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EFFECT OF TWO STUNNING METHODS ON WELFARE INDICATORS AND CARCASS LESIONS IN CALIFORNIA RABBITS

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ABSTRACT

Consumers have legitimate concerns about the application of animal welfare procedures during the slaughter of rabbits. However, there is insufficient evaluation of such practices, particularly in small-scale rabbit-breeding operations in Mexico. This study aimed to assess animal welfare indicators during slaughter under different stunning methods. A total of 120 California rabbits (*Oryctolagus cuniculus* L.) were used, each one of which weighed 2 kg, and were distributed into four treatments in a 2^2 factorial arrangement to relate two methods of stunning (a_1 = concussion, a_2 = electronarcosis) and the sex of the animal (b_1 = male, b_2 = female) with the behaviors observed during slaughtering and the lesions in the carcass as factors that affect the animal's welfare. Management indicators (number and precision of the application), behavioral indicators (attempts at escaping, kicking, vocalization, gaping, and arching of the back), and lesions in the carcass were registered. Descriptive statistics were obtained, and the behaviors were compared using nonparametric tests. Additionally, risk factors were identified in the carcass related to the slaughter methods, weight, and sex. During stunning, precision and kicking were different ($p < 0.05$), unlike vocalization ($p = 0.7$). During the slitting of the throat, time ($p = 0.4$), vocalization ($p = 0.6$), blinking ($p = 0.7$), corneal reflex ($p = 0.8$), and dilated pupils ($p = 0.2$) presented no differences between methods. However, there were differences in kicking ($p < 0.01$), gaping ($p < 0.01$), and arching of the back ($p < 0.01$). In the *post-mortem* evaluation of lesions, the carcasses that displayed the lowest number of lesions, with the smallest size and located on the legs, were from rabbits on which the method of electronarcosis ($p < 0.001$) was applied. The slaughtering method was a risk factor in the appearance of bruises ($p > 0.0003$). The method of electronarcosis was concluded to be more effective than concussion to induce the animal to lose consciousness during the slaughtering of rabbits.

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INTRODUCTION

In recent years, consumer demand has increasingly emphasized the importance of ensuring that animal-derived products are obtained in accordance with animal welfare standards (Stoier *et al.*, 2016). This has promoted the development of slaughter systems that consider the well-being of animals, enhancing meat quality and creating new economic opportunities. In the case of the rabbits, pre-slaughter stunning induces unconsciousness, minimizing stress during exsanguination. The assessment of unconsciousness in rabbits prior to slaughter is typically based on behavioral indicators, including the presence or absence of ocular reflexes, blinking, pupil dilation, limb movements such as kicking, loss of body posture, head lifting, back arching, vocalizations, and monitoring of the respiratory rate (Verhoeven *et al.*, 2015). According to the Mexican Official Standard NOM-033-SAG/ZOO-2014 (DOF, 2014), animals must not exhibit signs of pain, stress, or distress at the time of slaughter, as such conditions compromise their welfare, physical integrity, health status, biochemical profile, and ultimately the quality and yield of the meat. Similarly, in the European Union, compliance with higher animal welfare standards has been associated with improved carcass quality and a reduction in lesions (European Commission, 2017). The primary objective of stunning is to rapidly induce unconsciousness, which is the inability to perceive and respond to external stimuli due to profound brain depression. This procedure is intended to prevent the animal from experiencing pain and stress during neck cutting and subsequent bleeding (DOF, 2014).

In countries such as Italy and Hungary, stunning by electronarcosis is a common practice before slaughtering rabbits in slaughterhouses (European Commission, 2017). In Mexico, the most widely used stunning methods are cervical dislocation and mechanical concussion stunning. Some countries, along with stunning by concussion, use electronarcosis and penetrating and non-penetrating captive bolt stunning. Stunning by electronarcosis consists of running an electric current through the animal's head at a magnitude that can induce tonic-clonic epileptiform activity, resulting in a state of insensitivity (McKinstry and Anil, 2004). Meanwhile, the concussion method involves delivering a forceful impact to the occipital region at the base of the head using a long, blunt, non-sharp solid object or the hand.

Electronarcosis induces immediate unconsciousness in pigs, poultry, and rabbits, thereby contributing positively to animal welfare. To ensure effective stunning, electrodes must be positioned correctly, as improper placement may fail to induce unconsciousness and can exacerbate fear, anxiety, pain, stress, or even result in death (Stoier *et al*., 2016). According to Anil *et al*. (1998), electrical stunning can produce a sufficiently long duration of insensibility, making it a suitable method for the humane slaughter of rabbits.

Several indicators are recommended to assess and determine unconsciousness before slaughtering, exsanguination, and skinning. If the animal is not considered unconscious after evaluating the indicators, the stunning procedure must be repeated (Verhoeven *et al.*, 2015). Animal welfare must also be evaluated in the *ante-mortem* handling, along with its repercussions on the physical quality of the carcass. Bruises are indicators of improper handling of the carcass prior to slaughter, which may include insufficient grasping of the animal, inadequate transportation, and extended waiting periods before slaughter. (Grandin, 2017).

The interaction of the sex of the rabbits with the stunning method before slaughtering has been scarcely studied. Studies performed during stunning and slaughtering do not distinguish between females and males and focus only on the method of stunning, as observed in the work carried out by Anil *et al.* (1998), Petracci *et al.* (2010), and Valkova *et al.* (2021b).

The hypothesis in this study was that electronarcosis, as a stunning method used for slaughtering rabbits, has a lesser impact on animal welfare compared to the mechanical concussion method. Therefore, the aims were to compare the effectiveness of electronarcosis and concussion as stunning techniques in California rabbits, as well as to evaluate the animal welfare conditions with both methods and to assess the interaction between the sex of the rabbits and the stunning method used.

MATERIALS AND METHODS

The study was carried out at the Rabbit Breeding Unit of the Livestock Program of the Postgraduate College, Campus Montecillo, Mexico, located at 19° 27′ 48.4′′ N and 98° 54′ 30.8″ W, at an altitude of 2250 m. The stunning and slaughter procedures were carried out following the regulations for the use and care of animals destined for research at the Postgraduate College. The experiment was conducted between January and May 2021.

A total of 120 California breed rabbits were utilized in this study, comprising 60 males and 60 females, each aged 65 ± 5 days and weighing 2.2 ± 0.2 kg. The animals were not subjected to prior fasting. They were randomly distributed into four treatment groups in a completely randomized design with a 2 × 2 factorial arrangement. The main factors considered were the type of stunning (mechanical stunning by concussion (a_1) and electronarcosis (a_2)) and sex (male (b_1) and female (b_2)). Each treatment combination included 30 replicates, with each rabbit representing one experimental unit. The animals were organized into five groups of five rabbits each and transported to the fattening area located adjacent to the slaughterhouse. Stunning and slaughter procedures commenced immediately; however, the rabbits were held for a waiting period of 10 min prior to processing.

The mechanical stunning was performed by striking the base of the heads in the occipital region with our hands. A manual electric stunning machine (model VS200, Midwest Processing Systems, Minneapolis, MN, USA) with 120 V and 1 A was used for electronarcosis stunning. The rabbits received an electric discharge of 600 V and 1 A in the occipital region for 2 s. After the application of the stunning method, the rabbit was hung by its hind legs, upside down, and its neck was slit. The time elapsed between stunning and slaughtering was measured using a stopwatch, and the assessment of bruises was carried out using a millimeter ruler.

Evaluation of the method of stunning

Management and behavioral indicators

The evaluation of handling indicators and rabbit behavior commenced at the moment the animal was removed from its cage, located in the facility adjacent to the slaughterhouse, and concluded upon slaughter. A single trained observer conducted the assessments, independently reviewing each indicator, while a designated operator administered the stunning procedure according to the assigned treatment (either concussion or electronarcosis).

For both stunning methods, the following variables were recorded: the precision of the application (i.e., whether the anatomical target site was correct, specifically the occipital region, or incorrect, involving any other area), the number of applications (one or more than one), and the time elapsed between stunning and slaughter (<30 or >30 s). Additionally, the presence or absence of behavioral indicators was documented at three critical stages: during restraint (escape attempts and kicking), stunning (vocalization and kicking), and slaughter (vocalization, kicking, blinking, corneal reflex, pupil dilation, gaping, head lifting, and arching of the back), in accordance with established criteria (Grandin, 2017) (Table 1).

Table 1. Ethogram of the behavioral indicators evaluated during the stunning of California rabbits (*Oryctolagus cuniculus* L.).

Indicator	Definition
Attempt to escape	The animal performs movements to find a way out and avoid being held.
Kicking	Violent movement of hind legs; when this takes place after stunning, it refers to the clonic phase.
Vocalization	Voluntary sounds are produced by the vibration of the vocal cords. Short and high-pitched squeals.
Blinking	Opening and closing of the eyelids.
Corneal reflex	Reaction when touching the eyeball with the tip of the finger after stunning.
Dilated pupils	Increase in the diameter of the pupils.
Gaping	Deep, non-rhythmical breaths through the open mouth.
Lifting head	Lifting or attempting to lift its head.
Arching of the back	Any reflex that tends to take the body to its normal position.

Evaluation of carcass lesions

The carcass was divided into two regions: limbs (front and hind legs) and torso (neck, thorax, and back). The traumatic lesions with blood vessel ruptures, leading to blood accumulation without skin discontinuity, were considered as bruises. All observed injuries were recorded, including their location and size. The extent was determined based on the approximate diameter of the affected area and classified into three levels: ≤ 0.5 cm, between 0.6 and 1 cm, and > 1 cm. In carcasses with more than one bruise of different extents, the criterion of the largest size was used for classification (Knock and Carroll, 2019).

Statistical analysis

Descriptive statistics were obtained for the handling indicators (precision of application, number of applications, and time between stunning and slaughtering) and behavioral indicators (attempt to escape, kicking, vocalization, blinking, corneal reflex, dilated pupils, gaping, lifting of the head, and arched back). These data were transformed into ranges and analyzed using the Mann-Whitney U test and analysis of variance via the Kruskal–Wallis test. To evaluate the association between the presence of carcass lesions and variables such as the stunning method, sex, animal weight, and time between stunning and slaughtering, a logistic regression analysis was conducted. This analysis enabled the estimation of risk or opportunity factors (odds ratios, OR). All statistical analyses were performed using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA). The general model used was as follows:

$$P\left(Y=\frac{1}{X}\right)=\frac{e^{(\beta_0+\beta_1X_1+\beta_2X_2+\cdots\beta_4X_4)}}{1+e^{(\beta_0+\beta_1X_1+\beta_2X_2+\cdots\beta_4X_4)}}$$

where P is the probability that variable Y_i takes the value of $Y = 1$ if lesions appear and $Y = 0$ otherwise; $\beta_0, \beta_1, \ldots, \beta_4$ are unknown parameters, and $X_1, \ldots, X_4$ are independent variables (method of stunning, sex of the rabbit, size of the animal, and time between stunning and slaughtering).

RESULTS AND DISCUSSION

Rabbit behavior and handling during restraint and stunning

During restraint, when animals were removed from their cages and held in the area adjacent to the slaughterhouse, 28 % of rabbits attempted to escape, while 43 % exhibited kicking behavior. These responses were interpreted as indicators of stress, potentially reflecting a reduction in animal welfare. The precision of the operator in applying the stunning method varied significantly ($p < 0.009$), resulting in an overall failure rate of 17.5 %, with 13.3 % of these failures occurring during the use of the concussion method. According to established standards, the maximum acceptable failure rate is 1 %; rates exceeding 4 % are indicative of serious deficiencies in handling during the slaughter process. Furthermore, 5 % of the animals required a second application of the stunning method ($p < 0.095$), which represents the upper limit of acceptability (Grandin, 2013).

Rabbit behavior during slaughter

To avoid rabbits regaining consciousness, slaughter must be performed within 30 s after stunning (Anil *et al*., 1998). The interval between stunning and slaughtering is determined by the operator's ability rather than by the stunning method used, thereby impeding direct comparison between methods. Nonetheless, 10.8 % of the rabbits were slaughtered beyond the time threshold. Behavioral indicators such as kicking, gaping, head lifting, and back arching exhibited significant differences between stunning techniques ($p < 0.02$), with electronarcosis identified as the most benign method (Table 2).

Table 2. Indicators evaluated during the stunning and slaughtering process of California rabbits (*Oryctolagus cuniculus* L.).

Indicators	Total			Concussion			Electronarcosis			
	%	±	SEM	%	±	SEM	%	±	SEM	*p*-value
				Stunning						
Precision	17.5		7.7	13.3		8.2	4.2		9.8	0.009
Applications	5.0		9.5	4.2		9.8	0.8		----	0.095
Vocalization	5.8		9.3	2.5		10.9	3.3		10.2	0.698
Kicking	43.3		5.2	35.8		5.9	7.5		9.0	<.001
				Slaughtering						
Vocalization	2.5		10.9	1.7		12.7	0.8		----	0.560
Kicking	49.2		4.7	35.8		5.9	13.3		8.2	<.001
Blinking	26.7		6.8	12.5		8.3	14.2		8.1	0.681
Corneal reflex	14.2		8.1	7.5		9.0	6.7		9.1	0.794
Dilated pupils	26.7		6.8	10.8		8.5	15.8		7.9	0.217
Gaping	30.0		6.8	10.0		9.3	20.0		8.0	0.017
Straightened head	15.8		7.9	13.3		8.2	2.5		10.9	0.0012
Arched back	11.7		8.4	9.2		8.7	2.5		10.9	0.023

SEM: standard error of the mean. Statistical differences are presented between rows.

The behaviors that indicate unconsciousness differ between physical and electrical stunning methods. In the case of physical stunning, the most important indicators are the righting and ocular reflexes, whereas for the methods that do not physically destroy the brain, such as electric stunning, the most important indicators are the righting reflex and vocalization (Verhoeven *et al*., 2015). The European Food Safety Authority considers an indicator to be 100 % sensitive if it correctly identifies all conscious animals (EFSA, 2020).

Vocalization before and during stunning

No differences were found between methods for vocalization before ($p = 0.698$) or during stunning ($p = 0.56$). In a rabbit-specific slaughterhouse, Rota-Nodari *et al*. (2009) reported vocalization rates ranging from 0.1 to 0.3 % prior to and during the application of electric stunning. In the present study, the percentage of vocalization for each method remained below 5 %. For bovines and pigs, acceptable vocalization thresholds during handling and stunning have been established at ≤3 and ≤5 %, respectively (Grandin, 2013). However, standardized acceptable vocalization levels for rabbits have yet to be defined.

Vocalization is considered a behavioral indicator, as rabbits infrequently vocalize, and they typically do so only when conscious and experiencing significant pain or stress (Mayer, 2007). Nevertheless, not all conscious animals vocalize; thus, the absence of vocalization cannot be taken as definitive evidence of unconsciousness. Vocalizations occurring immediately prior to stunning may indicate handling issues, whereas vocalizations during the stunning process suggest inadequate application of the stunning method. Following effective stunning, no vocalization should be observed (Grandin, 2013). Vocalization is a readily measurable indicator, with a sensitivity of approximately 71 % for physical methods and 57 % for electrical methods (EFSA, 2020).

Clonic phase (post-stunning kicking)

A significant difference was observed in the clonic phase between both stunning methods ($p < 0.001$). This variation can be attributed to the neural circuits responsible for reciprocal leg movements, which are located in the spinal cord. These circuits require a functional spinal cord but do not depend on cerebral coordination. Spinal reflexes, such as kicking, tend to manifest more vigorously following physical stunning methods. In contrast, electrical stunning more frequently results in a mild tonic-clonic phase (Grandin, 2013), which facilitates its identification and recording when the concussion method is used.

Adequate stunning causes the tonic (rigid) and clonic (repeated muscular contractions) phases, during which an individual is unconscious. An error in evaluating this behavior is mistaking the clonic phase for a return to sensitivity, despite the fact that kicking reflexes can be present after effective desensitization, and the absence of these phases is due to the animal not becoming desensitized (Grandin, 2013). The appearance of the tonic-clonic phase is a medium-difficulty indicator with 89–93 % sensitivity for a physical and electric method, respectively (EFSA, 2020).

Corneal reflex, blinking, and dilated pupils

No statistically significant differences were observed between treatments compared to the presence of corneal reflex, blinking, or dilated pupils ($p > 0.05$). In cases of physical stunning, the absence of corneal reflexes and blinking is expected due to the cerebral trauma inflicted. However, these indicators may still be observed following effective electrical stunning as a consequence of residual brainstem activity (Gregory and Shaw, 2000). For instance, Vogel *et al*. (2011) reported the occurrence of corneal reflex and blinking in 93.8 and 40.8 % of electrically stunned pigs, respectively. In contrast, the present study recorded these responses in only 6.7 and 14.2 % of cases, respectively. This discrepancy may be attributed to the timing of the evaluations. In the current study, corneal reflex was measured approximately 6 s after stunning, or about 30 s after the start of slaughter. It is possible that the blood loss caused by this point was enough to impair brainstem function, preventing the detection of these reflexes during examination (Vogel *et al*., 2011).

Conversely, Rota-Nodari *et al*. (2009) reported even lower frequencies of corneal reflex (1.8 %) and blinking (2.6 %) than those found in the current study. This variation may be due to procedural differences, as data in the aforementioned study were collected in a specialized commercial slaughterhouse where longer delays prior to observation could have further diminished the visibility of these indicators. Although the unconsciousness of the animal can be assured when the behaviors are absent, their presence does not necessarily imply that the animal is conscious (Verhoeven *et al.*, 2015). The corneal reflex is an indicator with a medium difficulty in measurement, with a sensitivity of 96 and 94 % for the concussion and electric methods, respectively, whereas blinking has a sensitivity of 69 %, regardless of the method of stunning. The dilated pupils (midriasis) are good indicators of death and have a sensitivity of 98 %, regardless of the stunning method, although measuring them is difficult (EFSA, 2020).

Gaping

The gaping showed significant differences between concussion and electronarcosis methods ($p < 0.02$). The last respiratory pattern in a dying animal is gaping or agonal breathing, which always results in terminal apnea and can appear after adequate electric stunning and is considered a positive sign (Pluta and Romaniuk, 1990).

Righting reflex

There was a significant difference between the methods for this indicator ($p < 0.05$). Vogel *et al*. (2011) discovered a 14.3 % righting reflex in electrically stunned pigs, while this study found only 2.5 %. The reflex of righting refers to any movement that causes the body to return to its normal position, such as lifting the head or arching the back. A conscious animal can exhibit this reflex following a failed stunning (EFSA, 2020). The recovery movements are oriented but can be difficult to distinguish from others (Terlouw *et al*., 2016). The righting reflex is a medium-difficulty indicator with a 77 % sensitivity (EFSA, 2020).

Evaluation of the lesions in the carcass

The *post-mortem* evaluation of lesions has been studied in cows, pigs, sheep, goats, poultry, and rabbits, mainly related to the transportation from the farms to the slaughterhouses (considering factors including the type and time of transportation and load density) and, to a lesser extent, with the method of stunning (Mendonça *et al*., 2016; Valkova *et al*., 2021a, 2021b).

Location of the lesions

The post-mortem lesions found in carcasses during slaughterhouse inspections reflect animal management prior to slaughter. Inspecting the carcasses for evaluation helps value the lesions individually, highlighting any bruises that would otherwise go unnoticed. These lesions can be evaluated based on where they are located in the body (torso or limbs) (Huneau-Salaün *et al*., 2015).

Of all the rabbits evaluated, 93 % displayed at least one lesion in the carcass (Table 3). Differences were found ($p < 0.01$) in the location of the lesions, with 24 % on the torso alone, 20 % on the limbs, and 48 % on the torso and limbs. Valkova *et al.*(2021b), in their study comparing the position of *post-mortem* traumatic lesions in rabbits, found an incidence of traumatic lesions of 1.52 %, out of which 0.83 % were on the limbs and 0.69 % on the torso, finding differences between both ($p < 0.01$ In another study, Petracci *et al*. (2010) discovered that 2 % of carcasses had lesions, though they only looked at hematomas larger than 1 cm^2, with the majority of hematomas on the limbs, thorax muscles, and inner back.

The concussion and electronarcosis methods showed differences in terms of the location of the lesions ($p < 0.01$). The concussion method produced 16.7 % of lesions on the torso and 0.8 % on the limbs, whereas electronarcosis produced 7.5 % on the torso

Table 3. Evaluation of the lesions in carcasses of California rabbits (*Oryctolagus cuniculus* L.) after using two stunning methods.

	Total			Concussion			Electronarcosis			
	%	±	SEM	%	±	SEM	%	±	SEM	*p*-value
Carcasses with lesions	93.3		0.61	50.0		4.51	43.3		5.27	0.004
				Anatomic location						
Torso	24.2		7.05	16.7		7.80	7.5		8.96	0.019
Limbs	20.8		7.38	0.8		----	20.0		7.46	<.001
Both	48.3		4.76	32.5		6.24	15.8		7.89	<.001
None	6.7		9.91	0.0		----	6.7		9.91	0.004
				Number of lesions						
Low (0–3)	54.2		4.22	18.3		8.17	35.8		6.12	<.001
High (4–14)	45.8		4.99	31.7		6.60	14.2		8.70	<.001
				Size of lesions						
Small (≤0.5 cm)	18.3		8.17	0.0		----	18.3		8.17	<.001
Medium (0.6–1 cm)	10.0		9.30	4.2		10.67	5.8		10.11	0.545
Large (>1 cm)	65.0		2.79	45.8		4.98	19.2		8.07	<.001
None	6.7		9.91	0.0		----	6.7		9.91	0.004

SEM: standard error of the mean. Statistical differences are presented between rows.

and 20 % on the limbs. The electronarcosis method produces more lesions on the limbs than on the torso, as opposed to the concussion method, which affects the torso more, most likely due to a lesion caused by the stunning method in the occipital region. As a result, the concussion method can explain 32.5 % of lesions in both carcass regions, compared to 15.8 % for electronarcosis.

The location of the lesions may be related to the handling prior to slaughter, which damages the animals' limbs more than their torsos because the limbs are also a central part of the body through which rabbits are captured during catching, loading and unloading, and hanging in the slaughterhouse (Petracci *et al.*, 2010). Data on hematoma percentages between studies and slaughterhouses are difficult to compare due to differences in veterinary inspection and carcass classification methods (Petracci *et al.*, 2010).

Number and size of lesions

The concussion method displayed a more significant number of lesions, between 4 and 14 (31.7 ± 6.6), unlike the electronarcosis method, between 0 and 3 (35.8 ± 6.12) ($p < 0.01$). Regarding the size of the lesion, when the lesions were medium, there were no differences ($p = 0.54$); when they were large, the highest frequency was presented in the concussion method (45.8 ± 4.98). Therefore, applying the concussion method causes a higher number and more extensive lesions than the method of electronarcosis ($p < 0.01$).

Small lesions (18.3 ± 8.17, $p < 0.01$) were more commonly associated with electronarcosis in limbs (20 ± 7.46, $p < 0.01$). However, there was no significant difference in kicking behavior between stunning and the concussion method ($p < 0.001$). Such lesions could be caused by the passage of electric currents, which can cause muscle contractions, resulting in muscle fiber damage and hemorrhage. The hemorrhage is due to a substantial increase in the intravascular pressure, and as a result, blood capillaries can break and lead to bleeding (Kranen *et al.*, 2000). Studies on cows displayed more significant small and medium lesions (74.9 and 19.1 %, respectively) (Knock and Carroll, 2019). On sheep, a prevalence of small lesions has been found (Teiga-Teixeira *et al.*, 2021).

Lesion comparison based on the treatment used

The comparison of ranges (Kruskal-Wallis) expressed as categorical values displayed differences between treatments (*ChiSq* < 0.01) (Figure 1), with treatments 1 and 2 being different from treatments 3 and 4; that is, the frequency of lesions had more significant scores when the concussion method was used (*ChiSq* < 0.05), without differences between sexes (*ChiSq* > 0.05).

There was an average of 3.76 lesions per carcass, ranging from 0 to 14, across the 120 carcasses. The average number of lesions per method was 4.81 for concussion and 2.7 for electronarcosis ($p < 0.01$). The treatment means were T1 = 4.77, T2 = 4.87, T3 = 2.9, and T4 = 2.5, with a standard error of 0.49 ($p < 0.0005$). Small species, such as rabbits,

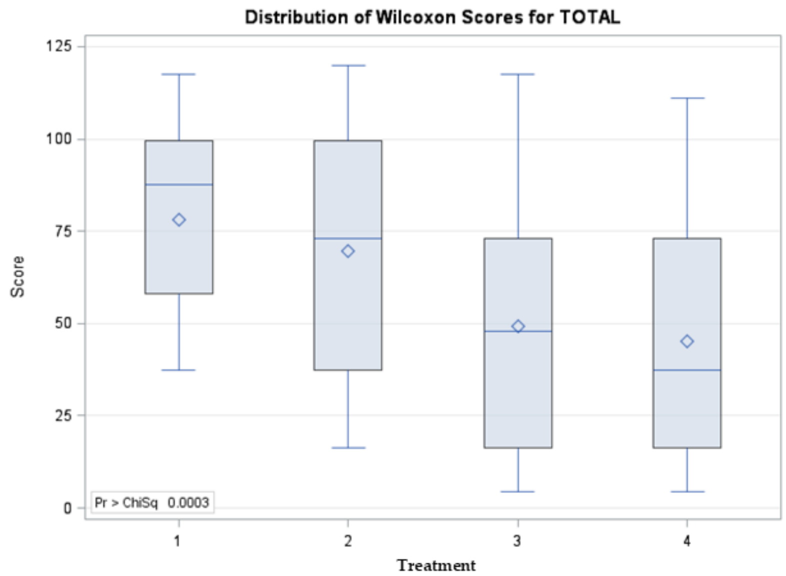

Figure 1. Kruskal-Wallis test comparing the total frequency of lesions in California rabbits (*Oryctolagus cuniculus* L.), depending on the treatment applied. T1: concussion, males; T2: concussion, females; T3: electronarcosis, males; T4: electronarcosis, females. Categories are presented in ranges.

are easier to handle and restrain, allowing for better control of external factors that can cause lesions prior to slaughter. As a result, the lesions discovered during the post-mortem carcass evaluation are associated with the stunning method.

Risk factors for the overall presentation of lesions in the carcass

The logistic regression analysis revealed that the sex and weight of the rabbits, as well as the time between stunning and slaughtering, had no relationship with the total number of lesions found in the carcass (*ChiSq* > 0.05). The concussion method was found to be 4.6 times more likely to cause lesions compared to the electronarcosis method (Table 4; *ChiSq* < 0.01). In other studies, the risk factors associated with the lesions found in the *post-mortem* evaluation of the carcass were sex, race, bodily condition, live weight, zootechnical objective, transportation distance and time, lodging type during transportation, load density, handling conditions, type of truck, loading and unloading conditions, season of the year, farm of origin, and resting time prior to slaughter (Petracci *et al.*, 2010; Tarumán *et al.*, 2018; Bethancourt-Garcia *et al.*, 2019; Knock y Carroll, 2019; Teiga-Teixeira *et al.*, 2021).

Table 4. Probability of lesions in California rabbits (*Oryctolagus cuniculus* L.) for each variable based on the logistical regression analysis.

Variable	Category		Parameter	SEM (b_i)	OR	IC 95 %	*p > ChiSq*
Method	Concussion Electronarcosis	(0) (1)	1.53	0.42	4.60	2.01–10.49	0.0003
Sex	Male Female	(0) (1)	0.40	0.41	1.49	0.66–3.35	0.34
Weight	2.0–2.2 Kg 2.2–2.4 Kg	(0) (1)	-0.19	0.46	0.82	0.33–2.04	0.68
Time	<30 s >30 s	(0) (1)	0.16	0.66	1.17	0.32–4.24	0.81

SEM: standard error of the mean; OR: risk factor; IC: trust interval at 95 %.

CONCLUSIONS

Electronarcosis is an effective method for stunning rabbits before slaughtering, as it causes fewer negative behaviors related to kicking, gaping, lifting of the head, and arching of the back in comparison to the method of concussion, without being influenced by the weight and sex of the animal. The concussion method hurts the welfare of rabbits during slaughter and is not affected by the sex and weight of the animal, either. However, it is affected by the evaluated handling categories.

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