Muscle fiber area and warner bratzler shear force (WBSF) value of Aceh cattle semitendinosus muscle

H Sofyan\textsuperscript{1,2}, A S Satyaningtijas\textsuperscript{3}, C Sumantri\textsuperscript{4}, E Sudarnika\textsuperscript{5} and S Agungpriyono\textsuperscript{3}

\textsuperscript{1}Physiology and Pharmacology Study Program, IPB University, Bogor, Indonesia
\textsuperscript{2}Laboratory of Anatomy, Faculty of Veterinary Medicine, Syiah Kuala University, Banda Aceh, Indonesia
\textsuperscript{3}Department of Anatomy, Physiology, and Pharmacology, Faculty of Veterinary Medicine, IPB University, Bogor, Indonesia
\textsuperscript{4}Department of Animal Production and Technology, Faculty of Animal Science, IPB University, Bogor, Indonesia
\textsuperscript{5}Department of Animal Infectious Diseases and Veterinary Public Health, Faculty of Veterinary Medicine, IPB University, Bogor, Indonesia

Email: ysrihadi@apps.ipb.ac.id

Abstract. Aceh cattle serves as the first choice in providing beef in Aceh Province, Indonesia. This study was aimed to measure the area of muscle fibers in Aceh cattle and its correlation with the meat tenderness. The study used semitendinosus muscle samples from four Aceh bulls aged 18-30 months with an average body weight of 320.75±71.41 kg. The paraffin sections were stained with hematoxylin-eosin (HE) staining, while muscle samples were processed for meat tenderness measurement. The measurement of the area of muscle fibers was carried out under a light microscope and by using IMAGE J software, while the analysis of meat tenderness was done using the Warner-Bratzler Shear Force (WBSF). The results were compared with reference values in Bali cattle and Ongole grade cattle. The average area (µm\textsuperscript{2}) of muscle fibers in Aceh cattle was 2 752.17 (95% CI: 1 334.34-4 170.00). This value is not different from those of Bali cattle and Ongole grade cattle. WBSF value (kg cm\textsuperscript{-2}) in Aceh cattle was 9.35 (95% CI: 4.21-14.49). The average of WBSF value in Aceh cattle was higher but not significantly different from those of Bali cattle and Ongole grade cattle. The study concluded that beef of Aceh cattle is as tender as the beef of Bali and Ongole grade cattle.

Keywords: semitendinosus muscle, muscle fiber area, meat tenderness, Aceh cattle

1. Introduction

Meat tenderness is one of the quality factors of meat that is considered by consumers, in addition to color, taste, and juiciness. Meat tenderness can affect eating quality. Variations in the level of the tenderness of meat can influence consumers to buy meat [1,2]. Indonesian people generally prefer tender meat than hard meat, but for some types of cuisine, consumers prefer meat with a low tenderness. Indonesian society has a different way of cooking with people in European countries. Indonesians people cook meat with high heating and a long-time period. How Indonesian cook meat causes the level of the tenderness of beef has not been a significant problem for consumers in
Indonesia at this time. However, the supply of meat with a tenderness level according to the desires of consumers needs to be done. [3] states that now and in the future, it is necessary to make adjustments between consumer tastes and beef production systems, and this is a challenge for all meat industries throughout the world.

Meat tenderness is influenced by several factors, such as breed, age, sex, livestock activity, feed, handling animals before and when slaughtered, and handling meat after cattle are slaughtered [4]. Sarcomere length, temperature, pH, and the process of proteolysis are also the main factors affecting meat tenderness, especially during the process of muscle conversion to meat [2,5]. The composition of the type of muscle fibers, muscle buffering capacity, and nutritional status of livestock contribute to causing variations in meat tenderness. Warner bratzler shear force is one method that is often used to measure the tenderness of meat [6,7]. Meat tenderness is associated with low WBSF value, minimal collagen content, and small size of muscle fibers [8]. All of these factors affect the condition of muscle fibers as the main constituent of meat.

Skeletal muscle is a meat-forming structure composed of different muscle fibers caused by differences both in the ultrastructure and in the biochemical and physiological properties within myofiber [9]. Muscle characteristics are influenced by various factors, including species, breed, sex, age, birth weight, livestock activity, hormonal use, cut weight, muscle type and location, and sampling location in muscles [10]. The area of muscle fibers is one of the muscle microstructure variables, which is a significant factor in determining muscle mass and is closely related to meat quality because it affects the tenderness of the meat. Muscle fibers that have a large area tend to produce meat with a low tenderness level [6]. Semitendinosus muscle is one of the muscle compilers of silverside, which is much in demand by consumers [7,11]. Meat tenderness derived from bovine semitendinosus muscle has been studied by several researchers [6,7,11,12]. This muscle tends to have a low tenderness level [7].

Aceh cattle is one of Indonesia's local breed of cattle. Aceh cattle is well known as a provider of beef in Aceh Province. High demand for Aceh beef cattle is due to the sweet taste of meat, although the price of Aceh beef cattle is still relatively high compared to the cost of meat from other breeds [13]. The quality of Aceh cattle beef, especially the level of tenderness, has not been a significant problem in the current condition. However, screening for the level of Aceh beef tenderness needs to be done as a basis for making Aceh beef quality improvement programs in the future. This study aimed to measure the area of Aceh semitendinosus muscle fibers and their relationship using WBSF values.

2. Material and Methods
2.1 Ethics Approval
This study has received ethical approval from the IPB University Ethics Committee 2018 Number: 101-2018 IPB.

2.2 Sample
The study used semitendinosus muscle samples from four Aceh bulls aged 18-30 months (I1-I2) with an average body weight of 320.75±71.41 kg. Some samples were processed histologically and stained with hematoxylin-eosin (HE) staining, while other parts of the samples were processed for meat tenderness measurement. The measurement of the area of muscle fibers was carried out under a light microscope using IMAGE J software (Figure 1), while the analysis of meat tenderness was done using the Warner-Bratzler Shear Force (WBSF) following the previously published procedures [14].

2.3. Data Analysis
The measurement results are expressed in a mean and 95% confidence interval for further analysis descriptively and compared with secondary data from Bali cattle and PO. A correlation test was performed using the Pearson correlation method using SPSS ver. 21.
3. Result and discussion

The results of measurements of muscle fiber area and WBSF values in Aceh cattle and their comparison with Bali and PO cattle are presented in Table 1. Semitendinosus muscle of Aceh cows has an average area of muscle fibers (µm$^2$) of 2 752.17 (95% CI: 1 334.34-4 170.00) with a WBSF value (kg cm$^{-2}$) of 9.35 (95% CI: 4.21-14.49). Based on a 95% confidence interval, the average area of Aceh semitendinosus muscle fibers was not significantly different from Bali and PO cattle, although their size was more extensive than those of the other two cattle breeds.

Table 1. The area of semitendinosus muscle fibers in Aceh cattle and their comparison with Bali and Ongole grade cattle.

| Breed                | Area muscle fiber (µm$^2$) (95% CI) | WBSF value (kg cm$^{-2}$) (95% CI) |
|----------------------|-------------------------------------|------------------------------------|
| Aceh cattle          | 2 752.17 (1 334.34-4 170.00)a       | 9.35 (4.21-14.49)a                 |
| Bali cattle [11]*    | 2 445.20 (1 990.33-2 900.07)a       | 5.80 (3.69-7.91)a                 |
| Ongole grade cattle  | 1 533.70 (1 030.29-2 037.11)a       | 6.40 (4.29-8.51)a                 |

Note: *: Data have been processed
Different letters in the same column show significant differences 95% CI: 95% confidence interval

Based on the level of tenderness criteria compiled by [15], Aceh beef derived from the semitendinosus muscle is included in the hard meat group because it has a WBSF value between 8.24-10.12 kg cm$^{-2}$, while the semitendinosus muscle of Bali and Ongole grade cattle is included in the group slightly tender meat with a range of WBSF values between 5.00-6.71 kg cm$^{-2}$. Based on the level of tenderness criteria compiled by [7], the semitendinosus muscle of Aceh cattle, Bali cattle, and Ongole grade cattle is included in hard meat because it has a WBSF value > 4.9 kg cm$^{-2}$. Based on the criteria compiled by [16], Aceh beef, Bali beef, and Ongole grade beef derived from the semitendinosus muscle are also included in the category of hard meat because it has a WBSF value > 5.37 kg cm$^{-2}$.

Figure 1 Histological structure of the semitendinosus muscle of Aceh cattle with HE staining. Area of one muscle fibers (a).
Based on a 95% confidence interval, the WBSF value of Aceh cattle in the present study was not different from Bali cattle and Ongole grade cattle, but the average value of WBSF obtained in Aceh cattle was higher than those of the other two cattle breeds. It is caused by the broader area of muscle fibers of Aceh cattle. The wider the muscle fibers, the higher the power needed to cut muscle fibers to produce a higher WBSF value.

[8] states that a low WBSF value is associated with tender meat, whereas a high WBSF value is associated with less tender meat. The wider area the muscle fibers, so the lower the tenderness of the meat. However, in this study, no correlation was found between the area of muscle fibers and WBSF values in semitendinosus muscles. The same thing was also found in a survey conducted by [8], but in that study found a negative correlation (-0.13) between tenderness and area muscle fibers in the longissimus thoracis muscle. It is possible that in this study, other factors affect meat tenderness. The content of collagen [6], postmortem withering process, and degradation of muscle protein [17] can also affect meat tenderness. [6] states that between muscle types, there are too many variations. Thus, the correlation of each type of muscle to each meat quality factor can be used as the basis for a program to increase profits selling meat.

Aceh cattle are included in Bos indicus species, so genetically, the species has a lower meat tenderness compared to Bos taurus. [18] states that Bos indicus has a higher WBSF value compared to Bos taurus. Aceh cattle and ongole grade cattle belong to the Bos indicus group, while Bali cattle are Bos javanicus.

4. Conclusion
Semitendinosus muscle of Aceh cattle has broad fibers, and WBSF values are the same as Bali cattle and Ongole grade cattle. Based on these two variables, the semitendinosus muscle is known to have the same level of tenderness as the tenderness of Bali cattle beef and Ongole grade cattle beef.

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