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Pig Slaughter Operators' Perception of Stunning Benefits: A Comparative Analysis of Electrical and Captive Bolt Effectiveness

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ABSTRACT

The pre-slaughter phase, which includes stunning, aims to reduce animal stress, ensuring a more compassionate and efficient process in the meat industry. Various methods are often used in slaughtering pigs, with electrical, mechanical, and chemical stunning being the most common techniques. Several studies have shown that selecting the appropriate method requires operators to comprehensively understand the slaughter process. Therefore, this study focused on evaluating the comprehension of pig slaughter operators regarding the benefits and effectiveness of electrical and captive bolt stunning methods. A total of 17 pigs slaughtered from seven slaughterhouses were selected as samples. Data collection was carried out using questionnaires, interviews, and direct observation. The results showed that operators clearly understood the benefits of stunning in terms of speed and ease. However, their comprehension regarding pig stress reduction before death remained limited. Although captive bolt stunning was known to have various benefits, such as shortening the duration of leg movements after slaughter, it required longer operation time, compared to the electrical method. Therefore, it can be concluded that there is no ideal stunning method as both methods of electrical and captive bolt stunning have their respective advantages and disadvantages.

Keywords: Captive bolt stunning, Effectiveness, Electrical stunning, Comprehension of operator

INTRODUCTION

Slaughter is an essential step in transforming animals into meat for human consumption, requiring compliance with established standards comprising hygiene, safety, working conditions, and welfare (Beageaud-Blacker, 2007). This step must be carried out sympathetically by minimizing the pain experienced by animals and recognizing their intrinsic value (Nakyinsige et al., 2013).

Stunning before slaughter is a legal requirement designed to induce unconsciousness and insensibility (inability to perceive stimuli), ensuring that the subsequent slaughter is performed without causing fear, anxiety, pain, suffering, and distress (EFSA, 2004). According to previous studies, stunning refers to any intentional process that induces painless loss of consciousness and sensitivity, even methods leading to instant death (EC, 2009). A comprehensive understanding of the unconsciousness and insensibility of animals before death holds significant importance, and the assessment of this parameter can be used to assess the effectiveness of various methods (EFSA, 2004). In practical settings, the evaluation of stunning effectiveness comprises observation of eye reflexes, reactions to painful stimuli, resumption of normal rhythmic breathing, and foot-righting reflexes (EFSA, 2004). This shows that it is important for all individuals associated with stunning and slaughter to be competent, adequately trained, and have a positive attitude toward the welfare of the animals (EFSA, 2004).

Pre-slaughter stress can affect postmortem muscle metabolism and meat quality, leading to increased levels of catecholamines and creatinine kinase in the body, rapid glycolysis, and lactic acid buildup in the meat (Bourguet et al., 2011; Pisestyani et al., 2015). Animal stress levels can be measured using neutrophil-lymphocyte ratio (Litmer et al., 2020). Previous studies have shown that pigs executed with electrical stunning had a lower ratio, and this condition showed reduced stress (Anugrah et al., 2022), further supported by a decrease in superoxide dismutase level (Prayoga et al., 2020).

Various stunning methods are commonly used in the pig slaughter process, including electrical, mechanical, and chemical methods (OIE, 2011). The electrical method relies on passing a large electrical current through the brain, thereby inducing generalized epilepsy and immediate loss of consciousness (EFSA, 2004). Meanwhile, the mechanical method is often carried out using a captive bolt or hitting the forehead with a wooden block (Goba et al., 2013). To avoid complications, the use of stunning must be informed by a proper understanding and knowledge, considering that the duration of unconsciousness and insensibility vary across different methods, species, and animals (EFSA, 2004).

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Although there are no ideal methods for stunning and killing farm animals, it is necessary to select procedures that offer more advantages in terms of welfare (EFSA, 2020). The choice of an inappropriate method can lead to significant losses (EFSA, 2004). In slaughterhouses of Bali, electrical and captive bolt methods are often used, with the captive bolt being a recent development. The Animal Australia Foundation introduced this current procedure in collaboration with the Faculty of Veterinary Medicine, Udayana University, and the Department of Agriculture and Food Crops, Badung Regency, Bali, Indonesia. Therefore, this study aims to assess the understanding level of pig slaughter operators and evaluate the effectiveness of electrical and captive bolt stunning methods.

MATERIALS AND METHODS

Ethical approval

This study was approved by the committee of the institution of Animal Care and use at the Faculty of Veterinary Medicine, Udayana University, with reference number B/233/UN14.2.9/PT.01.04/2021.

Experimental site

The experiment was carried out from May to July 2022 at the pig slaughterhouse located in Taman sub-village, Darmasaba village, Abiansemal subdistrict, Badung regency, Bali, Indonesia, as a pilot project of cooperation between the Faculty of Veterinary Medicine, Udayana University with Animal Australia Foundation and the Department of Agriculture and Food crops of Badung district, Bali-Indonesia.

Data collection

A total of 17 pig slaughter operators, all specializing in Landrace pig slaughter, were interviewed. These operators were selected from 7 different slaughterhouses at Taman sub-village, Darmasaba village, Abiansemal sub-district, Badung-Bali, Indonesia. The interviews aimed to gauge their comprehension level using a set of questionnaires, focusing on the benefits of stunning in the slaughter process and its correlation with meat quality. Furthermore, the electrical stunning method (230-volt, 60A, 50 Hz) in this study was carried out by operators. It involved attaching one electrode or stunning tongs to the head of the pig. In contrast, the treatment of the captive bolt stunning method was carried out using penetrating captive bolt guns, such as Matador Super Securit 3000. The process was performed when the pig was in a blangsung or iron restraint shaped like a block or tube. The effectiveness of electrical stunning 230 volt, 60A, 50 Hz, and captive bolt was evaluated by direct observation with several variables such as sound ends, leg movement ends, operational time in using the tool, and the value score of tool repetition to achieve fainting.

Data analysis

Data from the questionnaire, which assessed the operators' level of understanding, were processed descriptively. The relationship between variables was examined using the Chi-square test to determine the significance level. If $p < 0.05$ means significantly different, and $p > 0.05$ means not significantly different. Furthermore, data on the effectiveness of the pig stunning device were tested for normality using the Shapiro Wilk Test Subsequently, Wilcoxon Test was employed to find a mean difference between both methods. All data was analyzed using the SPSS-25 program (Santoso, 2018).

RESULTS AND DISCUSSION

Slaughter of pigs with the stunning method was performed at a slaughterhouse in Taman sub-village, Darmasaba village, Abiansemal sub-district, Badung-bali. The types of stunning methods used included electrical and captive bolt stunning, as well as hitting with a wooden stick (Table 1). The use of captive bolt was still relatively new and unique to Bali. The data of the study based on the interviews of all operators (17 operators) originating from all slaughterhouse businesses (7 locations) are tabulated in Table 1.

As can be seen in Table 1, of 17 operators, 13 (76.47%) had experience in performing stunning methods, while others had no experience (23.53%). Among the 13 participants with experience, the majority had been involved for 6-10 years and 11-15 years, accounting for 38.46%, followed by those with over 16 years at 23.08%. Furthermore, the type of stunning used was dominated by electrical (46.15%), followed by a combination of captive bolt and electrical (30.776%), and hitting with wood (23.08%). The profiles of pig slaughterer operators for each slaughterhouse are presented in Table 2.

Table 2 indicates that 7 (41.18%), 6 (35.92%), and 4 (23.53%) operators aged 51-60, 30-49, and 41-50 years old, respectively. According to the Central Statistics Agency of Indonesia, the productive age is between 15 and 64 years. Accordingly, the majority of operators were considered to be within the productive age, and this age range had a positive relationship with labor productivity (Suyono and Hermawan, 2013). This phenomenon was supported by the better

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knowledge and high responsibility for tasks exhibited by these individuals. At the productive age, the workforce could adapt quickly and easily adopt new technology. The results showed that the non-productive age often had problems with physical abilities and difficulty learning new technology, leading to suboptimal productivity (Ukkas, 2017).

A total of 7 (41.18%), 4 (23.53%), 4 (23.53%), and 2 (11.76%) respondents had worked as pig slaughter operators for 6-10, >16, 1-5, and 11-15 years, respectively. A study by Trijanuar revealed that a worker's experience level could be influenced by the length of service, level of knowledge, skills, and mastery of work and equipment. Experience is the basic capital in understanding and comprehending a job, and extended duration tends to provide maximum performance (Trijanuar, 2016).

Table 1. Profile of the seven pig's slaughterhouse business at Taman sub-village, Darmasaba village, Abiansemal sub-district, Badung-Bali, Indonesia during April-May 2022

Variables	Category	Percentage
Doing stunning	Yes	76.47% (13/17)
	No	23.53% (4/17)
Duration of the stunning device (years)	6-10	38.46% (5/13)
	11-15	38.46% (5/13)
	>16	23.08% (3/13)
The type of stunning	Electrical	46.15% (6/13)
	Captive Bolt and Electrical	30.77% (4/13)
	Hitting with a wooden	23.08% (3/13)

Table 2. Profile of pig slaughterer operators who work at Taman sub-village, Darmasaba village, Abiansemal sub-district, Badung-Bali, Indonesia during April-May 2022

Variables	Category	Percentage
Age (years)	30-40	35.29% (6/17)
	41-50	23.53% (4/17)
	51-60	41.18% (7/17)
Length of work (years)	1-5	23.53% (4/17)
	6-10	41.18% (7/17)
	11-15	11.76% (2/17)
	>16	23.53% (4/17)
Level of education	ES	5.88% (1/17)
	JHS	47.06% (8/17)
	SHS	41.18% (7/17)
	College	5.88% (1/17)

ES: Elementry school, JHS: Junior high school, SHS: Senior high school

The education level of pig slaughter operators predominantly consisted of individuals with junior high school education, accounting for 8 respondents (47.06%). This was followed by senior high schools, elementary schools, and colleges, with 7 (41.18%) and 1 (5.88%) participants, respectively. These findings underscore that education of the workforce at the pig slaughterhouse in Taman sub-village, Darmasaba village, was still relatively low due to the dominance of elementary and junior high school education among nine respondents (Table 2). These results were in line with a previous study indicating that abattoirs were one of the sectors where a level of education was not required for employment (Sidabalok et al., 2018). Table 3 presents the results of the data analysis concerning the operators' understanding of pig stunning benefits at Taman sub-village, Darmasaba village.

Based on Table 3, the majority of operators, comprising 9 individuals (69.23%), who employed the stunning method before slaughter expressed that it facilitated easier handling of pigs. In contrast, 4 operators (30.77%) showed the absence of a significant effect. These results indicated that most respondents were aware of the benefits of the method. According to a previous study, stunning could facilitate production work due to its quick operation time (Beageaud-Blacker, 2007).

The majority of operators at the abattoir (69.23%) were of the opinion that stunning did not reduce the stress of pigs. This opinion correlated with education level. Specifically, 83.33% of respondents with junior high school certificates (5 participants) expressed the belief that stunning did not alleviate stress, compared to 66.67% (4 participants) of those with senior high school education. Out of 13 operators (30.77%), only 4 stated that the method could reduce stress, consisting of 1, 2, and 1 participants with junior high school, senior high school, and college education levels (100%), respectively. These results suggest that a significant proportion of operators were unaware of the stress-reducing effects of stunning, and educational levels appeared to impact this understanding. Furthermore, a

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higher level of education affected better understanding of stunning in reducing stress. Based on Table 3, 7 operators (53.85%) agreed that the method positively affected the quality improvement of produced pigs and enhanced consumer acceptance, with others disagreeing due to their level of education.

In this study, operators' understanding of the benefits of pig stunning at the Taman sub-village, Darmasaba village, correlated with their education levels. Education is an attempt to develop individuals' thinking abilities (Franco et al., 2018). Education can increase the insight and knowledge of a workforce and improve work skills (Suyono and Hermawan, 2013). The understanding levels of pig slaughter operators in the Taman sub-village, Darmasaba Village, were in a good category. This could be seen from the high percentage of respondents' understanding level of the benefits of stunning to facilitate easier pig handling and the effect of the method on meat quality and duration of slaughter process or cutting.

Table 3. Analysis of understanding of operators of benefits of stunning of pigs at Taman sub-village, Darmasaba village, Abiansemal sub-district, Badung-Bali, Indonesia during April-May 2022

Variables \ Category		Yes	No
Easy to handle pig		69.23% (9/13)	30.77% (4/13)
Reducing pig stress		30.77% (4/13)	69.23% (9/13)
Influencing quality pig (better)		53.85% (7/13)	46.15% (6/13)
Repairing reception of pig consumers (better)		53.85% (7/13)	46.15% (6/13)
Shortening the pig-cutting process		100% (13/13)	- (0/13)
Operators will recommend pig stunning to other slaughterhouses		100% (13/13)	- (0/13)
Association of operators education's level in comprehension stress on pig	JHS	16.67% (1/6)	83.33% (5/6)
	SHS	33.33% (2/6)	66.67% (4/6)
	Collage	100% (1/1)	- (0/1)
Association of operators education's level in the comprehension effect of pig stunning increase of pig quality	JHS	50.0% (3/6)	50.0% (3/6)
	SHS	50.0% (3/6)	50.0% (3/6)
	Collage	100% (1/1)	- (0/1)
Association of education level of operators regarding the relation of pig stunning process on the consumer perceptions in acceptance of pig produced	JHS	50.0% (3/6)	50.0% (3/6)
	SHS	50.0% (3/6)	50.0% (3/6)
	Collage	100% (1/1)	- (0/1)

JHS: Junior high school, SHS: Senior high school

The effectiveness of stunning with the electrical and captive bolt

The use of electrical stunning and captive bolt stunning before slaughter at a slaughterhouse located in the Taman sub-village, Darmasaba, can be observed in Figures 1 and 2. The effectiveness of stunning with electrical and captive bolts based on several variables is presented in Table 4.

As can be seen in Table 4, the sound ends of the pig after electrical stunning was 3.8 seconds, while stunning with a captive bolt was 3.65 seconds. There was no significant difference between the two methods in terms of the sound ends of pigs ($p > 0.05$). According to the European Food Safety Authority (EFSA, 2020), vocalizations or sounds are expected to occur only in aware animals and are used to monitor the animals' consciousness levels. Some animals are likely not to produce sounds in consciousness. Based on the results, the absence of vocalizations did not necessarily show unconsciousness.

The leg movement for electrical stunning was 3.85 minutes and captive bolt stunning was 3.10 minutes, with significant differences ($p < 0.05$). Compared to electrical stunning, the captive bolt showed a better outcome due to the shorter time required to achieve fainting. However, the operational time for the electrical method was 2.8 minutes, which was significantly shorter than a captive bolt at 3.65 minutes ($p < 0.05$). Stunning process in animals must be carried out quickly to minimize the return of consciousness (EFSA, 2020). Procrastination or improper device sticking could lead to fear, pain, and discomfort (EFSA, 2004). This is an essential aspect of stunning as well as a concern in animal welfare (EFSA, 2020). The score of the device repetition to achieve fainting in pig for electrical stunning (3.80 times) was not significantly different from the captive bolt (3.85 times, $p > 0.05$). The repetition was carried out due to the failure or ineffectiveness of the device, which was marked by the level of return to consciousness in pigs. According to the European Food Safety Authority (EFSA, 2020), the assessment of the consciousness level had two possibilities, namely outcomes of consciousness and unconsciousness. The use of stunning equipment, use duration, placement of tools on animals, and storage and maintenance of equipment were factors affecting the effectiveness of the process (Edwards, 2018). Moreover, the European Food Safety Authority (EFSA, 2020) stated that the effectiveness of electrical stunning depends on two important factors. First, the electrodes must be placed on either side of the head, between the eyes and the base of the ear, to facilitate penetration to the brain. Second, the current delivered to the brain must be sufficient to induce an immediate epileptic seizure. According to the Humane Slaughter Association (HSA, 2016), electrical stunning

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could be effective in pigs at an electrical voltage of 250 Volts, with a current and resistance of 1.6 Ampere and 150 Ohms. When the tool is used beyond a reasonable timeframe, an issue with the equipment may occur, necessitating its replacement with a more suitable alternative.

Figure 1. Stunning pig with electrical at slaughterhouse located in Taman sub-village, and Darmasaba village, Abiansemal sub-district, Badung-Bali, Indonesia

Figure 2. Stunning pig using captive *bolt* at slaughterhouse located in Taman sub-village, Darmasaba village, Abiansemal sub-district, Badung-Bali, Indonesia

Table 4. The effects of electrical and captive bolt stunning methods at slaughterhouses of Taman sub-village, Darmasaba village, Abiansemal sub-district, Badung-Bali, Indonesia on several variables of fainting in pigs

Variables	Electrical stunning	Captive bolt stunning	P-value
Sound ends after stunning (seconds)	3.80 (0.41)	3.65 (0.75)	0.7384^{ns}
Leg movement ends after stunning (minutes)	3.85 (0.37)	3.10 (0.72)	0.0005*
Operational time in using the tool (minutes)	2.80 (041)	3.65 (0.49)	0.0001*
The value score of tool repetition to achieve fainting (times)	3.80 (0.41)	3.85 (0.37)	1.0000^{ns}

The numbers in the table show the mean value (SD). *significantly different ($p < 0.05$), ns: Not significantly different ($p > 0.05$)

CONCLUSION

In conclusion, the application of stunning methods during pig slaughter in Taman sub-village, Darmasaba village, Abiansemal sub-district, Badung-Bali, Indonesia, was perceived by operators as a means to enhance the efficiency and ease of the slaughter process and reduce the stress levels of the animal. Furthermore, the use of the captive bolt and electrical stunning presented a set of advantages and disadvantages. Captive bolts induced faster unconsciousness in animals than electrical stunning but required an extended operational time.

DECLARATIONS

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Availability of data and materials

The authors confirm that all data supporting this study has been used to write this article.

Authors' contributions

All authors contributed equally to the study. I Wayan Suardana conceived and designed the study. Putu Devidia Trisha Suciada conducted the trial and collected the samples. Romy Muhammad Dary Mufa analyzed the data. All authors have read and approved the final manuscript.

Ethical considerations

The authors written the article originally and also check the last draft manuscript for similarity index. This article is not submitted to anywhere else and the findings analysed and written under supervsions of all authors.

Competing interests

The authors declare that there are no conflicts of interest for this study.

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