

Water Holding Capacity (WHC)

The average value of WHC of meats from various muscles of young and adult male Ongole Cross PO was 26.73%. The WHC of young male Ongole Cross was 27.96% and that of the adult one was 25.50%. The WHC of LD, BF, TB, and PP muscles successively were 30.48%, 25.20%, 23.08%, and 28.15% (Table 4).

The value of WHC affects the performance of meat physical quality such as colour, pH, textures and raw meat compactness, juiciness, tenderness and cooking loss (Lawrie, 1995). One of the factors causes the Different WHC among muscles is dissimilar glycogen amount after the slaughter, which determines pH post mortem. Wismer-Pedersen (1971) stated that WHC is influenced by the differences of kinds of muscles, species, age, and the function of muscles. The value of WHC is related to the value of meat's pH. When the pH is higher or lower than the isoelectric point of meat protein, the WHC increases (Soeparno, 1994). The different kinds of muscles, taken from adult male Ongole Cross raised traditionally, had very significant influence to the value of WHC (Soeparno, 1994).

Table 4. The average WHC (%) of meats from various muscles of young and adult male Ongole Cross

Age of Bull (U)	Kinds of Muscles (T)				Average
	LD (T1)	BF (T2)	TB (T3)	PP (T4)	$(U)^{ns}$
Young Bull (U1)	32.17	25.69	25.71	28.26	27.96
Adult Bull (U2)	28.80	24.71	20.44	28.03	25.50
Average (T)	30.48^{a}	25.20^{b}	23.08^{b}	28.15^{ab}	26.73

a,b Different letters in the same line shows significant difference ($P<0.05$)
ns Non-significant

The difference of WHC among LD, BF and TB muscles is caused by the different levels of activities among those muscles. BF and TB are more active than LD (Swatland, 1984). WHC of LD was 30.48%, significantly higher ($P<0.05$) than BF that was 25.20% and TB that was 23.08%. It indicated that BF and TB had higher levels of activities than LD. In addition, the filament binding within the fibres of the two muscles at rigormortis was also higher than LD. Soeparno (1990) stated that the different kinds of muscles significantly influence the meat WHC of male Ongole Cross raised traditionally. He also mentioned that the active muscles tend to result in meat with lower WHC than the less active ones (Soeparno, 1994).

Cooking Loss

Cooking loss of meat from various muscles of young and adult male Ongole

Table 5. Average cooking loss (%) of various kinds of muscles of young and adult male Ongole Cross

Age of Bull (U)	Kinds of Muscles (T)				Average
	LD (T1)	BF (T2)	TB (T3)	PP (T4)	$(U)^{ns}$
Young Bull (U1)	25.21	29.86	29.33	28.45	28.21
Adult Bull (U2)	29.24	34.33	37.23	3137	33.04
Average (T)	27.23^{a}	32.09^{b}	33.28^{b}	29.91^{ab}	30.36

a, b Different kinds of letters in the same line shows significant difference ($P<0.05$)
ns Non-significant

Cross averagely was 30.63% (27.23-33.28%). The cooking loss of LD, BF, TB, and PP muscles respectively were 27.23%, 32.09%, 33.28%, and 29.91%. The meat of young and adult male Ongole Cross were successively 28.21% and 33.04%, see Table 5.

BF and TB were predicted to have more fibres with shorter length than LD, so that they had higher cooking loss than LD. It means that LD experiences less nutrient leaching when boiled, compared to BF and TB, so that the meat of LD muscles had better quality than that of BF and TB, based on their cooking loss consideration. The more active muscles will have the higher cooking loss. BF muscles produced meat with higher cooking loss than LD (Browning, er. al., 1990). The result of this study indicated that the more active the lower the WHC and the higher the cooking loss. Soeparno (1994) stated that meat with high cooking loss usually has low WHC. The cooking loss can increase when the value of WHC decreases. Lawrie (1995) stated that when meat had high cooking loss, it would lose more nutrients due to leaching during boiling process. Meat with high cooking loss had low quality (Bouton, *et al.*, 1978). The cooking loss of male Ongole Cross in this study was still within the range of cooking loss of good quality meat, which is 15-40% (Soeparno, 1994).

Tenderness

The tenderness of meat derived from various muscles of young and adult male Ongole Cross in this study was 3.77 kg/cm^2 (3.20-4.15 kg/cm^2). The average tenderness of the young male Ongole Cross was 3.39 kg/cm^2 and that of the adult was 4.15 kg/cm^2. The tenderness of LD, BF, TB, and PP muscles successively were 3.20, 4.00, 4.13, and 3.75 kg/cm^2 (Table 6).

Table 6. Average tenderness of (kg/cm^2) of meat from various kinds of muscles of young and adult male Ongole Cross

Age of bull (U)	Kinds of Muscles (T)				Average
	LD (T1)	BF (T2)	TB (T3)	PP (T4)	(U)
Young Bull (U1)	2.92	3.58	3.80	3.26	3.39 A
Adult bull (U2)	3.48	4.42	4.46	4.24	4.15 B
Average (T)	3.20^a	4.00^b	4.13^b	3.75^b	3.77

a, b Different letters in the same line shows significant different (P<0.05)
ns Non-significant

Acceptability and palatability of meat to the consumers is determined by the meat tenderness (Lawrie, 1995). The information regarding the tenderness is necessary as the basis of the consumer's acceptability and their *eating satisfaction* (Wheller, *et al.*, 1996). Huffman, *et al.*, (1996) mentioned that 51% of consumer's acceptability to the meat is determined by its level of tenderness.

The meat of young male Ongole was significantly tenderer (P<0.05) than that of adult male Ongole Cross. This was due to the muscles of young male Ongole Cross had different *crossed binding*, structure, and strength than the adult ones. Bouton, *et al.*, (1978) stated that the tenderness of meat decreases when the age of bull increases. Wulf, *et al.*, (1996) stated the age of bull had positive correlation of 0,16 to the tenderness of its meat. Soeparno (1994) mentioned that older cattle commonly had more reticulin than the young one, so that the meat of young cattle is more tender that that of old cattle. Forrest, *et al.*, (1975) and Wulf, *et al.*, (1996) stated that the roughness of texture of muscles increases in accordance with the addition of the age of cattle, and this causes the toughness of its meat also increases.

The difference of fibres and tissues within muscles causes different tenderness of their meats, either for different muscles of the same carcass of the same muscles of different carcasses (Bernholdt, 1975). The texture of fibres, age, kinds, locations, activities and WHC of muscles, are the factors influencing the tenderness of meat (Soeparno, 1994). Meat derived from front part of cattle is relatively tougher than that of back part of cattle, meaning that the front part of cattle is more active than the back part (Lawrie, 1995).

The value of tenderness of LD was higher (P<0.05) than that of BF, TB, and PP, meaning that LD, which was less active, had higher level of tenderness than BF, TB, and PP. The difference of functions, locations, and activities, textures, and size of fibres of muscles was assumed as the factors influencing the tenderness of LD was higher than that of BF, TB, and PP. Soeparno (1990) stated that different kinds of muscles of male Ongole Cross raised traditionally showed different kinds of tenderness, and LD muscles was significantly more tender than BF. Shackelford, *et al.*, (1995b) stated that BF and TB of Bos Indicus meat had higher tenderness (shear force) than LD.

Collagen

The meat taken from of various kinds of muscles of young and adult male Ongole Cross in this study contained average collagen of 1.09% (0.74-1.37%). The

Table 7. Average collagen content (%) of various muscles of young and adult male Ongole Cross

Age of Bull (U)	Kinds of muscles (T)				Average (U) ^{ns}
	LD (T1)	BF (T2)	TB (T3)	PP (T4)	
Young Bull (U1)	0.69	0.99	1.12	0.76	0.89
Adult Bull (U2)	0.79	1.41	1.61	1.39	1.30
Average (T)	0.74^{a}	1.20^{b}	1.37^{b}	1.07^{ab}	1.09

$^{a, b}$ Different letters in the same line shows significant difference (P<0.05)
^{ns} Non-significant

collagen content of young male Ongole Cross was 0.89% and that of the adult was 1.30%. The collagen content of LD, BF, TB, and PP respectively were 0.74%, 1.20%, 1.37%, and 1.07% (Table 7).

Lower collagen content of LD, compared to BF and TB, was assumed to appear due to lower levels of activities, number and strength of crossed binding muscle tissues. Judge, *et al.*, (1989) stated that active muscles tended to have more and stronger crossed binding muscle tissues that caused their protein content to increase. As the major component of collagen is protein hydroxyprolin, when the protein content increases, the collagen content increases too. The levels of collagen content in meat are predicted to affect its tenderness. The result of this study showed that the meat of LD muscles had significantly lower collagen content and tenderer than the meat of other muscles. Soeparno (1990) stated that the low collagen content indicated that the *mecain* strength of the meat also low, so that the meat tenderness automatically increase. The collagen content of LD of male Ongole Cross in this study was 0.74%, which is significantly lower than that of BF (1.20%). Soeparno (1990) stated that the collagen content of LD was significantly lower than that of BF, namely 0.396% of LD and 0.817% of BF (Soeparno, 1990). This indicated that tenderness has a very close relation to the collagen content. LD muscles, which was proved to be more tender, had lower collagen content.

Conclusion

The following were the characteristics of the meat quality taken from various kinds of muscles of young and adult male Ongole Cross, measured from several variables of meat physical quality. The meat colour chard was 7.38 (6.70-8.00), pH was 5.48 (5.30-5.62), Water holding Capacity (WHC) was 26.73% (23.08-30.48%), cooking loss was 30.63% (28.21-33.28%), tenderness was (shear force) 3.77 kg/cm^2 (3.20-4.13 kg/cm^2) and collagen content was 1.09% (0.74-1.37 %).

The kinds of muscles significantly influenced the physical quality ($P<0.05$), namely significantly influenced the pH, WHC and collagen content ($P<0.05$); had significant difference ($P<0.01$) from the meat colour, cooking loss, and tenderness. The age of the male Ongole Cross significantly influenced the tenderness of the meat ($P<0.05$) but did not affect the other variables of the meat physical quality.

Meat from LD muscles and young male Ongole Cross was significantly more tender than that of three other kinds muscles and adult male Ongole Cross. The colour of meat derived from LD and PP muscles had more attractive colour compared to BF TB. The meat of young male Ongole Cross was also more attractive than that of the adult one. The quality of meat derived LD was relatively better than that of BF, TB, and PP. the meats of various muscles of male Ongole cross, either young or adult, were relatively palatable to be consumed.

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