Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan
ISSN 2303-2227 eISSN 2615-594X
Accredited by National Journal Accreditation No. 105/E/KPT/2022
Vol. 13 No. 3 October 2025, Page: 146-151
DOI: https://doi.org/10.29244/jipthp.10.2.146-151
Available online at https://journal.ipb.ac.id/index.php/ipthp/index

Improvement of The Physical Quality of Local Beef with Different Wet Aging Period

G.T. Prilyadi[1], R. Priyanto[1], H. Nuraini[1*], & Supratikno[2]
[1]Department of Animal Production and Technology, Faculty of Animal Science, IPB University
[2]Division of Anatomy, Histology and Embryology, School of Veterinary Medicine and Biomedical Sciences, IPB University
Jl. Agatis, Kampus IPB Darmaga Bogor 16680, Indonesia
*Corresponding author: hnuraini@apps.ipb.ac.id
(Received 10-12-2024; Revised 08-03-2025; Accepted 22-05-2025)

ABSTRACT

Local cattle in Indonesia generally have lower productivity and meat quality, so fulfilling high-quality meat needs still relies on imported supplies. The study aims to explore the potential of lower-quality local beef to be aged so that the quality of local meat can be improved with parameter observed WBSF value, pH value, water binding capacity and percentage of cooking loss. This study used the wet aging method and the chosen samples of Bali cattle, Ongole crossbred cattle and Simmental crossbred cattle with aging periods of 1 day, 7 days, 14 days, 21 days and 28 days. Data were analyzed using a split plot split in time design. The results showed that aging improves the physical qualities of the beef, namely a significant decrease in WBSF value, while pH value, water binding capacity and percentage of cooking shrinkage were still within the standard value range despite changes observed within the aging period. Bali cattle achieved tender category (3.9-4.4 kg cm^{-2}) at 14 days aging period (4.08 kg cm^{-2}), while Ongole and Simmental crossbreds achieved tender category at 21 days aging period (4.27 and 3.76 kg cm^{-2}, respectively).

Keywords: Aging, beef, local cattle, tenderness

ABSTRAK

Sapi lokal di Indonesia pada umumnya memiliki produktivitas dan kualitas daging yang lebih rendah sehingga pemenuhan kebutuhan daging berkualitas tinggi masih bergantung pada suplai impor. Tujuan dari penelitian ini adalah untuk mengeksplor potensi daging sapi lokal yang berkualitas lebih rendah untuk dilayukan dengan tujuan meningkatkan kualitas daging tersebut. Penelitian ini menggunakan metode *wet aging* dengan sampel yang digunakan berasal dari sapi Bali, sapi Peranakan Ongole, dan sapi Peranakan Simmental yang dilayukan dengan periode 1 hari, 7 hari, 14 hari, 21 hari dan 28 hari. Data penelitian dianalisis menggunakan rancangan acak lengkap petak terpisah pada waktu berbeda. Hasil penelitian menunjukkan peningkatan kualitas fisik pada daging, terutama pada penurunan nilai WBSF secara signifikan, sementara untuk nilai pH, daya mengikat air dan susut masak masih dalam rentang nilai normal meskipun terdapat perubahan selama proses pelayuan. Daging sapi Bali mencapai nilai keempukan kategori empuk (3.9-4.4 kg cm^{-2}) dalam waktu pelayuan 14 hari (4.08 kg cm^{-2}), sementara daging sapi Peranakan Ongole dan Peranakan Simmental mencapai kategori yang sama dalam waktu pelayuan 21 hari (secara berurutan, 4.27 dan 3.76 kg cm^{-2}).

Kata kunci: Daging sapi, keempukan, pelayuan, sapi lokal

INTRODUCTION

Along with the development of technology, information exchanges as of today have become faster and broader. Cultural exchanges and spreads between regions, one of which is related to the meat culinary industry. In general, the foreign culinary industry requires high-quality food ingredients, such as beef, that meet specific standards. Therefore, imported goods were used to fulfill the needs. According to BPS (2024), the percentage of imported goods from the livestock industry in 2023 for the beef commodity is 35.79%, while for the live cattle commodity is 14.59%.

Beef tenderness is one of the physical qualities that determines the standard of beef quality. Based on the American Society for Testing and Materials International (2013), beef tenderness could be measured using the Warner Bratzler Shear Force (WBSF), with tenderness value ranges from >4.4 kg cm^{-2} is tough, 3.9-4.4 kg cm^{-2} is tender and <3.9 kg cm^{-2} is very tender.

Several local cattle in Indonesia have higher tenderness value, such as Bali cattle that descends from *Bos javanicus* cattle has the value of 5.8 kg cm^{-2}, Ongole crossbred cattle that descends from *Bos indicus* cattle has the value of 6.4 kg cm^{-2}, and Simmental crossbred cattle that descends from *Bos taurus* cattle has the value of 5.4 kg cm^{-2} (Safitri *et al.* 2018). These values mean that the local beef still falls in the 'tough' category, making it difficult for local cattle to enter the special culinary industry.

Beef aging is one of many methods for improving beef quality, such as flavor and tenderness, that utilize the activity of enzymes inside the beef itself (Kahraman and Gürbüz 2018). Beef aging has two methods; the dry and wet aging. According to Vitale *et al.* (2014), the wet aging method is more favorable to the customers. Despite its advantages, aging is generally used for imported beef, while local beef is rarely aged. Therefore, aged local beef businesses and studies are seldom found. One study exploring the theme is the aging of Bali cattle by Yulianti *et al.* (2023). The study compared Bali cattle's muscles in different aging periods, namely 1 day, 21 days and 42 days. The study resulted in a significance decrease WBSF value, achieving the tender category within 21 days aging period. Further study is needed to see the exact week the decrease of WBSF value achieves the tender category, while simultanously compare the decrease of WBSF value to other local aged beef. Therefore this study was conducted to further analyze the characteristics and determine which aged beef from seceral local cattle in Indonesia that has the potential to be premium commodity such as imported beef in a precise and optimum aging period. This study used local cattle that commonly found in Indonesia, descended from *Bos javanicus* cattle (Bali cattle), *Bos indicus* cattle (Ongole crossbred cattle) and *Bos taurus* cattle (Simmental crossbred cattle) with specified aging period that is 1, 7, 14, 21, and 28 days to obtain aged beef with tenderness value 3.9-4.4 kg cm^{-2} or 'tender' category.

MATERIALS AND METHODS

The research was conducted from December 2024 to March 2025, with samples taken from abattoirs in Bogor and Garut regencies, West Java. The samples were analyzed at the Department of Animal Production and Technology, Faculty of Animal Science, IPB University.

Local Beef Sampling

The research was conducted out using three different cattle breeds for the sample: Bali cattle, Ongole crossbred cattle, and Simmental crossbred cattle. The cattle were all female with an age range of I1-I2 or 1-2 years, estimated by dentition. The selection is due to the availability of the cattle in each abattoir that are frequently slaughtered. This study used 3 Bali cattle, 4 Ongole crossbred cattle and 4 Simmental crossbred cattle. The samples were taken from the *Longissimus dorsi* muscle, which was cut into five parts (without fixed weight) for five different aging periods (1 day, 7 days, 14 days, 21 days and 28 days). The aging method used was wet aging, with chilling temperature of 0-4 °C throughout the aging process.

pH Value

The pH value was measured by pH meter HANNA HI 99163 that has been calibrated. The beef was sliced slightly on the surface for the probe of the pH meter to measure the pH value. The measurements were done two times for every subsample, each in a different area of the same sample.

WBSF Value (Tenderness)

Beef tenderness was measured by the Warner-Bratzler Shear Force. Referring to Yulianti *et al.* (2023), around 200g of beef sample was cooked until the internal temperature of the beef reached 81°C (measured by a bimetal thermometer). The cooked beef sample was cut with a corer in the same direction as the beef's fibres. The cut sample was then measured tenderness using Warner-Bratzler Shear Force cutter.

Cooking Loss

The method to measure cooking loss referred to Soeparno (2009). Before cooking, the beef sample was weighed first with digital scales. The beef sample was cooked until the internal temperature reached 81 °C, and left for 24 hours to cool. The sample was weighed until it reached stable weight. The percentage of the cooking loss was calculated using the equation below.

$$CL (\%) = ((A-B) / A) \times 100\% \quad (1)$$

Where A is Raw sample's weight; B is Cooked sample's weight.

Water Holding Capacity

Water holding capacity was measured by measuring the area of the water formed around the sample between the Whatman paper filter pressed by the pressure gauge tool (Yulianti *et al*. 2023). The area of the water formed was measured by planimeter and calculated using the equation below (Hamm 1972).

$$mg\ H_2O = ((wet\ area\ (cm^2) / 0.0948) - 8.0 \quad (2)$$

The result of the equation above was then converted into percentage using another equation below.

$\%H_2O$ = (mg H_2O / sample's initial weight) × 100% (3)

Data Analysis

Data analysis used the split plot split in time method for the physical characteristics of the beef variable. The main plot was the breed of the cattle, while the sub-plot was the repetition factor. The analysis used the Generalized Linear Models program in the SAS OnDemand for Academics software.

RESULTS AND DISCUSSION

Local Cattle and Carcass Characteristics

The samples taken for this research were observed for each cattle's production characteristics, which is live weight, carcass weight and the carcass percentage. The results can be seen in Table 1. According to the observation results, the productivity of local cattle is still below the national average (Priyanto *et al.* 2019). Based on the same study done by Priyanto *et al.* (2019), cattle with lower productivity are more likely to produce lower carcass and beef quality; hence, it was suggested for farmers to improve the cattle's body fatness before slaughter. Factors that could lead to lower productivity are the traditional fattening system by local farmer that isn't optimized, uncontrollable cross-breeding, and other factors.

Leo *et al.* (2012) said that the average optimal Bali cattle live weight is around 300-350 kg, while Simmental crossbred is around 458,68 kg and Ongole crossbred is around 340-400 kg (Setiyono *et al*. 2017; Priyanto *et al.* 2019). Lower live weight cattle would produce lower carcass weight and percentage. According to Priyanto *et al*. (2019), the live weight, carcass weight and carcass percentage of local cattle indicate that slaughtered cattle were still in the feeder cattle category, meaning it hasn't reached the ideal characteristics to be slaughtered.

pH Value of The Aged Local Beef

The changes in pH value of the aged beef with different aging periods can be seen in Table 2. Results in Table 2 show that the means of pH values for all samples show significant changes in the first week of aging, but there is no interaction between the aging period and cattle breeds. From the second until the last week of aging, the changes are not significant. Research done by Ding *et al.* (2022) reveals that the beef would reach the ultimate pH value within 24 hours after the rigor mortis process.

Changes in pH value presumably come from accumulation of lactic acid and H^+ ions which are byproducts of the glycolysis and hydrolysis of ATP. According to Yulianti *et al.* (2023), the ultimate pH value achieved when the glycolysis and hydrolysis of ATP stopped, specifically when the glycogen reserve was fully depleted. This is why glycogen reserve is essential, as it will affect the pH value. One of the many factors that can affect glycogen reserve is stress level. Cattle with higher stress level may have lower or higher glycogen reserve than normal, resulting in PSE (pale, soft and exudative) or DFD (dark, firm and dry) beef.

Gliga *et al.* (2024) reported that the decline of the pH value happened because there is a decline of ion charge in the muscle's protein until it reached the isoelectric point. Referring to Buckle *et al.* (1987), the normal pH value after rigor mortis was around 5.1-6.2, while according to Kurniawan *et al.* (2014), the pH value at the isoelectric point was around 5.4-5.8. In this study, the only sample that reached the isoelectric point was the beef from Simmental crossbred cattle. The other two samples have pH values below the isoelectric point, allegedly because the cattle before slaughter undergo stress, which triggers lower decline of pH value.

WBSF Value (Tenderness)

The changes in WBSF value or tenderness of the aged beef with different aging periods are shown in Table

Table 1. Distributions of live weight, carcass weight and carcass percentage

Cattle Breeds	Variable		
	Live weight (kg)	Carcass weight (kg)	Carcass percentage (%)
Bali	219.66 ± 69.66	108.43 ± 33.42	49.54 ± 0.11*
Ongole crossbred	230.00 ± 35.59	94.75 ± 9.32**	41.47 ± 0.25
Simmental crossbred	362.50 ± 15.00*	152.25 ± 21.07*	41.88 ± 0.44

Numbers with different star sign on columns show significant differences (P<0.05)

Table 2. Average pH value of the aged beef

Aging Period	Cattle Breeds			
	Bali	Ongole Crossbred	Simmental Crossbred	Average
D1	5.46 ± 0.09	5.37 ± 0.08	5.47 ± 0.08	5.43 ± 0.04*
D7	5.33 ± 0.09	5.21 ± 0.08	5.30 ± 0.08	5.28 ± 0.04**
D14	5.42 ± 0.09	5.24 ± 0.08	5.42 ± 0.08	5.37 ± 0.04
D21	5.34 ± 0.09	5.15 ± 0.08	5.64 ± 0.08	5.38 ± 0.04
D28	5.25 ± 0.09	5.18 ± 0.08	5.60 ± 0.08	5.34 ± 0.04
Average	5.36 ± 0.04*	5.23 ± 0.03**	5.49 ± 0.03***	

Numbers with different star sign on columns (cattle breeds) and rows (aging period) show significant differences (P<0.05)

Table 3. The average of WBSF value of the aged beef (kg cm^{-2})

Aging Period	Cattle Breeds			
	Bali	Ongole Crossbred	Simmental Crossbred	Average
D1	7.11 ± 0.36	6.64 ± 0.31	6.79 ± 0.31	6.84 ± 0.19*
D7	4.87 ± 0.36	5.30 ± 0.31	6.25 ± 0.31	5.47 ± 0.19**
D14	4.08 ± 0.36	4.67 ± 0.31	4.52 ± 0.31	4.42 ± 0.19***
D21	3.55 ± 0.36	4.27 ± 0.31	3.76 ± 0.31	3.86 ± 0.19
D28	3.15 ± 0.36	3.95 ± 0.31	3.35 ± 0.31	3.48 ± 0.19****
Average	4.55 ± 0.16	4.97 ± 0.13	4.93 ± 0.13	

Numbers with different star sign on columns (cattle breeds) and rows (aging period) show significant differences (P<0.05)

3 below. According to ASTM International (2013), the WBSF value is the weight needed (kg) to cut through the surface of the beef (cm^{-2}). Higher WBSF value means the beef is tougher and vice versa. The WBSF value has three categories: the tough category has value more than 4.4 kg/cm^2, the tender category has value between 3.9-4.4 kg/cm^2, and the very tender category has value less than 3.9 kg/cm^2. Based on the analysis in Table 2, significant differences in WBSF value are seen throughout the process of aging period, except for the third week (D21). On the other hand, there is no significant difference between all breeds, yet there are differences in the decrease of the WBSF values to reach the tender category for each cattle breed. Bali cattle need 14 days to reach the tender category, while Ongole crossbred and Simmental crossbred need 21 days to reach the same category.

Sutarno and Setyawan (2016) report that Bali cattle have good carcass and meat quality because the *Bos javanicus* cattle are descendants of Zebu cattle and local bison. Due to its small frame, Bali cattle have an early-maturing trait and have less connective tissue in their muscles. Therefore, Bali cattle beef could achieve the tender category quicker than other breeds.

Zebu cattle originated from India, from which Ongole cattle came. Even though both have the same blood, Ongole crossbred cattle show a slower decrease of WBSF value, which can be seen in a longer time to reach the tender category and have tougher meat than Bali cattle. This was suspected due to cattle that are a descendant of *Bos indicus,* usually used to work because of its larger frame; therefore, the related connective tissue would become more rigid to accommodate heavy workload. As the muscle becomes more rigid, the beef would be tougher. That is why the Ongole crossbred showed a higher WBSF value.

Simmental crossbred is a descendant of a meat-type *Bos taurus* (Sutarno and Setyawan 2016). Local cattle were crossbred with *Bos taurus,* hoping to achieve a type of cattle that produces good quality of meat and carcass but has good adaptability in tropical climate. According to the analysis result, even though it wasn't significant, the Simmental crossbred's tenderness in the last week of aging is higher than Bali cattle but lower than Ongole crossbred cattle. This result was suspected because the percentage of *Bos taurus*'s blood is lower, hence the decrease in the quality of the beef. The genetic changes in this case are more complex to trace because local farmers aren't used to recording things when they crossbred cattle, so the results would be harder to trace and predict (Putro 2009).

Water Holding Capacity

The percentage of free water formed in the aged beef in different aging periods is shown in Table 4 below. The percentage of free water formed could be used to estimate the water holding capacity of the beef. A higher percentage of free water formed means a lower in water binding capacity of the beef and vice versa. Based on Table 4, all breeds' water holding capacity significantly decreased in the first week, yet it is still in the normal range.

The percentage of water holding capacity correlates with changes in pH value. Yulianti *et al.* (2023) said that water holding capacity may increase after 24 hours of aging process due to changes in ions stored in the muscle protein. The same conclusion reported by Brugiapaglia *et al.* (2015) is that there is an interaction between protein and ion changes, hence the room in the capillary could absorb water more water. The mentioned studies above go according to

Table 4. The average of water holding capacity percentage of the aged beef (%)

Aging Period	Cattle breed			Average
	Bali	Ongole Crossbred	Simental Crossbred	
D1	30.67 ± 0.53	30.89 ± 0.46	29.93 ± 0.46	30.50 ± 0.29*
D7	31.50 ± 0.53	32.31 ± 0.46	30.38 ± 0.46	31.40 ± 0.29**
D14	33.39 ± 0.53	32.20 ± 0.46	29.59 ± 0.46	31.72 ± 0.29
D21	32.18 ± 0.53	32.48 ± 0.46	29.76 ± 0.46	31.47 ± 0.29
D28	33.92 ± 0.53	31.80 ± 0.46	30.27 ± 0.46	31.99 ± 0.29
Average	32.33 ± 0.25	31.94 ± 0.21	29.99 ± 0.21*	

Numbers with different star sign on columns (cattle breeds) and rows (aging period) show significant differences (P<0.05)

Tabel 5. The average of cooking loss percentage of the aged beef (%)

Aging Period	Cattle Breeds			Average
	Bali	Ongole Crossbred	Simmental Crossbred	
D1	43.33 ± 3.56	47.13 ± 3.08	51.19 ± 3.08	47.21 ± 1.93
D7	50.07 ± 3.56	55.61 ± 3.08	65.39 ± 3.08	57.02 ± 1.93*
D14	40.37 ± 3.56	47.08 ± 3.08	51.10 ± 3.08	46.18 ± 1.93
D21	44.42 ± 3.56	53.51 ± 3.08	48.85 ± 3.08	48.92 ± 1.93
D28	45.68 ± 3.56	51.11 ± 3.08	45.82 ± 3.08	47.54 ± 1.93
Average	44.77 ± 1.64*	50.88 ± 1.42	52.47 ± 1.42	

Numbers with different star sign on columns (cattle breeds) and rows (aging period) show significant differences (P<0.05)

Hamm's theory of electrostatic (1972), which states that the increase of water holding capacity is determined by the amount of charged protein, which repels groups of protein molecules with the same negative or positive charge. The repelations trigger swelling of myofibrils and partial destruction of actomyosin complexes (Kudryashov and Kudryashova 2023). Therefore, the water holding capacity of the beef became higher as the aging process went longer. This phenomenon can be seen for all the samples, from Bali cattle beef with lower pH value and water holding capacity to Simmental crossbred with higher pH value and water holding capacity.

Cooking Loss

The percentage of cooking loss of the aged beef in different aging periods is shown in Table 5 below. Based on the results shown in Table 4, the overall cooking loss percentages are higher than those of Brahman Cross cattle (Brahmantiyo *et al.* 2000; Yanti *et al.* 2008) but considerably lower than the percentage of Bali cattle in the research of Yulianti *et al.* (2023). One of the factors suspected to have affected the result is the difference in carcass handling for every slaughterhouse and the sample collection method.

The muscle of the beef with different sarcomere length, sample weight and the contraction of myofibril status would result in different percentages of cooking loss (Kiran *et al*. 2015; Yulianti *et al.* 2023). Moreover, the percentage of cooking loss was affected by pH value and the percentage of water holding capacity.

According to Soeparno (2015) and Moniaga *et al.* (2023), the decrease in pH value would further affect the water holding capacity of the beef, hence the increase in cooking loss percentage of the beef. The same sentiment reported by Wyrwisz *et al.* (2016) is that the percentage of cooking loss is affected by the activity of enzymes which can be seen in the decrease of the pH value. However, based on the results shown in Table 5, the percentage of cooking loss did not go according to the mentioned studies above. According to Kudryashov and Kudryashova *et al.* (2023), when the meat undergoes the cooking process, it could trigger denaturation and coagulation of the protein, which causes the water binding capacity of the meat to decrease. Therefore, the percentage of cooking loss would be higher for the Simmental crossbred beef sample.

In the study by Lawrie and Ledward (2006), it was stated that high quality beef has lower percentage of cooking loss. This is due to higher percentage of cooking loss, which means higher weight loss in the cooked beef; therefore, the amount of beef that customers could eat would be less. This can cause significant economic loss for both the customer and seller if not handled appropriately. However, according to Ortez *et al.* (2022), customers would be willing to pay more for a higher quality beef, such as aged beef. Therefore, the seller could increase the beef price with added value (aging) that aligned with the increase in the beef's quality.

CONCLUSION

The wet aging method on local cattle beef increased the tenderness of the beef. The aging period could decrease WBSF value and improve the beef's tenderness significantly, while for other physical qualities have also changed considerably, but are still within the normal range. The ideal aging time for local beef varies for each breed, namely 14 days for Bali cattle and 21 days for Ongole and Simmental crossbred cattle. Further study is needed for the cattle sampled to be at optimum live weight and stress-free before slaughter to achieve the best result. Another suggestion is to directly compare the increase in aged beef's physical qualities for local and imported cattle to highlight more of the local cattle's potential to be a premium quality product.

ACKNOWLEDGEMENT

The sample of Bali cattle was provided by the Pan-transcriptome of Bali Cattle Project, Badan Riset dan Inovasi Nasional (BRIN) in November 2024.

REFERENCES

ASTM International (American Society for Testing and Materials International). 2013. Standard specification for tenderness marketing claims associated with meat cuts derived from beef. doi: 10.1520/F2925-11R18.

BPS (Badan Pusat Statistik). 2024. Peternakan dalam angka 2024. Jakarta: Direktorat Statistik Peternakan, Perikanan dan Kelautan. ISSN:2714-8416.

Brahmantiyo, B. 2000. Sifat fisik dan kimia daging sapi brahman cross, angus, dan murray grey. Med Vet. 13(3):153-161.

Brugiapaglia, A., G. Destefanis, & L. Vincenti. 2015. Extended dry ageing time effect on water holding capacity and colour of piemontese cull cow beef. 61st International Congress of Meat Science and Technology; 2015 Agu 23-28, Clermont-Ferrand, Perancis. Perancis: INRA-Centre de recherce, Auvergne-Rhône-Alpes.

Buckle, K. A., R. A. Edwards, G. H. Fleet, & M. Wootton. 1987. Ilmu Pangan. Hari Purnomo Adiono; penerjemah. Jakarta: UI Press.

Gliga, M. C., A. P. David, G. M. Câtunescu, I. M. Bodea, M. León-Camacho, & M. Tofanâ. 2024. The pH trends of beef meat during two aging processes. Agricultura. (1-2):358-264.

Hamm, R. 1972. Colloidal chemistry meat: Water-binding capacity of muscle in theory and practice. Berlin: Paul-Parey-Verlag.

Kahraman, H. A., & U. Gürbüz. 2018. Aging applications on beef meat. MJEN. 6(1):7-13.

Kiran, M., B. M. Naveena, K. S. Reddy, M. Shashikumar, V. R. Reddy, V. V. Kulkarni, S. Rapole, T. H. More. 2015. Muscle-specific variation in buffalo (Bubalus bubalis) meat texture: biochemical, ultrastructural and proteome characterization. J Texture Stud. 46(4):254-261.

Kudryashov, L. S., & O. A. Kudryashova. 2023. Water-holding and water-binding capacity of meat and methods of its determination. Theory Prac Meat Precess. 8(1):62-70.

Kurniawan, N. P., D. Septinova, & K. Adhianto. 2014. Kualitas fisik daging sapi dari tempat pemotongan hewan di Bandar Lampung. JIPT. 2(3):133-137.

Lawrie, R. A., & D. A. Ledward. 2006. Lawrie Meat Science 7th Edition. UK: Woodhead Publishing Limited.

Leo, T. K., D. E. Leslie, S. S. Loo, M. Ebrahibgmi, Z. A. Aghwan, J. M. Panandam, A. R. Alimon, S. A. Karsani, & A. O. Sazili. 2012. An evaluation on growth performance and carcass characteristics of integration (oil palm plantation) and feedlot finished Bali cattle. J Anim Vet Adv. 11:3427-3430.

Moniaga, C. A., N. L. P. Sriyani, & N. L. G. Sumardani. 2023. Kualitas fisik daging sapi bali segar, dingin dan beku. J Peternakan Tropika. 11(2):386-396.

Ortez, M., N. O. Widmar, N. M. Thompson, & Y. H. B. Kim. 2022. Valuation of dry and wet aged beef by U.S. consumers. Q Open. 2:1-15.

Priyanto, R., H. Nuraini, Muladno, M. Ismail, & H. Wijayanto. 2019. Slaughter, carcass and non-carcass characteristics of local cattle and buffalo in Indonesia. PJN. 18(2):117-124.

Putro, P. 2009. Crossbreeding impact on the reproduction of parent offspring, clinical study results. Workshop on Crossbreeding Cattle in Indonesia: Applications and Implications for Development of Cattle in Indonesia, Lustrum VIII. Universitas Gadjah Mada.

Safitri, A., R. Priyanto, I. K. M. Adnyane, & H. Nuraini. 2018. Karakteristik fisik dan mikrostruktur otot semitendinosus pada sapi lokal dan sapi impor. JVeteriner. 19(4):488-496.

Setiyono, A. H. A. Kusuma, & Rusman. 2017. Pengaruh bangsa, umur, jenis kelamin terhadap kualitas daging sapi potong di Daerah Istimewa Yogyakarta. Bul Peternakan. 41(2):176-186.

Soeparno. 2009. Ilmu dan Teknologi Daging. Yogyakarta: Gadjah Mada University Press.

Sutarno, & A. D. Setyawan. 2016. The diversity of lokal cattle in Indonesia and the efforts to develop superior indigenous cattle breeds [review]. Biodiversitas. 17(1):275-295.

Vitale, M., M. Pèrez-Juan, E. Lloret, J. Arnau, & C. E. Realini. 2014. Effect of aging time in vacuum on tenderness, and color and lipid stability of beef from mature cows during display in high oxygen atmosphere package. Meat Sci. 96(1):270-277.

Wyrwisz, J., M. Moczkowska, M. Kurek, A. Stelmasiak, A. Póltorak, & A. Wierzbicka. 2016. Influence of 21 days of vacuum-aging on color bloom development and WBSF of beef semimembranosus. Meat Sci. 122:48-54.

Yanti, H., Hidayati, Elfawati. 2008. Kualitas daging sapi dengan kemasan plastik PE (polyethylene) dan plastik PP (polypropylene) di pasar Arengka Kota Pekanbaru. J Peternakan. 5(1):22-27.

Yulianti, K. D., R. Priyanto, & H. Nuraini. 2023. Karakteristik fisik tiga jenis otot dengan lama pelayuan yang berbeda. JIIIP. 26(1):11-20.