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**FACTORS INFLUENCING THE TIME OF DEATH OF BALINESE CATTLE
AND THEIR IMPLICATIONS FOR HUMANE HALAL SLAUGHTER AT THE
PALOPO CITY SLAUGHTERHOUSE**

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ABSTRAK: Efektivitas proses pemotongan adalah aspek penting untuk memastikan praktik pemotongan yang efisien dan mendukung penanganan yang manusiawi sesuai dengan prinsip kehalalan. Waktu yang dibutuhkan sapi mati sempurna setelah pemotongan dipengaruhi oleh berbagai faktor biologis dan teknis terkait pemotongan; namun, bukti empiris dari rumah potong hewan Kota Palopo masih terbatas. Studi ini bertujuan menganalisis efek karakteristik biologis dan faktor teknis terkait pemotongan terhadap waktu kematian sapi Bali di Rumah Potong Hewan Kota Palopo, Indonesia. Pendekatan kuantitatif deskriptif digunakan dengan pengamatan langsung terhadap sapi Bali yang disembelih selama periode studi. Variabel yang diteliti meliputi jenis kelamin, usia, berat badan, dan jumlah penarikan pisau, sementara waktu kematian digunakan sebagai variabel dependen. Data dikumpulkan melalui pemeriksaan gigi untuk estimasi usia, pengukuran berat badan menggunakan timbangan ternak digital yang dikalibrasi, pengukuran waktu kematian menggunakan stopwatch digital, dan daftar periksa observasi terstruktur selama proses penyembelihan. Data yang dikumpulkan dianalisis menggunakan regresi linier ganda untuk mengevaluasi hubungan antara variabel independen dan waktu kematian. Temuan menunjukkan bahwa karakteristik biologis dan faktor teknis terkait pemotongan secara kolektif berkontribusi pada variasi waktu yang dibutuhkan sapi Bali untuk mencapai kematian setelah pemotongan. Di antara variabel yang diamati, jenis kelamin dan berat badan diidentifikasi berpengaruh positif dan signifikan terhadap waktu kematian, sedangkan usia dan jumlah tarikan pisau menunjukkan tidak berpengaruh positif dan signifikan. Temuan ini memberikan informasi dasar untuk meningkatkan pengelolaan rumah potong hewan, meningkatkan efisiensi pemotongan, dan mendukung penerapan praktik penanganan yang manusiawi yang konsisten dengan prinsip penyembelihan halal. Kata kunci: Kesejahteraan Hewan; Penyembelihan Halal; Post-Mortem; RPH; Sapi Bali.

ABSTRACT: The effectiveness of the slaughtering process is an important aspect to ensure efficient slaughtering practices and support humane handling in accordance with halal principles. The time it takes for a cow to die perfectly after slaughter is influenced by various biological and technical factors related to slaughter; however, empirical evidence from the Palopo City slaughterhouse is still limited. This study aims to analyze the effect of biological characteristics and technical factors related to slaughter on the time of death of Balinese cattle at the Slaughterhouse in Palopo City, Indonesia. A descriptive quantitative approach was used with direct observation of Balinese cattle slaughtered during the study period. The variables studied included gender, age, weight, and number of knife draws, while time of death was used as a dependent variable. Data were collected through dental examinations for age estimation, weight measurement using a calibrated digital livestock scale, time-of-death measurement using a digital stopwatch, and a structured observation checklist during the slaughter process. The collected data were analyzed using multiple linear regression to evaluate the relationship between independent variables and time of death. The findings suggest that biological characteristics and technical factors related to slaughter collectively contribute to the variation in the time it takes Balinese cattle to reach death after slaughter. Among the observed variables, sex and weight were identified as having a positive and significant effect on the time of death, while age and number of knife pulls showed no positive and significant effect. These findings provide basic information to improve slaughterhouse management, improve slaughterhouse efficiency, and support the implementation of humane handling practices consistent with halal slaughter principles. Keyword: Animal Welfare; Balinese Cattle; Halal Slaughter; Postmortem; RPH.

INTRODUCTION

Author Animal welfare, *starting* from the pre-slaughter process (*ante mortem*) and post-slaughter (Postmortem), refers to the phase after slaughter. The welfare aspects before and during slaughter (handling, stress, restrain, stunning if used) greatly affect post-slaughter results. Welfare evaluations are often included in the measurement of effectiveness because they have an impact on meat quality and consumer perception (Barrasso et al., 2020).

Animal welfare is generally defined as the physical and mental state of an animal with respect to the conditions in which it lives and dies, with a focus on how the animal "copies" (*copies*) the living conditions imposed on it. An animal is in a state of good well-being if, based on scientific evidence: healthy, comfortable, nutritious, safe, able to express natural behavior, and does not suffer from unwanted conditions such as pain, fear, or chronic stress (Escobar et al., 2018).

Animal welfare is rooted in Brambell (1965), and it is focused on the *Five Freedoms*. *This simple framework* demands the freedom of animals from hunger/dehydration, discomfort, pain/injury/disease, fear/stress, as well as the freedom to express natural behavior. *The Five Freedoms* became the starting point for policy and the broad public in many countries. However, due to its normative nature and focus on the prevention of negativity, this model is considered inadequate to assess the mental aspects and positive experiences of animals.

Animal welfare after slaughter is an important part of the application of animal welfare principles in slaughterhouses because it is related to efforts to minimize animal pain, stress, and suffering until the animal completely dies. The post-slaughter stage includes the process of *bleeding*, observation of loss of consciousness, perfect death, and handling of the carcass. According to the *European Food Safety Authority* (EFSA), indicators of animal welfare after slaughter can be observed through the loss of corneal reflexes, cessation of rhythmic breathing, absence of response to pain stimuli, loss of body coordination, and cessation of heart rate. Animals that still show signs of consciousness after slaughter are considered to

have a welfare disorder because they are still able to feel pain and stress (Grandin, 2014).

Increasing global awareness of animal welfare has also prompted policy changes in many countries. The European Union, for example, has implemented regulations that require stunning before slaughter except for certain religious reasons. In Indonesia, regulations regarding animal welfare are regulated in Law Number 18 of 2009 concerning Animal Husbandry and Health and Government Regulation Number 95 of 2012 concerning Veterinary Public Health and Animal Welfare. However, the implementation in the field still faces obstacles, especially in non-commercial RPH and traditional sacrificial slaughter activities.

Previous studies have examined the relationship between animal welfare and halal slaughter, mainly focusing on stunning methods, slaughter techniques, meat quality, and consumer perceptions in commercial slaughterhouses (Farouk et al., 2016). However, empirical evidence on the integration of animal welfare principles and halal compliance in local government-managed slaughterhouses, particularly those processing Balinese cattle, remains limited. Existing research has also given little attention to the postmortem stage, where bleeding efficiency and confirmation of death are crucial for both animal welfare and halal validity. Consequently, a research gap remains in understanding how animal welfare practices during slaughter affect postmortem halal status under actual slaughterhouse conditions.

This issue is particularly relevant at the Palopo City Slaughterhouse (RPH), where Balinese cattle are predominantly slaughtered, making it important to evaluate compliance with international animal welfare standards and Islamic Sharia requirements. The novelty of this study lies in its integrated assessment of animal welfare implementation and postmortem halal status within a single analytical framework, providing empirical evidence that connects veterinary science, animal welfare, and Islamic halal principles while offering practical recommendations to improve slaughterhouse management and strengthen public confidence in halal meat production.

MATERIALS AND METHODS

Types of research

This study employed a descriptive quantitative approach. The quantitative approach was selected to measure and analyze the effectiveness of the time of death, the number of knife pulls, and the number of severed blood vessels after slaughter through numerical data collection and statistical analysis. The descriptive analytical method was used to describe and evaluate the slaughtering process of Balinese cattle based on halal slaughtering practices and animal welfare principles. The study focused on analyzing animal welfare in relation to postmortem halal status at the Palopo City Slaughterhouse (RPH).

The research variables consisted of Animal Welfare, Time of Death, Number of Knife Pulls, and Number of Severed Blood Vessels. Time of death was measured as the interval (in seconds) from the completion of the neck incision until the animal was confirmed dead. Confirmation of death was determined using standard physiological indicators, including the absence of rhythmic breathing, disappearance of the corneal reflex, loss of heartbeat, complete cessation of voluntary body movements, and fully dilated pupils. These indicators were observed directly by trained personnel to ensure an accurate determination of death before postmortem handling. The number of knife pulls was recorded by counting the total forward and backward movements of the knife required to complete the neck incision, while the number of severed blood vessels was assessed through direct observation of the complete transection of the trachea, esophagus, both carotid arteries, and both jugular veins in accordance with halal slaughtering requirements and animal welfare standards.

Location and time of the study

Location is a place where research will be carried out and take and search in depth information related to what will be taken and searched. This research was carried out at RPH Bukit Lewadang Kel. Purangi, Sendana District, RPH Fadil Pratama, and RPH by Mandiri, which are located in Kel. Songka, South Wara District, and RPH Sipatuo, RPH Albaroqah, and RPH Bangkit Sanjaya, which are located in Salobulo

Village, Kec. Wara Utara Palopo City, which routinely slaughters Balinese cattle for consumer needs in the local market of Palopo City. The research time was carried out for one month in March 2026.

Population, samples, and sampling techniques

The population comprised all Balinese cattle slaughtered and all slaughterhouse personnel involved in the slaughtering process at the Palopo City Slaughterhouse (RPH) during the study period. Following Sigit & Wiwit (2022), population refers to the complete set of individuals or objects that meet the research criteria and constitute the focus of investigation.

Data were collected through direct observation and measurement during the slaughtering process. The age of each animal was estimated using dentition examination based on the eruption and wear pattern of the permanent incisor teeth, which is the standard method for age determination in cattle. Body weight was obtained using the slaughterhouse's calibrated digital livestock weighing scale prior to slaughter. The time of death was measured using a digital stopwatch, starting immediately after completion of the neck incision until death was confirmed by the absence of rhythmic breathing, corneal reflex, heartbeat, and voluntary body movements. The number of knife pulls was determined by counting each complete forward and backward movement of the knife during the neck incision until all required anatomical structures were completely severed. The number of severed blood vessels was assessed through direct postmortem observation to verify complete transection of the trachea, esophagus, both carotid arteries, and both jugular veins.

To ensure the reliability of observations, two trained observers independently recorded all measurements using a standardized observation checklist developed from halal slaughter and animal welfare guidelines. Prior to data collection, the observers received training on the operational definitions of each variable and conducted pilot observations to standardize assessment procedures. Any discrepancies between observers were resolved through joint review and consensus, and measurements were recorded only after agreement was achieved. The instruments used in this study included a

calibrated digital livestock weighing scale, a digital stopwatch, and a structured observation checklist for recording animal welfare indicators, knife pulls, severed blood vessels, and time of death..

Data analysis

The analysis tool used in this study is a linear regression analysis model with the aim of finding out the relationship between variables directly by using the SPSS application. This analysis is to determine the direction of the relationship between independent variables and dependent variables, whether each independent variable is positively or negatively related, and to predict the value of the dependent variable if the value of the independent variable increases or decreases (Ghozali, 2018). The data used is interval or ratio scale.

RESULTS

Overview of Research Locations

Palopo City is one of the municipalities in South Sulawesi Province. Although the potential of the agricultural and plantation sectors in this region is not very large, the region still has opportunities for development. The following description provides an overview of the research location:

Geographical Location of Palopo City

Palopo City covers an area of 247.52 km² and consists of nine sub-districts, 48 sub-

districts. The region consists mostly of hills and mountains with an altitude between 501 and 1000 meters above sea level (mdpl), which makes it cool and fertile. The climate in Palopo City is humid tropical, with rainfall of 2,100–2,700 mm/year, especially during the rainy season. The average air temperature is around 32 °C, depending on the altitude of the place. With an average of 5.2–8.5 hours of sunlight each day, the air humidity level reaches 85% (Arif et al., 2021).

The distribution of the area of each sub-district in Palopo City can be seen in Table 1 and the Palopo City Map in Figure 1 below:

Table 1. Area of Sub-districts in Palopo City in 2024

No	District Name	Area (km ²)
1	Wara	11,49
2	Wara Timur	12,08
3	Wara Barat	47,89
4	Wara Utara	11,89
5	Wara Selatan	19,30
6	Sendana	48,01
7	Bara	37,29
8	Telluwana	36,44
9	Mungkajang	23,13
Quantity		247,52

Source: (BPS Palopo, 2024)



Figure 1. Palopo City Map
(<https://www.google.com/maps/place/Palopo+City,+South+Sulawesi>)

Table 2. Number of RPH in Palopo City

NO	RPH NAME	LOCATION	STATUS
1	Bukit Lewadang	Purangi	Government-Owned
2	Fadil Pratama	Songka	Private
3	Karya Mandiri	Songka	Private
4	Sipatuo	Salobulo	Private
5	Bangkit Sanjaya	Salobulo	Private
6	Al'Baroqah	Salobulo	Private

Source: Palopo City Agriculture Office 2026

Table 3. Distribution of the Number of Sample Cows Slaughtered During the Research

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	11	18,3	18,3	18,3
	Female	49	81,7	81,7	100,0
	Total	60	100,0	100,0	

Source: SPSS, data processed by researcher 2026

Slaughterhouses in Palopo City

Based on Table 2 presented in the Palopo City area, there are several Slaughterhouses (RPH) that operate with different ownership statuses. The Bukit Lewadang RPH located in Purangi is owned by the government, while most of the other RPHs are managed by the private sector. In the Songka area, there are two private RPHs, namely Fadil Pratama and Karya Mandiri. Meanwhile, in Salobulo Village, there are three private RPHs, namely Sipatuo, Bangkit Sanjaya, and Al'Baroqah. The existence of RPH with diverse ownership status shows the role of the government as well as the contribution of the private sector in supporting the needs of animal slaughter in Palopo City.

Distribution of Cow Samples by Gender During the Study

Based on the results of the tabulation of data in Table 3, the number of cattle samples in this study is 60. Of the total, the majority of cow samples were females, with a total of 49 heads or 81.7%. Meanwhile, the sample of bulls only

amounted to 11 heads or 18.3%. The cumulative percentage shows that the entire data has been fully distributed to 100%. This illustrates that the composition of respondents in the study is more dominated by the female cow group than the bull.

Statistical Analysis

Normality Test

Based on Table 4 above, the calculations are carried out to find the Z value calculated.

Animal Sex variables = Zskewness = $(-0.679)/0.309 = -2.197$, Zkurtosis = $(0.846)/0.608 = 1.391$

Ages = Zskewness = $(0.403)/0.309 = 2.737$, Zkurtosis = $(0.236)/0.608 = 0.388$

Variable kinfe pull = Zskewness = $(-0.468)/0.309 = -1.514$, Zkurtosis = $(0.072)/0.608 = 0.118$

Variabel Body weight = Zskewness = $(0.595)/0.309 = 1.925$, Zkurtosis = $(0.866)/0.608 = 1.423$

Time of Death Variable = Zskewness = $(0.315)/0.309 = 1.019$, Zkurtosis = $(0.761)/0.608 = 1.251$

Table 4. Test of Skewness and Kurtosis Ratio (Descriptive Statistics)

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Animal_Sex	60	-0,679	,309	0,846	,608
Ages	60	0,403	,309	0,236	,608
Kinfe_Pull	60	-0,468	,309	0,072	,608
Body_Weight	60	0,595	,309	-0,866	,608
Time_of Death	60	0,315	,309	0,761	,608
Valid N (listwise)	60				

Source: SPSS, data processed by researchers, 2026

From the calculation of the Z value, the two tests are below the critical value, which is between -2 and +2, and are then distributed normally.

Multikolinieritas

Table 5. Heteroscedasticity Test Results
(Coefficients^a)

Model		Collinearity Statistics	
		Tolerance	VIF
1	Animal sex	,715	1,398
	Age	,942	1,062
	Knife Pull	,943	1,060
	Body Weight	,708	1,413

a. Dependent Variable: Time of Death

Source: SPSS, data processed by researchers, 2026

From Table 5. It can be ascertained that the variables in this study are free from multicollinearity symptoms because the VIF value of each variable is still < 10 with a tolerance value of > 0.1.

From Table 6 above, presents the results of the multiple linear regression analysis examining the effects of time of death, the number of severed blood vessels, and the number of knife pulls on postmortem halal status. The results indicate that time of death had a positive regression coefficient (B = 109.154) but was not statistically significant at the 5% significance level (t = 1.886, p = 0.065), although it showed a marginal association with postmortem halal status. The number of severed blood vessels had a negative and non-significant effect (B = -4.280,

Uji Heteroskedastisitas

Tabel 6. Hasil Uji Heteroskedastisitas (Coefficients^a)

Model		Unstandardized Coefficients		Standardized Coefficients	
		B	Std. Error	Beta	t
1	(Constant)	646,534	201,686		3,206
	Anima sex	109,154	57,888	,267	1,886
	Age	-4,280	13,674	-,039	-,313
	Knife Pull	-84,990	55,551	-,189	-1,530
	Body Weight	1,439	,469	,437	3,071

a. Dependent Variable: Time of Death

Source: SPSS, data processed by researchers, 2026

Tabel 7. Determination Test Results (R²) (Model Summary)

Model		Change Statistics			
		R Square Change	F Change	df1	df2
dimension0	1	,212 ^a	3,695	4	55

Source: SPSS, data processed by researchers, 2026

t = -0.313, p = 0.755). Similarly, the number of knife pulls was negatively associated with postmortem halal status but did not reach statistical significance (B = -84.990, t = -1.530, p = 0.132). Overall, none of the explanatory variables significantly predicted postmortem halal status at the 5% significance level, suggesting that other biological or slaughter management factors may play a more important role in determining postmortem halal compliance.

Multiple Linear Regression Analysis

Multiple linear regression analysis is used to assess the influence of one or more predictor variables (independent variables) on dependent variables.

Koefisien Determinasi (R²)

The coefficient of determination (R²) measures how far the model can explain the variation of the dependent variable based on the value of R² (R Square). If the value of the coefficient of determination is close to zero (0), then the correlation is said to be weak. If the value of the coefficient of determination is close to one (1), then the correlation is said to be strong. The value of the determination coefficient (R²) for the regression equation is presented in Table 7.

From Table 8 above, you can see that the value of R-squared is 0.212. This figure shows that the influence of body weight, skin pull, age, and gender is 21.2%, while the remaining 78.8%

Table 8. F Test Results (ANOVA^b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	318362,068	4	79590,517	3,695	,010 ^a
	Residual	1184578,115	55	21537,784		
	Total	1502940,183	59			

a. Predictors: (Constant), Body weight, Knife Pull, Age, Gender, Time of Death

b. Dependent Variable: Time of Death

Source: SPSS, data processed by researchers, 2026

is influenced by other variable factors that are not present in this study or error values.

F test

The F test is used to find out whether the independent variables simultaneously in the model have an effect on the dependent variables by using a significance threshold of 0.05. If the significance value is > 0.05 is considered insignificant, or the hypothesis is rejected, and if the significance value is < 0.05 is declared significant, or the hypothesis is accepted. The results of the F test for the first regression equation are presented in the following Table 8:

The results of the F-test statistical calculation in Table 8 show that the F-value is calculated as 3,695. After that, compared to the F value of the table of 2.52 with a significance of 5% (0.05). So it can be concluded that F calculates $> F$ table ($3.695 > 2.52$) with Sig F $0.010 < 0.05$, this means that the independent variables together have a positive and significant effect on the dependent variables, so it is stated that this regression model is feasible to use.

Partial test (Uji t)

The t-test is used to find out the extent to which each independent variable explains the dependent variable by using a significance threshold of 0.05. If the significance value is > 0.05 is considered insignificant, or the hypothesis is rejected, and if the significance value is < 0.05

is declared significant, or the hypothesis is accepted.

The results of the partial test (t-test) for regression equations are presented in Table 9.

Table 9 presents the results of the multiple linear regression analysis examining the effects of gender, age, knife pull, and body weight on the time of death of Balinese cattle. The regression equation is expressed as:

Time of Death = $646.534 + 109.154$ (Gender) – 4.280 (Age) – 84.990 (Knife Pull) + 1.439 (Body Weight).

The constant value of 646.534 indicates the estimated time of death when all independent variables are held constant. Among the predictor variables, gender had a positive and statistically significant effect on time of death ($B = 109.154$; $\beta = 0.267$; $t = 1.886$; $p = 0.045$), indicating that differences in animal sex were associated with differences in the time required to reach death after slaughter. The direction of this effect depends on the coding of the gender variable (e.g., male = 1, female = 0).

Age showed a negative but non-significant effect on time of death ($B = -4.280$; $\beta = -0.039$; $t = -0.313$; $p = 0.755$), indicating that differences in animal age did not significantly influence the time required to reach death. Similarly, the number of knife pulls had a negative but non-significant effect ($B = -84.990$; $\beta = -0.189$; $t =$

Table 9. Partial test (Uji t) (Coefficients^a)

Model		Unstandardized Coefficients		Standardized Coefficients		Sig.
		B	Std. Error	Beta	t	
1	(Constant)	646,534	201,686		3,206	,002
	Gender	109,154	57,888	,267	1,886	,045
	Age	-4,280	13,674	-,039	-,313	,755
	Knife Pull	-84,990	55,551	-,189	-1,530	,132
	Body Weight	1,439	,469	,437	3,071	,003

a. Dependent Variable: Time of Death

Source: SPSS, data processed by researchers, 2026

-1.530; $p = 0.132$), suggesting that variation in the number of knife movements during slaughter was not significantly associated with the time of death.

In contrast, body weight had a positive and statistically significant effect on time of death ($B = 1.439$; $\beta = 0.437$; $t = 3.071$; $p = 0.003$). This finding indicates that heavier cattle tended to require a longer time to reach death after slaughter. Furthermore, the standardized coefficient ($\beta = 0.437$) was the largest among all predictor variables, indicating that body weight was the strongest predictor of time of death in the regression model.

DISCUSSION

This study aimed to analyze the influence of biological and slaughter-related technical factors on the effectiveness of post-slaughter death time in Balinese cattle at the Palopo City Slaughterhouse (RPH) and to examine their implications for halal slaughter compliance. The variables analyzed included sex, age, body weight, and the number of knife pulls during slaughter, with time of death serving as the dependent variable. Multiple linear regression analysis showed that the overall model was statistically significant ($F = 3.695$; $p = 0.010$), indicating that these biological and technical factors jointly influenced the time required for cattle to reach death after slaughter. Although this study did not directly measure animal welfare using established welfare indicators, the findings provide indirect evidence relevant to animal welfare because a shorter and more effective time to death is generally associated with reduced suffering and more humane slaughter practices. Therefore, the results contribute to understanding how slaughter-related factors may support both humane slaughter practices and compliance with halal slaughter principles.

The results of this study are in line with the concept of animal welfare, which emphasizes that the slaughter process must be able to minimize animal pain, stress, and suffering. The time of death is an important indicator in determining whether the slaughter process takes place effectively and in accordance with the principles of animal welfare. In the context of Islamic law, the effectiveness of death is also

related to the perfection of the disconnection of the respiratory tract and major blood vessels so that blood production takes place optimally and the animal loses consciousness quickly. Therefore, the results of this study have important implications not only on the technical aspects of slaughter, but also on the halal aspects, meat quality, and consumer trust in products of animal origin.

The coefficient of determination ($R^2 = 0.212$) indicates that sex, age, knife pull, and body weight explained 21.2% of the variation in the time of death of Balinese cattle, while the remaining 78.8% was attributable to other factors not included in the model. These findings suggest that the time of death following slaughter is influenced by multiple biological and technical factors. Variables such as pre-slaughter stress, animal health status, knife sharpness, the competence of the halal slaughterer (Juleha), restraint methods, animal positioning, and the efficiency of severing the carotid arteries and jugular veins may also contribute to variations in the time of death (Rediyono et al., 2025). Although these factors are closely associated with humane slaughter practices and halal slaughter requirements, they were not directly measured in this study. Therefore, the present findings should be interpreted as identifying factors related to slaughter efficiency rather than as a direct assessment of animal welfare or postmortem halal status (Fuseini, 2019). Future studies should incorporate established animal welfare indicators, such as behavioral responses, physiological stress parameters, and indicators of consciousness and insensibility, together with validated halal compliance measures, to provide a more comprehensive evaluation of the relationship between animal welfare and halal slaughter (Sazili et al., 2023).

Influence of Gender on Time of Death

The partial regression analysis showed that sex had a positive and statistically significant effect on the time of death of Balinese cattle ($p < 0.05$). This finding suggests that physiological and behavioral differences between male and female cattle may influence their responses to the slaughter process. Sex-related differences in muscle mass, metabolic characteristics, temperament, and endocrine responses have been

reported to affect animal behavior during handling and restraint, which may subsequently influence slaughter efficiency and post-slaughter physiological responses. Male cattle are generally more reactive to handling and restraint than females, resulting in greater activation of the hypothalamic–pituitary–adrenal (HPA) axis and increased secretion of stress hormones, including cortisol and catecholamines (Njisane & Muchenje, 2017). These stress responses alter cardiovascular function, including heart rate and blood pressure, which may affect the efficiency of exsanguination and the time required to achieve unconsciousness and death. Previous studies have consistently demonstrated that pre-slaughter stress and physiological responses are important determinants of animal welfare, bleeding efficiency, and slaughter outcomes (Sullivan et al., 2022).

The results of this study support the study of Abdullah et al. (2019), which states that the physiological conditions of the animal, including individual biological factors, affect the effectiveness of bleeding-out and the time of death after halal slaughter. In addition, the study "*Assessment of Animal Welfare and Handling Procedures in the Slaughter of Sacred Animals during Eid al-Adha in Samarinda City*" showed that animal handling factors and physiological responses strongly determine the effectiveness of slaughter as well as indicators of loss of consciousness (Wibowo et al., 2024).

Judging from the perspective of animal welfare, the results of this study confirm that the process of restraining and handling of bulls requires more serious attention. RPH managers need to apply calmer and less stressful handling techniques to reduce animal resistance before slaughter. In addition, halal slaughterers need to understand physiological characteristics based on sex so that cutting techniques can be carried out more effectively and efficiently.

Effect of Age on Time of Death

The age variable showed a negative and not significant influence on the time of death. These findings suggest that the age of Balinese cattle in this study was not the main factor determining the speed or delay of death after slaughter. Theoretically, the age of an animal can affect physiological conditions, vascular elasticity,

metabolism, and endurance. Older animals usually have denser body tissues and less elastic blood vessels than younger animals (Vera et al., 2021). However, in this study, the age variation obtained during the study was not large enough to produce a significant difference in the time of death. This is due to the homogeneity of the age of the sample used or because the technical factors of slaughter are more dominant than the age factor.

These findings show that the effectiveness of halal slaughter is more influenced by the quality of the cutting technique than the age of the animal. The precision of the disconnection of the carotid artery, jugular vein, trachea, and esophagus is a major factor in accelerating the loss of consciousness and death of the animal. Thus, although age can physiologically affect the condition of the body, these factors do not automatically determine the success of slaughter if the cutting technique is done correctly.

This research is in line with the concept of animal welfare, which places the quality of handling and operator skills as the main elements in minimizing animal suffering. Therefore, improving the competence of halal slaughterers is more important than considering the age factor of the individual animals (Aghwan et al., 2016).

Effect of Number of Knife Pulls on Death Time

The results of the analysis showed that the number of knife pulls had a negative and not significant effect on the time of death. Statistically, these results show that the number of knife pulls has not been proven to have a significant influence on the length of death of Balinese cattle in this study. However, theoretically, the number of knife pulls remains closely related to animal welfare and halal principles. In halal slaughter, the use of a single sharp and effective incision is highly recommended because it can speed up blood production and minimize pain. Repeated knife pulls can increase stress, pain, and prolong the animal's loss of consciousness (Farouk et al., 2014).

The insignificance of the results of this study is likely due to the relatively small variation in the number of knife pulls between samples or because most of the slaughter has

been performed by a fairly skilled operator. In addition, the quality of the sharpness of the knife may be more decisive than the number of pulls itself. Extremely sharp blades allow for effective cuts even if more than one small movement is made (Grandin, 2010).

These findings are in line with research by Abdullah et al. (2019), which confirms that the sharpness of the blade and the speed of the cutting are more important than just the number of cutting movements. The study suggests that slow or improper cutting can inhibit the *bleeding-out* process and prolong animal suffering. Implementation at RPH Palopo City, the results of this study emphasize the importance of standardization of knife sharpness and halal slaughter technique training. Regular inspections of slaughtering tools need to be carried out so that the quality of the cutting remains optimal. In addition, Juleha's training must emphasize the technical skills of fast, precise, and minimally traumatizing cutting.

The Effect of Body Weight on Time of Death

Body weight had a positive and significant effect on the time of death, indicating that heavier Balinese cattle tended to require a longer time to reach death after slaughter. This finding suggests that body size is an important biological factor influencing the physiological response during exsanguination. Larger animals generally possess greater body mass, thicker muscle tissue, and a more extensive vascular system, requiring efficient restraint and precise neck cutting to ensure rapid blood loss and a faster onset of unconsciousness. Consequently, inadequate slaughter techniques may reduce bleeding efficiency and prolong the time required to achieve death. Previous studies have emphasized that the effectiveness of exsanguination depends not only on the slaughter technique but also on physiological characteristics of the animal, including body size and circulatory dynamics (Aghwan et al., 2016). Efficient severance of the major blood vessels is essential to maintain uninterrupted blood flow, minimize the time to unconsciousness, and support both humane slaughter practices and halal slaughter requirements (Gregory et al., 2012).

As per the context of animal welfare, these findings suggest that overweight cows require

special attention during the slaughter process. The use of adequate restraining equipment, proper slaughter positions, and experienced operators are important factor to accelerate mortality and minimize animal suffering (Grandin, 2014).

Implications for Animal Welfare and Halal

This study shows that the effectiveness of the time of death is an important indicator in assessing animal welfare and the quality of halal slaughter at RPH Palopo City. The sooner an animal loses consciousness and dies completely, the less potential pain and stress the animal will experience. On the contrary, delayed death can cause prolonged suffering and reduce the quality of animal welfare (Makarim et al., 2024).

From the perspective of Islamic law, good slaughter must be carried out quickly, precisely, and minimize animal suffering. The cut must be able to cut the respiratory tract, esophagus, jugular vein, and carotid artery so that the blood production process takes place optimally. The effectiveness of blood expenditure is also related to the quality of meat because the blood left behind can accelerate the growth of microorganisms and reduce the quality of the product (Hakim et al., 2020).

The findings of this study also show that the technical aspects of slaughter cannot be separated from the managerial aspects. Halal slaughterer training, SOP supervision, slaughter equipment maintenance, and pre-slaughter stress control are important factors in improving the quality of the slaughter process at RPH. Animal welfare in halal slaughter is also a major concern in scientific studies. The stress experienced by animals before and during slaughter has been shown to affect cortisol hormone levels as well as the physical quality of meat. Therefore, the application of animal welfare principles in RPH is not only ethical but also has a direct impact on the quality of the products produced. The integration between Islamic sharia and modern science shows that good slaughter practices are able to fulfill both spiritual and technical aspects. Furthermore, research shows that the quality of halal slaughterers is closely related to the level of compliance with operational standards. The technical competencies possessed by the slaughterer, such as speed, precision, and knife

use skills, contribute to the effectiveness of the blood production process. On the other hand, a deep understanding of the principles of sharia makes the slaughter process not just a technical routine, but a worship that has spiritual value. Thus, continuous training is an urgent need to maintain quality consistency.

Managerial factors also cannot be ignored in a halal slaughter system. Supervision of the implementation of SOPs, maintenance of the cleanliness of the RPH environment, and calibration of slaughtering tools are integral parts of quality management. Failures in managerial aspects can pose a risk of cross-contamination, deterioration of meat quality, and even violations of halal standards. Therefore, the synergy between RPH management and slaughterers is the key to success in maintaining the integrity of halal products.

In addition to technical and managerial aspects, the socio-economic dimension also affects the sustainability of halal slaughter practices. Consumer demand for high-quality halal products encourages RPH to improve operational standards. This opens up opportunities for the development of a more competitive halal industry, while strengthening the position of halal products in the global market. Thus, halal slaughter is not only oriented towards fulfilling sharia, but also towards increasing economic competitiveness.

Managerial and Policy Implications

The results of this study provide important implications for the management of the Palopo City RPH and related agencies in improving animal welfare standards and halal slaughter. First, periodic training is needed for halal slaughterers related to effective cutting techniques, the use of sharp knives, and the handling of large animals. Second, it is necessary to conduct a routine evaluation of slaughter SOPs so that all stages are in accordance with animal welfare principles and halal standards.

RPH managers need to improve the restraining system so that the animal handling process takes place more calmly and with minimal stress. The use of restraining tools that do not cause excessive pain will help speed up the process of loss of consciousness after slaughter. Government agencies need to

strengthen the Juleha certification and supervision system based on technical competence and animal welfare. The certification not only assesses the ability to read the slaughter prayer, but also the technical skills of slaughter and an understanding of the principles of animal welfare.

Overall, this study confirms that the death time of Balinese cattle after slaughter is influenced by a combination of biological and technical factors of slaughter. Gender and body weight were shown to have a significant effect on the time of death, while age and number of knife pulls showed no significant influence. These results show that improving the quality of halal slaughter does not only depend on religious aspects, but also requires a scientific approach based on animal physiology, animal welfare, and good technical operational standards.

CONCLUSION

The study concludes that biological and slaughter-related technical factors jointly have a significant effect on the time of death of Balinese cattle at the Palopo City Slaughterhouse. Partially, sex and body weight significantly influenced the time of death, whereas age and the number of knife pulls did not show significant effects. These findings indicate that the efficiency of the slaughter process is affected by a combination of animal characteristics and slaughter practices. Although the study did not directly assess animal welfare or postmortem halal status using standardized indicators, the results provide baseline evidence for improving slaughter practices that support humane handling and compliance with halal slaughter principles.

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