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Physicochemical Characteristics and Microbiological Quality of the Topside and Longissimus Dorsi of Indonesian Local Buffalo Meat

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ABSTRACT

The physicochemical characteristics and microbiological quality of buffalo meat are influenced by differences in muscle type. This study aimed to evaluate the physiochemical characteristic and microbiological quality of the topside (active muscle) and longissimus dorsi (passive muscle) of Indonesian local buffalo meat. Samples used in this study were buffalo meat from local swamp buffalo, aged more than four years old on the topside and longissimus dorsi. This study used a completely randomized design, with three repetitions in each treatment. All data were analyzed using analysis of variance (ANOVA). The result of the study on the topside and longissimus dorsi area showed a significant difference in the pH and cholesterol levels of the buffalo meat. The longissimus dorsi area had a lower level of pH and cholesterol compared to the topside area. Furthermore, this longissimus dorsi meat has a higher color, protein, ash, fat, essential amino acid, and lactic acid bacterial (BAL) content than the topside meat. However, the topside meat had higher carbohydrate, essential fatty acid, *Escherichia coli (E. coli)* and *Staphylococcus aureus (S. aureus)* content compared to the longissimus dorsi meat. Longissimus dorsi meat had better physicochemical characteristics and microbiological quality than the topside meat

Keywords*:* Buffalo meat, Longissimus dorsi, Microbiological quality, Physicochemical characteristics, Topside

Introduction

Buffalo meat is one of the nutritious food sources to meet the nutritional requirement (Decker and Park, 2010). The high nutritional quality of buffalo meat includes a higher protein content (20.39%) compared to beef (19.05%). The cholesterol content of buffalo meat is also lower (46%) than beef (59%). In addition to high protein content, buffalo meat contains balanced essential amino acids, high essential fatty acids, and vitamins that are good for humans (Decker and Park, 2010; Naveena and Kiran, 2014; Oh *et al.*, 2016).

The physicochemical and microbiological quality of meat are affected by the different types of active muscle (topside) and passive muscle (longissimus dorsi) (Kastalani *et al.*, 2016). The active and passive muscle in the animal has different muscle structure, chemical composition, and the bacterial population that all influence the physicochemical characteristics and microbiological quality of meat produced from those different types of muscle (Joo *et al.*, 2013). Alteration in the physicochemical and microbiological quality of meat are significantly influenced by both intrinsic and extrinsic factors of muscle type (Weglarz, 2010).

Due to a little movement activity on passive muscle, it has smaller muscle fibers than active muscle which tends to have greater movement. Hence, muscle structure and nutrient value are also different (Joo *et al.*, 2013). Longissimus dorsi meat has small muscle fiber, less connective tissue, and higher marbling fat content that affects the juiciness of the meat and increases its selling price compared to topside meat (Nuraini *et al.*, 2013). A study conducted by Lambe *et al.* (2008) reported that each part of the muscle has different physicochemical characteristics. Yet, it is often considered insignificant. Information regarding the physicochemical characteristics of meat from different types of muscles is necessary to optimize meat processing to produce high quality meat products.

Active and passive muscles differ in microbial contamination, as the closer position to the digestive system allows more contamination to occur (Kuntoro *et al.*, 2013; Joo *et al.*, 2013). Meat from bicep femoris has a greater total plate count (TPC) than longissimus dorsi et lumbarum meat (Kuntoro *et al.*, 2013).

The quality of buffalo meat is considered vital for the community. People are more aware of the health, freshness, security, and functional aspects of food (Shahidi, 2009). Each type of buffalo meat requires proper labeling information that is required for further meat processing to produce tastier products, increase the buffalo meat consumption, and eventually shape more buffalo meat market in Indonesia. Therefore, this study aimed to evaluate the physicochemical characteristics and microbiological quality of local Indonesia buffalo meat, particularly on the topside part (active muscle) and longissimus dorsi (passive muscle).

Materials and Methods

This study was carried out from September to October 2018 at *Institute Pertanian Bogor*. Materials used in this study included topside meat and longissimus dorsi meat from swamp cow-buffalo aged more than 4 years old and have permanent incisors and obtained from slaughtering in halal (Islamic) manner. Meat samples were collected from Galluga Leuwiliang abbatoir which marketed at Leuwiliang market of Bogor, West Java. Meat samples that have been deboned from topside and longissimus dorsi were collected as much as 3 kg each. The meat samples were then stored at -25°C freezer for 24 hours. Before analyzed for physicochemical characteristics and microbiological quality, samples were initially thawed.

Physicochemical analysis

pH value was measured according to AOAC (2005) using pH meter (HANNA Instruments, USA). pH meter probe was put on the sample and the pH value shown on the screen was recorded. Water activity (a_w) value was evaluated according to Salejda *et al.* (2014) using a_w meter (Novasiana, Switzerland). Before the measurement, samples were ground, and the a_w value shown on the screen was recorded. Meat color was evaluated according to Feng *et al.* (2013) using Chromameter CR 310 with the hunter method. The instrument was initially standardized with a white sheet (Y= 92.89, x= 0.3150 dan y= 0.3210). The measurement of the sample's surface and core color were carried out using L a b value. Total titrated acid (TTA) was analyzed according to AOAC (2005). TTA was obtained by mixing 10g of the sample with 10 ml of distilled water, then added with 0.1 N of NaOH until achieving a neutral pH value. The TAT value was calculated by the following formula.

Total Titrated Acid (%) =

$$\frac{\text{ml NaOH x N NaOH x0.01 N x 90}}{\text{sample (gram)}} \text{ x } 100\%$$

Proximate analysis

The nutrient values (water, ash, protein, fat, and carbohydrate) were evaluated based on AOAC (2005).

Cholesterol analysis

The cholesterol content was evaluated according to Sulaiman *et al.* (2016) using Lieberman-Buchards method. The cholesterol content was calculated based on this following formula.

Total of cholesterol (mg/100g) =

$$\frac{\text{Sample's absorbance x Standard concentration}}{\text{Satndard's absorbance x sample's weight}}$$

TBARS analysis

The thiobarbituric acid reactive substances (TBARS) was evaluated according to Manihuruk *et al.* (2017) using destilation method. TBARS value was calculated based on this following method.

TBARS=

$$\frac{\text{MDA concentration (µM)as on standard curve x volume of destilate (ml)}}{\text{sample's weight (g)}}$$

Amino acid composisition

Amino acid composition was evaluated based on Sulaiman *et al.* (2016) using high-performance liquid chromatography (HPLC). The amino acid composition was calculated based on this following formula.

Amino acid (%) =

$$\frac{\text{amino acids (µmol) X amino acids (Mr)}}{\text{sample (µg)}}$$

Fatty acid analysis

Fatty acid content was analyzed according to AOAC (2005) using gas chromatography. The fatty acid content was calculated based on this following formula.

Fatty Acid (%) =

$$\frac{\frac{\text{Sample's area}}{\text{Standard's area}} \text{ X Standard's concentration X} \frac{\text{Sample's volume}}{100}}{\text{Sample (g)}} \text{ x } 100\%$$

Microbiological analysis

Testing for LAB, *E. coli, S. aureus, Salmonella sp*., and *Shigella sp*. was performed according to Arief *et al.* (2016). 25 gram of meat sample was transferred into 22 ml buffer pepton water (BPW), and then homogenized. LAB was grown on Man Rogosa Sharpe Agar (MRSA) medium and incubated at 37°C for 36-48 hours. *E. coli, S. aureus, Salmonella sp.,* and *Shigella sp*. were grown on eosine methylene blue agar (EMBA) medium, braid parker ager (BPA) medium, xylose lysine deoxyholate ager (XLDA) medium, and *salmonella shiggela* agar (SSA) medium respectively, incubated at 37°C for 24 hours. The growing colony was counted based on this following formula.

$$\frac{\text{cfu}}{\text{g}} = \frac{\text{number of different colonies within the range } (25 - 250 \text{ colonies})}{(\text{number of first colony} + (0.1 \times \text{number of second colony})) \times \text{first dilution}}$$

The experimental design used in this study was completely randomized design (CRD), with two treatments and three replications. Treatments in this study were type of meat: P1 (buffalo topside meat) and P2 (buffalo longissimus dorsi

meat). Data were statistically analyzed with analysis of variance (ANOVA) on statistic software of SAS 9.4.

Results and Discussion

Physicochemical quality of buffalo meat (topside and longissimus dorsi)

The topside and longissimus dorsi buffalo meat differed significantly in pH value and total titrated acid (TTA) (Table 1). pH value of topside meat was higher than longissimus dorsi meat. The difference might be a result of different intrinsic factors, i.e. amount of glycogen and length of sarcomere of active and passive muscle (Weglarz, 2010). The high glycogen content affect glycolysis rate that accelerates the decrease in pH value of the meat (Ali *et al.*, 2008).

TAT value of longissimus dorsi buffalo meat was higher than topside meat. It indicates the difference of metabolic products yielded by LAB and glycogen amount available in active and passive muscle of those two different meat parts. The higher glycogen amounts available, the more lactic acid produced in the meat (Arief *et al.*, 2016).

Meat color evaluation which includes brightness intensity (L value), red intensity (a value), yellow intensity (b value), and HUE degree in the topside and longissimus dorsi buffalo meat shows significant differences (Table 1). The brightness intensity (L value) of longissimuss dorsi part was brighter than the topside part's. It might be caused by the differences in the activity of each muscle that lead to higher pH value in active muscle which generates darker color than in passive muscle (Ilavarasan *et al.*, 2016).

Red intensity (a value) of longissimus dorsi buffalo meat was higher than the topside's. The result demonstrates that the longissimus dorsi part has greater myoglobin than topside due to different function of each muscle (Jeong *et al.*, 2009). The intensity of yellow color (b value) in longissimus dorsi buffalo meat was yellower than the topside's. The longissimus dorsi might has higher adipose fat than the topside meat, resulting in the yellower meat. Luz *et al.* (2017) reported that the fresh buffalo meat produces red and yellow colors. Brightness intensity, red and yellow colors were significantly by the muscle types. HUE degree in this study ranges from 39.92 to 41.30 which generates red color (^{o}HUE = 18^{o}-54^{o}) (Totosaus, 2009).

Nutritional value of topside and longissimus dorsi buffalo meat

Ash, protein, fat, carbohydrate, and cholesterol contents of topside and longissimus dorsi buffalo meat observed in this study were significantly different (Table 2). Ash content of longissimus dorsi part was higher than topside's. It might be caused by the difference nutrient content between active and passive muscles which affected by the different function of each muscle (Oh *et al.*, 2016). The high ash content longissimus dorsi might come from its higher fero (Fe^{2+}) and myogloboin content, causing the longssimus dorsi meat to have a brigher color compared to the topside.

Protein content of longissimus dorsi was higher than topside's. The high myosin content might be the cause of this result as it affects the proteolotic degradation rate in each part of muscles (Merthayasa *et al.*, 2015). Futhermore, the myosin content also produces juicier taste to longssimus dorsi than the topside (Lawrie, 2003).

Fat content in longissimus dorsi was higher than the topside's. This is caused by the fact that longissimus dorsi is a muscle part that is less moving, so it contains less collagen (connective tissue) and greater fat content than the topside (Joo *et al.*, 2013). Oh *et al.* (2016) reported that passive muscle has smaller content of collagen. Hence, the longissimus dorsi is softer compared to the topside.

Carbohydrate content in the topside was higher than longissimus dorsi's. The higher carbohydrate content might be produced from more moving activity in active muscle to generate energy.

Cholesterol content of the topside muscle was higher than longissimus dorsi. Presumably, the development of sarcolemma that is elastic in muscle fiber and has important role in the muscle shortening and stretching activity might be the cause of this result (Mendoza *et al.*, 2015).

Table 1. Physical characteristics of topside and longissimus dorsi buffalo meat

Variables	Meat Part	
	Topside	*Longissimus dorsi*
Physical characteristic		
pH value	5.95±0.03^{a}	5.64±0.04^{b}
a_w	0.83±0.00	0.82±0.01
Total titrated acid (TTA) (%)	0.31±0.01^{a}	0.48±0.01^{b}
Color		
Brightness intensity (L*)	33.48±0.03^{b}	34.72±0.00^{a}
Red color intensity (a*)	3.23±0.03^{b}	5.24±0.02^{a}
Yellow color intensity (b*)	1.38±0.03^{b}	1.97±0.02^{a}
^{o}HUE	39.92±0.04^{b}	41.30±0.01^{a}

Different superscript in the same row indicates a significant different ($p<0.05$), L value (0) bright, value (100) dark; a value (+) red, value (-) green; b value (+) yellow, value (-) blue.

Table 2. Nutritional value of topside and longissimus dorsi buffalo meat

Variables	Meat Part	
	Topside	*Longissimus dorsi*
Nutritional value		
Water content (%)	76.49±0.39	77.20±0.23
Ash content (%)	1.08±0.02[b]	1.16±0.03[a]
Protein content (%)	17.13±0.10[b]	18.77±0.20[a]
Fat content (%)	0.32±0.01[b]	0.49±0.03[a]
Carbohydrate content (%)	4.98±0.41[a]	2.37±0.28[b]
Cholesterol content (mg/100g)	64.76±3.23[a]	52.02±1.13[b]
TBARS value (mg kg^{-1})	Nd	Nd

Different superscript in the same row indicates a significant different ($p<0.05$), Nd: Not detected.

The content of essential amino acids, namely valine, leucine, methionine, arginine, and lysine in topside and longissimus dorsi buffalo meat had significant differences (Table 3). The essential amino acids in longissimus dorsi was significantly higher than the topside's The high content of protein in longissimus dorsi buffalo meat might affect the proteolytic activity rate, which increase the availability of protein to form more essential amino acids (Soeparno, 2015).

The different amino acid contents in topside and longissimus dorsi buffalo meat is also caused by the different physiologic function, intrinsic and structural materials (Hall *et al.*and Hettie, 2013). In this study, longissimus dorsi buffalo meat had greater content of valine, leucine, and methionine than the topside's. The result in this study is in line with previour report by Szterk (2015), in which passive muscle has higher valine, leucine and methionine than active muscle.

The content of nonessential amino acids, namely alanine, glysine, serine, tyrosine, aspartate, and glutamate of topside and longissimus dorsi buffalo meat in this study were significantly different (Table 3). The non essential amino acids content in longissimus dorsi was higher than the topside. It might be caused by the difference protein content in active and passive muscle, influencing the proteolytic rate to cause different nonessential amino acids content (Hall and Hettie, 2013).

Saturated fatty acids (SFA) content, namely caprylic acid, myristic acid, palmitic acid, heptadecanoic acid, stearic acid, and arachidic acid of topside and longissimus dorsi buffalo meat were significantly different (Table 4). SFA composition in the longissimus dorsi part was higher than the topside's in this study. The high fat content in longissimus dorsi is assumed to influence the lipolytic activity rate that will increase the availability of lipid to form more fatty acids (Soeparno, 2015). Song *et al.* (2017) reported that SFA composition, such as myristic acid, palmitic acid, heptadecanoic acid, stearic acid, and arachidic acid in less moving passive muscle is greater than active muscle.

The content of mono unsaturated fatty acids (MUFA) was significantly different among topside and longissimus dorsi buffalo meat (Table 4). Oleic acid in longissimus dorsi buffalo meat was higher than the topside's. The different activity of each muscle may affect the lipolytic activity to cause this result (Soeparno, 2015). Luccia *et al.* (2003) reported that oleate content of buffalo meat from passive muscle parts was higher than the active muscle's.

The content of polyunsaturated fatty acids (PUFA), i.e. linoleic acid, Cis-8, 11, 14-eicosatrienoic acid, arachidonic acid, eicosapentaenoic acid (EPA), and docosahexanoic acid (DHA) of longissimus dorsi and topside buffalo meat in this study were significantly different (Table 4). The result might

Table 3. Amino acid profile of topside and longissimus dorsi buffalo meat

Variables	Meat part	
	Topside	*Longissimus dorsi*
Amino acids (%w/w)		
Essential amino acids		
Valine	0.97±0.01[b]	1.06±0.05[a]
Leucine	1.58±0.03[b]	1.70±0.06[a]
I-leucine	1.00±0.00	1.01±0.04
Methionine	0.42±0.02[b]	0.54±0.04[a]
Phenylalanine	0.86±0.03	0.90±0.04
Threonine	0.92±0.02	0.97±0.04
Arginine	1.20±0.01[b]	1.36±0.01[a]
Histidine	0.69±0.00	0.76±0.01
Lysine	1.55±0.01[b]	1.81±0.03[a]
Non essential amino acids		
Alanine	1.09±0.01[b]	1.24±0.03[a]
Glycine	0.81±0.02[b]	1.09±0.01[a]
Serine	0.73±0.02[b]	0.81±0.03[a]
Tyrosine	0.65±0.02[b]	0.71±0.02[a]
Aspartate	1.79±0.02[b]	1.92±0.02[a]
Glutamate	3.06±0.01[b]	3.25±0.04[a]
Total asam amino	17.32	19.13

Different superscript in the same row indicates a significant different ($p<0.05$).

Table 4. Fatty acid profiles of topside and longissimus dorsi buffalo meat

Variables	Meat part	
	Topside	Longissimus dorsi
Fatty acids (w/w) %		
Saturated fatty acids (SFA)		
Caprylic acid (C10:0)	0.02±0.00[b]	0.03±0.00[a]
Lauric acid (C12:0)	0.03±0.01	0.05±0.04
Myristic acid (C14:0)	0.65±0.02[b]	0.82±0.02[a]
Pentadecanoic acid (C15:0)	0.19±0.02	0.20±0.02
Palmitic acid (C16:0)	11.49±0.01[b]	13.17±0.59[a]
Heptadecanoic acid (C17:0)	0.82±0.05[b]	1.06±0.02[a]
Stearic acid (C18:0)	16.05±0.13[b]	22.40±0.64[a]
Arachidic acid (C20:0)	0.12±0.01[b]	0.16±0.02[a]
Henecosanoic acid (C21:0)	0.03±0.01	0.04±0.01
Behenic acid (C22:0)	0.10±0.02	0.09±0.02
Tricosanoic acid (C23:0)	0.06±0.01	0.06±0.02
Lignoceric acid C24:0	0.10±0.02	0.08±0.03
Unsaturated fatty acids (UFA)		
Mono unsaturated fatty acids (MUFA)		
Myristoleic acid (C14:1)	0.10±0.04	0.13±0.01
Palmitoleic acid (C16:1)	0.98±0.04	0.98±0.06
Cis-10-heptadecanoic acid (C17:1)	0.34±0.00	0.34±0.02
Oleic acid (C18:1n9c)	22.05±0.19[b]	24.22±0.13[a]
Cis-11-eicosatrienoic acid (C20:1)	0.04±0.01	0.05±0.01
Nervonic acd C24:1	0.04±0.01	0.03±0.01
Poly unsaturated fatty acids (PUFA)		
Linoleic acid (C18:2n6c)	5.65±0.32[a]	3.31±0.30[b]
g-Linoleic acid	0.04±0.01	0.03±0.01
Linolenic acid (C18:3n3)	1.10±0.15	0.83±010
Cis 11,14-Eicosatrienoic acid (C20:2)	0.07±0.02	0.07±0.02
Cis-8,11,14-Eicosatrienoic acid (C20:3n6)	0.55±0.04[b]	0.63±0.01[a]
Arachidonic acid (C20:4n6)	2.83±0.05[a]	1.95±0.02[b]
Cis-13,16 Docosadienoic acid (C22:2)	0.19±0.10	0.34±0.05
EPA (C20:5n3)	0.80±0.06[a]	0.59±0.07[b]
DHA (C22:6n3)	0.11±0.01[a]	0.08±0.01[b]
Total of fatty acids	64.53	71.74
SFA	29.66	38.17
UFA	34.87	33.57
MUFA	23.55	25.75
PUFA	11.32	7.82
SFA/UFA	0.85	1.14

Different superscript in the same row indicates a significant different ($p<0.05$), Saturated fatty acids (SFA); Unsaturated fatty acids (UFA); Mono unsaturated fatty acids (MUFA); Polyunsaturated fatty acids (PUFA).

be associated with the different function of each muscle, affecting the lipolytic activity rate (Soeparno, 2015). This study shows that lienoleic acid content in topside part was higher than longissimus dorsi's. Linoleic acid is functional in preventing deficiency symptoms, anticancer, and reducing insulin resistance (Lopes *et al.*, 2014; Liu *et al.*, 2015).

Arachidonic acid, EPA, and DHA content in topside part of the buffalo meat was higher than the longissimus dorsi's. Arachidonic acid, EPA, and DHA are able to to prevent neurologic disorders (Macajova *et al.*, 2004). DHA and EPA play role in preventing cardiovascular disease, increasing antirombotic activity by reducing thrombosyte aggregation, reducing blood pressure and antiatherogenic activity (Macajova *et al.*, 2004). Cis-8, 11, 14-eicosatrienoic acid in topside buffalo meat was higher thatn the longissimus dorsi's. The result is in line with the Liu *et al.*'s study (2015) in which Cis-8, 11, 140 eicosatrienoic acid content of passive muscle was higher than active muscle's.

Microbiological quality of topside and longissimus dorsi buffalo meat

The population of LAB, E. coli, and S. auereus in the topside and longissimus dorsi buffalo meat were observed to have significant differences (Table 5). LAB population of the topside was greater than the longissimus dorsi. Oh *et al.* (2016) reported that each part of muscle has different nutritional value that influences LAB population in the meat. LAB has antimicrobial proteperty for pathogenic bacteria (Voloski *et al.*, 2016).

E. coli population in the topside part of buffalo meat was greater compared to longissimus dorsi's. High *E. coli* population might be a result of contamination occurred during digestive content removing process. Hence, the topside part which is in close proximity to the digestive tract is more susceptible to contamination from intestinal bacteria (Lerma *et al.*, 2013). In addition, Salmela *et al.* (2013) reported that pathogenic bacteria contamination may occur during handling and maintaining of tools used. In the BSN (2009), Indonesian National Standar (SNI) sets the standard number of *E. coli* bacteria in fresh meat is 1 log cfu g^{-1}.

Population of S. aureus in topside part was higher than the longissimus dorsi's. The high *S. aureus* population in the topside part might caused by the contatmination during the removing process of intestinal content. Muscles that situated closer to the digestive tract are more prone to intestinal bacteria contamination (Lerma *et al.*, 2013). In BSN 2009, SNI sets a standard that the *S. aureus* population in fresh meat is 2 log cfu g^{-1}.

Table 5. Microbiological quality of topside and longissimus dorsi buffalo meat

Variables	Meat part	
	Topside	*Longissimus dorsi*
Microbiological quality		
LAB (log cfu g^{-1})	5.42±0.10[a]	4.59±0.11[b]
E. coli (log cfu g^{-1})	2.45±0.03[a]	1.75±0.05[b]
S.aureus (log cfu g^{-1})	2.31±0.04[a]	1.82±0.04[b]
Salmonella sp. (log cfu g^{-1})	Negative	Negative
Shigella sp (log cfu g^{-1})	Negative	Negative

Different superscript in the same row indicates a significant different ($p<0.05$)

The presence of *Salmonella sp*. and *Shigella sp.* were not found in this study (Table 5). With good management and handling during slaughtering and meat processing can avoid the occurrence of microorganism contamination (Doulgeraki *et al.*, 2012). Thus, the topside and longissimus dorsi buffalo mea in this study were free form *Salmonella sp*. and *Shigella sp.* contamination. In 2009 BSN, SNI sets the standard number of *Salmonella sp*. and *Shigella sp*. in fresh meat is negative.

Conclusion

The differences of physicochemical and microbiological quality between topside and longissimus dorsi buffalo meat are associated with the muscle types. Longissimus dorsi meat has better physicochemical and microbiological quality the topside meat. Yet, both still has good meat quality. Different types of muscles also cause the level of bacterial contamination, in which longissimus dorsi had lower *E. coli* and *S. aureus* contamination than topside meat.

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