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Research Article

EVALUATION OF THE EFFECT OF INTRATESTICULAR MANNITOL IN GUINEA PIGS (*CAVIA PORCELLUS*) AND ITS INFLUENCE ON ZOOTECHNICAL PARAMETERS

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ABSTRACT

Objective: Chemical castration is emerging as an effective alternative to surgical sterilization, overcoming its disadvantages and allowing large-scale sterilization in a short period of time. The objective of this study was to evaluate the effect of intratesticular mannitol injection in guinea pigs and its influence on zootechnical parameters.

Methods: A total of 0.1 mL of 20% mannitol was administered intratesticular, forming three treatment groups: Surgically castrated guinea pigs (T0), one dose of mannitol (T1), and two doses of mannitol, 15 days apart (T2), over a period of 8 weeks. Variables such as body weight, weight gain, feed intake, feed conversion, and testicular morphometry were evaluated. Fifty-five days post-injection, testicular biopsies were taken for histological analysis.

Results: Guinea pigs in treatments T2 and T1 had higher final live weights compared to T0, with weekly gains of 39.33 g, 28.73 g, and 22.57 g, respectively. Feed intake and feed conversion were more efficient in T1 and T2. No complications or adverse effects were observed, although severe testicular atrophy was evident in T2. Histological findings indicated that mannitol negatively affects spermatogenesis and steroidogenesis.

Conclusion: Intratesticular mannitol represents a safe and effective option for the sterilization of male guinea pigs, allowing for the maintenance of zootechnical performance and avoiding post-operative complications associated with surgical castration.

Keywords: Chemical castration, Mannitol, Morphometry, Histology.

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INTRODUCTION

The province of Bolívar, located in the Andean region of Ecuador, provides favorable conditions for guinea pig (*Cavia porcellus*) production due to the species' adaptability and minimal space requirements. Guinea pig consumption is deeply rooted in local traditions, with production taking place in both traditional subsistence systems and intensive systems for commercial purposes [1].

Widely consumed in the Andean diet, the guinea pig holds cultural and spiritual significance in Indigenous life, including uses in medicine and ceremonial rituals. After colonization, the animal was exported and is now used in various contexts, such as pets or experimental models; however, in the Andes, it remains a key source of protein [2].

Archaeological evidence shows that guinea pigs were domesticated 2,500–3,600 years ago, as confirmed by findings at the Cerro Sechín temple in Peru, where guinea pig droppings from the Paracas culture were discovered – demonstrating ancient consumption [3].

The guinea pig's reproductive system includes the testes, vas deferens, urethra, and accessory glands (seminal vesicles, prostate, and bulbourethral glands), which produce semen during copulation [4]. Proper reproductive management is essential in production systems, as it improves economic performance, reduces inbreeding, and enhances animal survival. It also allows for higher stocking densities, ideal for slaughter and commercialization [5]. Castration and fertility control – primarily through male management – are recommended practices to prevent unwanted breeding in guinea pig production [5].

There are two main castration methods: orchiectomy, involving surgical removal of the testes, and chemical castration, which uses compounds to suppress testicular function. Orchiectomy is typically performed on young guinea pigs under anesthesia and with aseptic techniques to minimize infections. This procedure reduces aggressive behavior, facilitates group housing, and helps control population size.

However, like any surgical procedure, it carries risks such as infection, bleeding, and adverse anesthetic reactions, requiring trained personnel and proper post-operative care. The decision to castrate should be based on an evaluation of the benefits and risks, depending on the purpose of the procedure [6].

Types of castration

Although less common in guinea pigs than in other species, several castration methods are employed, each with its own advantages and disadvantages [7], including:

Surgical castration

Orchiectomy is the most commonly used method, involving the removal of the testes via scrotal incision under anesthesia. Aseptic conditions are required to minimize infection risk [7].

Crushing castration

Common in the livestock industry, this technique applies controlled pressure to the testicles to rupture them, eliminating reproductive

capacity. While perceived as cruel by some, it is considered quick and less invasive than other methods [8].

Immuno castration

Although less frequent in guinea pigs than in pigs, this method involves administering vaccines that stimulate the immune system to block hormone production responsible for sexual and reproductive development [8]. Each method has different implications in terms of effectiveness, risks, and animal welfare, and the choice depends on factors such as age, operator experience, equipment availability, and the purpose of castration [7].

Chemical castration

This method uses chemical agents injected intratesticularly to suppress testicular function by inhibiting hormone production and halting spermatogenesis. However, its use is less common due to risks of severe histological interactions, variable effectiveness, and potential side effects [7].

Use of hypertonic solutions in castration

Intratesticular injection of hypertonic saline solution

Recent studies in studies in rodents have evaluated this method, showing it to be safer and more effective compared to previously used agents. It induces a localized osmotic shock, resulting in severe dehydration and necrosis of testicular tissue. However, trials in adult dogs showed that this method was not effective for sterilization [9].

Use of mannitol

Mannitol ($C_6H_{14}O_6$) is a polyalcohol. Due to its chemical nature as a hypertonic solution, it has been investigated for use in surgical applications, including chemical castration [10].

Pharmacology of mannitol

Mannitol is used as a diuretic in cases of oliguric renal failure and to reduce intraocular and intracranial pressure. It assists in cases of toxicosis by promoting the excretion of water, sodium, and other electrolytes. Intravenous administration is generally safe but requires adequate renal blood flow and is incompatible with extreme solutions [11].

Mannitol in castration

According to Maadi *et al.* [10], 20% mannitol can act as a chemical castration agent in rats, causing irreversible damage to interstitial tissue, impairing steroidogenesis and sperm DNA integrity. Intratesticular application did not result in adverse effects such as inflammation, fistulas, or testicular pain and was well tolerated without signs of discomfort.

Based on the above, the objective of this study was to evaluate the effect of intratesticular mannitol injection in guinea pigs and its influence on zootechnical parameters.

METHODS

This research was conducted at the family farm "Fuentes & Gáleas," located in the province of Bolívar, in the canton of San Miguel, parish of San Vicente, specifically in the Cahuiche sector.

Study material

A total of 45 guinea pigs were used, and 0.1 mL of 20% mannitol was administered, following the methodology described by Maadi *et al.* [10].

Factors under study

The experimental design included two factors (Table 1 treatments under study):

1. Factor A: Chemical castration.
    - A1: One dose of 20% Mannitol;
    - A2: Two doses of 20% Mannitol.
2. Factor B: Productive parameters.

Research management

Housing preparation

The shed was adapted for the maintenance and distribution of experimental units. A total of 45 guinea pigs were divided into 3 groups of 15 animals each. The guinea pigs were 8–10 weeks old, with an average weight of approximately 500 g.

Cleaning and disinfection

After adaptation, thorough cleaning was performed using a germicidal solution with chlorides and quaternary ammonium. The facilities were flamed, and footbaths and disinfection areas were installed.

Feeding

A mixed feeding strategy was used (forage and concentrate), with 150 g of forage and 30 g of concentrate/day, for 8 weeks. Feeding occurred twice daily. Daily rations were estimated using the commercial feed provider's consumption tables.

Anesthesia protocol

Ketamine (40 mg/kg) and Xylazine (5 mg/kg) were administered intraperitoneally, and 0.01–0.1 mL of 2% Lidocaine was infiltrated into the testes. Surgically castrated guinea pigs received Carprofen at 0.1 mg/kg as an adjunct analgesic.

Intratesticular injection of mannitol

Following Maadi *et al.* [10], a 0.1 mL dose of 20% Mannitol was administered using 1 mL syringes. Scrotal trichotomy was performed, followed by antisepsis. A 1 mL syringe with a 27G 1½-inch needle was used to inject the solution from the distal segment of the testicle to the mediastinum, in a fan-shaped pattern. The needle was then removed and the area disinfected.

Fifteen experimental units received one dose of Mannitol at the start of the cycle. Orchiectomy was performed 55 days post-injection for testicular morphometry and histology.

Another 15 units received two doses – one at the beginning and a second 15 days later. Orchiectomy was performed 55 days after the first dose.

Testicular morphology

Morphometry was measured at 0 and 55 days, recording testicle length, diameter, and weight using a vernier caliper and a scale. Weekly weight and feed intake were also recorded.

Orchiectomy

Orchiectomy was performed on all 45 guinea pigs – 15 from surgically castrated guinea pigs (T0), T0 at the start, and the rest (one dose of mannitol [T1], and two doses of mannitol, 15 days apart [T2]) at day 55 post-injection. The procedure followed an open technique under anesthesia, ligating the spermatic cord and suturing the skin.

Histological study: Testes from T0, T1, and T2 groups were randomly selected. Transverse cuts were made at the mediastinum, stained with Hematoxylin and Eosin, fixed in buffered formalin, and analyzed at IPATHLAB. Histological structure, spermatogenesis, and steroidogenesis were evaluated and compared.

Evaluation methods

- Initial live weight: Animals were weighed at the beginning.
- Final live weight: Weighed at the end of the study.
- Accumulated weight gain: Final weight minus initial weight.
- Weekly weight gain: Difference between current and previous week's weight.
- Weekly feed intake: Supplied feed minus leftover feed.
- Feed conversion ratio (FCR): Weekly intake divided by weekly weight gain.
- Post-injection pain: Assessed using the Mouse Grimace Scale; scores ≥5 indicate moderate to severe pain according to Langford *et al.* [12].

Statistical analysis

Data were analyzed using SAS software version 9.4 to assess the effect of intratesticular mannitol injection on productive variables.

RESULTS AND DISCUSSION

Weight of guinea pigs

Statistical analysis using Fisher's significance test showed a significant effect (p=0.03) between treatments on the initial live weight of guinea pigs, with a coefficient of variation (CV) of 12.75%, indicating acceptable variability in the experimental data. Treatments T1 (one dose of mannitol) and T2 (two doses of mannitol) showed statistically similar averages, with T1 reaching the highest numerical value (613.87 g), followed by T2 (599.93 g) (Table 2). In contrast, treatment T0 (orchiectomy with saline solution) showed significant differences with the lowest average (544.60 g). These results differ from those reported by Santillán [13], who observed no significant differences in initial live weight between chemically castrated guinea pigs and controls at 35 days of age, with averages of 575.40 g and 577.33 g, respectively. The discrepancies could be attributed to the age and initial weight of the animals used in each study.

Regarding final live weight, Fisher's test showed highly significant effects (**), confirming clear differences between treatments, with a CV of 4.96%, within an acceptable range of variability. Treatment T2 achieved the highest average final weight (914.60 g), followed by T1 (843.67 g), while T0 had the lowest value (723.93 g). These results suggest that mannitol, as a chemical sterilization agent, not only did not negatively affect animal growth but may even have promoted better recovery and weight gain after treatment, compared to saline solution.

These findings are consistent with those of Benito [14], who reported that guinea pigs chemically sterilized with 2% iodine alcohol reached an average weight of 1253.89 g after 10 weeks, in contrast to 503.19 g in the control group and 591.39 g in the group with testicular atrophy. Although the absolute values of the present study are lower, both investigations agree that chemical sterilization does not cause severe tissue damage and allows maintaining or even improving the productive performance of the animals. Similarly, Ríos Álvarez *et al.* [15] reported that guinea pigs injected with saline solution as a placebo during castration trials showed lower weight gains compared to those treated with chemical agents, attributing this to the absence of physiological or anabolic stimulus in the saline group, which merely acts as a neutral vehicle.

Cumulative weight gain of guinea pigs

Fisher's significance test showed a highly significant effect (**), indicating that cumulative weight gain differed among treatments, with a CV of 15.06%. T2 showed the highest average and was statistically different from the others. T1 had a gain above 200 g, while T0 had the lowest (Table 3). Piscoya *et al.* [6] found that chemical castration using 2% iodine alcohol produced the highest gains (264.38 g), while control and immune castration showed 96.25 g and 154.38 g, respectively. The present results were higher, especially for T2, reinforcing the idea that some sterilizing agents cause less stress and damage in guinea pigs.

Weekly weight gain of guinea pigs

Fisher's significance test indicated a statistically significant effect (**), showing differences in weekly weight gain over 8 weeks, with a CV of 7.63%. T2 had the highest weekly gain, followed by T1, and T0 had the lowest (Table 4). Vega *et al.* [16], observed weekly gains of 63.42 g in chemically castrated guinea pigs using 2% iodine tincture compared to 28 g in intact animals. These higher results may relate to differences in feeding, age, study conditions, and environment.

Weekly feed intake of guinea pigs

Fisher's test showed a statistically significant effect (**) among treatments in weekly feed intake, with a CV of 6.36%, reflecting acceptable variability over 8 weeks with a 30 g/animal/day ration. T2 had the highest intake, followed by T1, and T0 the lowest (Table 5). Shiroma *et al.* [17] found weekly intake of 307.25 g and 346.75 g for chemically castrated and non-castrated groups, respectively, concluding that chemical castration positively affects intake.

FCR of guinea pigs

Statistical analysis using Fisher's test showed significant differences (**) in FCR among treatments. The CV was 11.01%, indicating acceptable dispersion. T0 (surgical castration) had the highest FCR, followed by T1 (one dose of mannitol), while T2 (two doses) had the best efficiency, requiring 5 kg of feed per kg of weight gain (Fig. 1).

Zapata [7] found that sterilized male guinea pigs improve their feed conversion, as nutrients are redirected toward the accumulation of body reserves, thereby increasing productive performance. In his study, surgically castrated guinea pigs had a conversion index of 5.58,

Table 1: Treatments under study

Treatment	Interaction	Description
0	Control	Surgically castrated guinea pigs+Productive parameters
1	A1×B	1 dose of 20% Mannitol+Productive parameters
2	A2×B	2 doses of 20% Mannitol+Productive parameters

A completely randomized design (CRD) was applied for this research

Table 2: Comparison of weight averages of guinea pigs

Treatments	Initial live	Final live
1 (1 dose of mannitol)	613.87 A	914.60 A
2 (2 doses of mannitol)	599.93 A	843.67 B
0 (Orchiectomy)	544.60 B	723.93 C

Table 3: Comparison of cumulative weight gain averages of guinea pigs

Treatments	Averages	Maximum	Minimum
2 (2 doses of mannitol)	314.67 A	382	255
1 (1 dose of mannitol)	229.80 B	405	70
0 (Orchiectomy)	179.33 B	255	108

Table 4: Comparison of weekly weight gain averages of guinea pigs

Treatments	Averages	Maximum	Minimum
2 (2 doses of mannitol)	39.33 A	44.58	36.33
1 (1 dose of mannitol)	28.73 B	30.92	27.24
0 (Orchiectomy)	22.57 C	25.33	18.93

Table 5: Comparison of average weekly feed intake of guinea pigs

Treatments	Averages	Maximum	Minimum
2 (2 doses of mannitol)	203.92 A	210.00	192.93
1 (1 dose of mannitol)	193.52 A B	205.40	172.13
0 (Orchiectomy)	183.39 A B	203.47	151.27

Table 6: Post-treatment pain in guinea pigs

≥5 characteristics			<5 characteristics	
Treatments	Frequency	%	Frequency	%
2 (2 dose of mannitol)	15	100	-	-
1 (1 dose of mannitol)	-	-	15	100
0 (Orchiectomy)	-	-	15	100

immunocastrated animals 8.04, chemically castrated ones 6.53, and intact males 17.50. These results are similar to those of the present study, although treatment T2 showed superior performance compared to Zapata's findings, as chemical castration optimized feed conversion for weight gain, unlike T0, which was affected by the stress of surgical castration.

Testicular morphometry of guinea pigs

Fisher's significance analysis showed statistically significant differences (**) in testicular length among treatments, with a CV of 6.07%, indicating acceptable variability. Treatment T0 had the greatest testicular length, followed by T1 and T2, which had the shortest length in millimeters (Fig. 2).

Rabanal [18] evaluated three castration methods in guinea pigs and found that those treated with 2% iodine showed a reduction in testicular length to 12 mm, compared to the testicular puncture and intact male groups, which had lengths of 25 mm and 22 mm, respectively. Similarly, Pico *et al.* [19] assessed testicular morphometry in guinea pigs subjected to three sterilization methods, observing that intratesticular administration of 1.3% iodine reduced testicular diameter from 23 mm to 18 mm. In comparison, the results of this study show a greater reduction in testicular size in treatment T2 with mannitol, indicating that mannitol is more effective in reducing testicular size than iodine.

Statistical analysis of testicular weight in guinea pigs

Fisher's test revealed statistically significant differences (**) in testicular weight among treatments, with a CV of 17.74%, indicating acceptable variability. Treatment T0 showed the highest testicular weight, followed by T1, while T2 had the lowest weight, demonstrating a notable reduction in guinea pigs treated with mannitol (Fig. 3).

Rosales *et al.* [20] investigated testosterone levels in guinea pigs subjected to chemical and surgical castration, as well as in intact males, finding that chemical castration significantly reduced testicular weight, with averages of 2 g in intact males and 1.5 g in chemically castrated animals. These results are comparable to those of the present study, where treatment T2 with mannitol also showed a significant reduction in testicular weight.

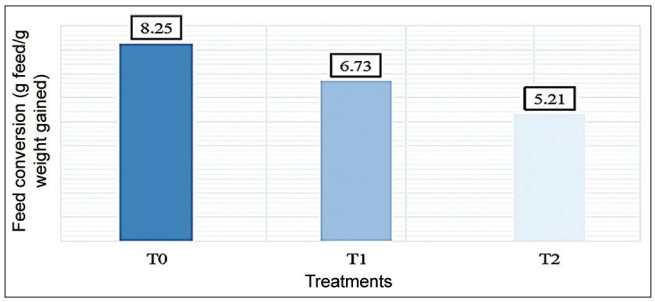

Fig. 1: Average feed conversion ratios of guinea pigs. Notes: T0: Control, T1: Treatment 1, T2: Treatment 2

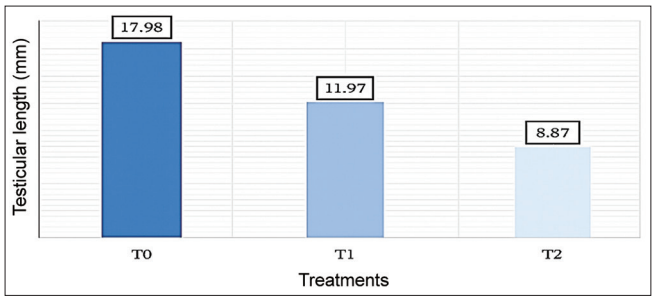

Fig. 2: Comparison of average testicular length in guinea pigs

Post-treatment pain in guinea pigs

The rodent pain scale showed that 100% of the surgically castrated guinea pigs experienced intense pain, while those treated with mannitol showed no signs of facial or bodily pain (Table 6). Calderón [21] also found that chemical castration using sodium chloride and lemon juice in guinea pigs promoted animal welfare without causing pain or stress, improving both weight and feed intake. These findings are consistent with our research, where chemical castration improved animal welfare compared to surgical castration, which involves pain and may reduce productivity.

Histological analysis of guinea pig testicles

Histological findings showed that animals in T0 presented normal testicular anatomy, with complete and well-organized spermatogenesis, displaying an appropriate distribution of Sertoli cells, spermatogonia, spermatocytes, and spermatids. In addition, steroidogenesis appeared normal, with Leydig cells in optimal configuration. In treatment T0+, which received only a needle puncture without chemical substances, histological integrity was preserved, with no inflammation or signs of tissue repair, confirming that this intervention does not alter testicular structure (Fig. 4).

The histological analysis of the mannitol treatments (T1 and T2) revealed that this sterilizing agent interferes with spermatogenesis and steroidogenesis. Apoptosis of spermatogonia and necrosis of adjacent tissue were observed, along with a complete absence of mature spermatozoa and Leydig cells. In T2, spermatogenesis was severely affected, showing a significant decrease in spermatogonia

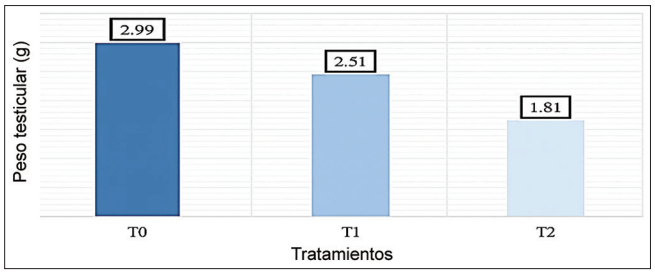

Fig. 3: Average testicular weight in guinea pigs

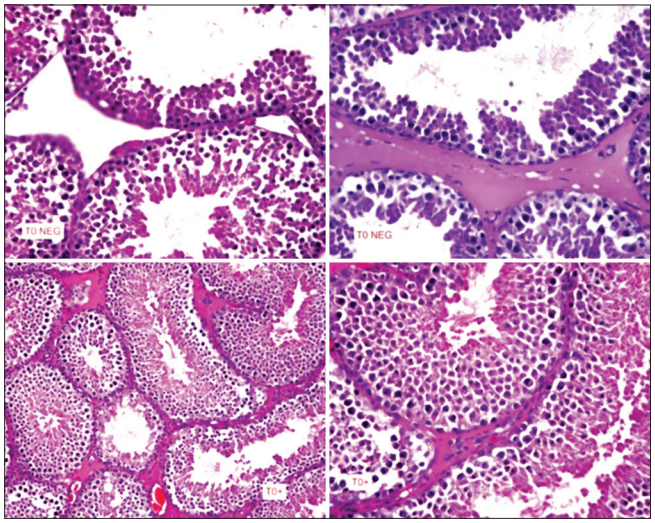

Fig. 4. Histological study of guinea pig testicles. Note. T0 NEG: Intact male guinea pig, T0+: Intact male guinea pig with only a needle puncture. Arrow: normal spermatogenesis organization; arrowhead: Leydig cells and interstitial space; circle: vascular congestion due to the castration process; square: Presence of mature spermatozoa indicating proper spermatogenesis

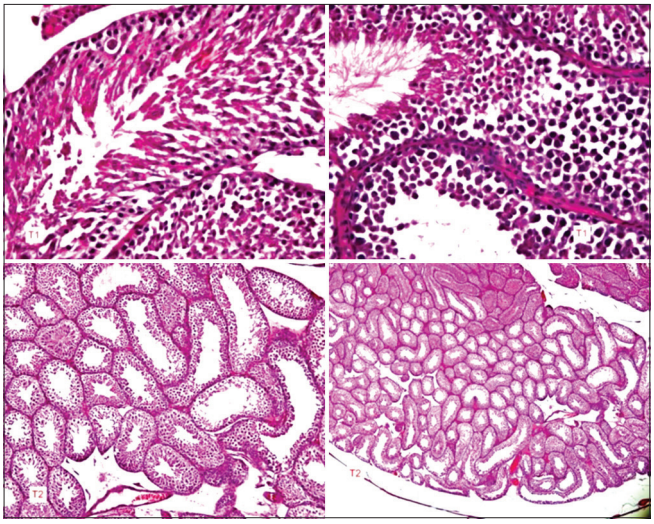

Fig. 5: Histopathological study of the testicles of guinea pigs in T1 and T2. Note. T1: Circle – apoptosis of spermatogonia; arrow – disorganization of spermatic tissue; arrowhead – loss of interstitial tissue (Leydig cells); square – cellular dysplasia. T2: arrow – loss of spermatogonia; arrowhead – complete loss of interstitial tissue; circle – necrosis of spermatic tissue in seminiferous tubules. H&E stain (×40)

and spermatids, as well as degeneration of the interstitial space (Fig. 5). These findings are consistent with those of Maadi *et al.* [10], who reported atrophy and vacuolization of seminiferous tubules in rats following mannitol injection, highlighting its detrimental effect on fertility.

To ensure reproducibility, the intratesticular injection technique followed standardized procedures. Guinea pigs were manually restrained, and the scrotal area was disinfected using 70% ethanol. A 1 mL syringe with a 26-gauge needle was used to inject 0.2 mL of the mannitol solution (either 10% for T1 or 20% for T2) directly into the center of each testicle. The injection was performed slowly to avoid reflux and ensure homogeneous diffusion of the solution within the testicular parenchyma. Care was taken to avoid vascular rupture or perforation of the epididymis. No sutures were required post-injection, and the animals were monitored for signs of inflammation or adverse reactions during the recovery period.

This precise injection protocol allows for consistency across replicates and facilitates reproducibility in future studies evaluating chemical sterilants in small animals.

CONCLUSION

The results indicate that mannitol acts as an effective sterilizing agent in guinea pigs, as it induces failures in spermatogenesis and the absence of Leydig cells, which are responsible for testosterone production. This leads to testicular atrophy and irreversible degenerative changes in the organ's functionality. Despite these adverse effects, guinea pigs treated with mannitol exhibited better productive performance, with greater weight gain and improved feed conversion efficiency.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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AUTHOR CONTRIBUTIONS STATEMENT

CFBC: Conceptualization, methodology design, data curation, and drafting of the original manuscript. FHFG: Experimental supervision, formal analysis, and statistical evaluation. ERRC: Histological processing, interpretation of testicular tissue findings, and critical review of the manuscript. JAR and SRN Project administration, funding acquisition, final editing, and coordination of research activities. This study was approved by the Institutional Ethics and Biosafety Committee of the Universidad Estatal de Bolívar (UEB)

REFERENCES

1. Chavez-Tapia I, Avilés-Esquivel D. Caracterización del sistema de producción de cuyes del cantón Mocha, Ecuador. Rev Investig Vet Peru. 2022;33(2):1. doi: 10.15381/rivep.v33i2.22576
2. Reyes F, Enríquez M, Aguiar S, Uvidia H. Análisis del manejo, producción Y comercialización del cuy (*Cavia porcellus* L.) en Ecuador. Dom Cien. 2021;7(6):1004-18.
3. Dávila-Solarte AP, Mora-Calvache CF, Córdoba-Herrera CA. Caracterización etológica del cuy (*Cavia porcellus*) en sistemas de producción tradicional y tecnificado. Rev Investig Pecuaria. 2018;5(1):5-15. doi: 10.22267/revip.1851.1
4. Ginting N, Suwarso E, Vincen Rumapea D, Nerdy N. Relaxation activity of tetanus (*Leea aequata* l.) leaf ethanolic extracton guinea pig isolated trachea. Asian J Pharm Clin Res. 2018;11(13):24-7. doi: 10.22159/ajpcr.2018.v11s1.26557
5. Cabrera Verdesoto C, Meza Bone C, Mieles Cedeño E, Cabrera Verdezoto R, Morán Morán J, Meza Bone G. Producción Y rentabilidad de cuyes alimentados con arbustivas forrajeras tropicales en zona rural de Quevedo, Ecuador. Cienc Tecnol. 2018;11(2):1-7. doi: 10.18779/cyt.v11i2.231
6. Piscoya C, Zapata M, Vílchez J, Díaz M. Castración inmunológica, química y quirúrgica sobre la actividad sexual en cuyes machos (*Cavia porcellus*) y su Rendimiento Productivo. Cienc Soc. 2021;1:29-40.
7. Zapata M. Efecto de Castración Quirúrgica, Química E Inmunológica en el Comprotamiento Sexual Y Productivo en Cuyes Machos (*Cavia porcellus*). Tesis de Pregrado. Universidad Nacional Pedro Ruiz Gallo; 2023. p. 55. Available from: https://repositorio.unprg.edu.pe/handle/20.500.12893/11441
8. Trillmich F, Guenther A, Jäckel M, Czirják GÁ. Reproduction affects immune defenses in the guinea pig even under ad libitum food. PLoS One. 2020;15(3):e0230081. doi: 10.1371/journal.pone.0230081, PMID 32176718
9. Canpolat I, Karabulut E, Eroksuz Y. Chemical castration of adult and non-adult male dogs with sodium chloride solution. IOSR J Agric Vet Sci. 2016;9(12):9-11.
10. Maadi MA, Behfar M, Rasaei A, Shalizar-Jalali A, Najafi G, Mohammadi V. Chemical castration using an intratesticular injection of mannitol: A preliminary study in a rat model. Turk J Vet Anim Sci. 2021;45(3):519-30. doi: 10.3906/vet-2010-111
11. Plumb D. Manual de farmacología veterinaria. Intermedica (Octava Ed). 2017;2. 1463 p. ISBN 9789505554560.
12. Langford R, Viscusi ER, Morte A, Cebrecos J, Sust M, Giménez-Arnau JM, *et al.* Efficacy of co-crystal of tramadol-celecoxib (CTC) in patients with acute moderate-to-severe pain: A pooled analysis of data from two phase 3 randomized clinical trials. Drugs R D. 2024;24(2):239-52. doi: 10.1007/s40268-024-00469-3, PMID 38874739
13. Santillán L. Efecto de la Castración Química en el Rendimiento y Calidad de Carcasa del Cuy (*Cavia porcellus*). Tesis de Pregrado. Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas; 2020. Available from: https://repositorio.untrm.edu.pe/handle/20.500.14077/2064
14. Benito L. Efectos de Diferentes Métodos de Castración en Cuyes Machos (*Cavia porcellus*) en Etapa de Crecimiento en la Estación Experimental de Patacamaya. Tesis de Pregrado. Universidad Mayor de San Andrés; 2021. Available from: https://repositorioslatinoamericanos.uchile.cl/handle/2250/4050769

15. Ríos Álvarez E, Vilalta Solé L, García de Carellán L. Comparison of subcutaneous sedation with alfaxalone oral faxalone-midazolam in pet guinea pigs (*Cavia porcellus*) of three different age groups. J Am Vet Med Assoc. 2022;260(9):1024-30. doi: 10.2460/javma.21.02.0104
16. Vega J, Pujada A, Astocuri K. Efecto de la castración química en el comportamiento productivo y conductual del cuy. Rev Investig Vet Peru. 2012;23(1):52-7. doi: 10.15381/rivep.v23i1.881
17. Shiroma L, Chauca L, Muscari J. Efecto de la Castración Con Alcohol Yodado Sobre el Crecimiento Y Rendimiento de la Canal En cuyes (*Cavia porcellus*). Vol. 1. Asociación Peruana de Producción Animal; 2024. p. 1-10. Available from: https://repositorio.inia.gob.pe/items/4a1f3926-7bf0-455f-a68e-97d314f5d57b
18. Rabanal A. Efecto de Tres Métodos de Castración en el Comportamiento Productivo de Cuyes (*Cavia porcellus*) de la Raza Perú - Cajamarca. Tesis De Pregrado. Universidad Nacional de Cajamarca; 2023. Available from: https://repositorio.unc.edu.pe/handle/20.500.14074/6660
19. Pico Zerna JM, Shagñay Rea SM, Moncayo Caravallo LA, Roche Angulo GM, Silva Borja VW. Evaluación de la agresividad y morfometría testicular en cuyes (*Cavia porcellus*) sometidos tres métodos de esterilización reproductiva. Cien Latina. 2023;7(3):7094-110. doi: 10.37811/Cl_Rcm.V7i3.6704
20. Rosales J, Ayala L, Aguilar Y, Dután J, Taboada J. Niveles de testosterona total en cuyes (*Cavia porcellus*) extirpados las espículas peneanas, castrados químicamente y enteros y relación con tamaño testicular y vesícula seminal. Rev Electrón Vet. 2017;18(12):1-8.
21. Calderón Y. Comparación del Efecto de Castración Química Mediante Jugo de limón vs Cloruro de Sodio Sobre el Comportamiento Productivo en Cobayos. Tesis de Pregrado. Pontificia Universidad Católica del Ecuador; 2022. Available from: https://repositorio.puce.edu.ec/items/a46a2052-20a4-4cec-ab53-0518522d941c