Archivos de Zootecnia
Journal website: https://www.uco.es/ucopress/az/index.php/az/
SHORT NOTE

Effect of two housing systems and sex on productive performance of lamb during the fattening

Muñoz-Osorio, G.A.[1,3@]; Aguilar-Caballero, A.J.[1]; Sarmiento-Franco, L.A.[1]; Wurzinger, M.[2] and Sandoval-Castro, C.A.[1]

[1]Campus de Ciencias Biológicas y Agropecuarias. Facultad de Medicina Veterinaria y Zootecnia. Universidad Autónoma de Yucatán. Mérida. Yucatán. México.
[2]Department of Sustainable Agricultural Systems, Division of Livestock Sciences, University of Natural Resources and Life Sciences, Vienna, Austria.
[3]Dirección General de Investigación e Innovación. Secretaria de Investigación, Innovación y Educación Superior. Mérida. Yucatán. México.

Additional keywords
Bedding.
Fattening systems.
Feedlot.
Raised pens.
Welfare.

SUMMARY

Raised pens (RP) have been promoted in the tropical regions of Mexico as a housing system to improves the productivity of growing male and female lambs. They showed high acceptance among farmers, however, there is a lack of studies about the RP system and the use of environmental enrichment in the system. Therefore, this study aimed to compare the productive performance of growing lambs (male and female) housed on RP or ground level (GL) using shaving woods as bedding material. Thirty-two lambs (15 males and 17 females) were used, with an average initial live weight and age of 10.54 ± 1.89 kg and 66.54 ± 22.43 days, respectively. Data were analysed by Variance Analysis considering main factors: housing system (RP and GL) and sex (male and female), and dependant variables: daily weight gain (DWG), feed intake (DMI), feed conversion (FC) and final body weight (FBW). The housing system did not affect DWG, DMI, FC and FBW (P > 0.05). Males presented higher values in all productive indicators than females (except FC). Under the conditions of this study, the productive performance of growing lambs housed either RP or GL was similar.

Efecto de dos sistemas de alojamiento y del sexo sobre el comportamiento productivo de corderos durante el engorde

Palabras clave
Materiales de cama.
Sistemas de engorda.
Sistemas intensivos.
Corrales elevados.
Bienestar.

RESUMEN

Los corrales elevados (RP) han sido promovidos en las regiones tropicales de México como un sistema de alojamiento que mejora el comportamiento productivo de los corderos en crecimiento y han mostrado una gran aceptación entre los productores, tanto para corderos machos como en hembras; sin embargo, han sido poco estudiados y usado sin enriquecimiento ambiental en los sistemas intensivos. Por lo tanto, el objetivo de este estudio fue comparar el comportamiento productivo de corderos en crecimiento tanto machos como hembras alojados en RP y a nivel del suelo (GL) usando viruta como material de cama. Se usaron 32 corderos, 15 machos y 17 hembras, con un promedio de peso vivo y edad inicial de 10,54 ± 1,89 kg y 66,54 ± 22,43 días, respectivamente. Los datos fueron analizados empleando análisis de varianza, incluyendo como efectos fijos el tipo de alojamiento (RP y GL) y el sexo (machos y hembras) y las variables dependiente ganancia diaria de peso (DWG), el consumo de alimento (DMI), la conversión alimenticia (FC) y el peso vivo final (FBW). El tipo de alojamiento no tuvo efecto sobre DWG, DMI, FC y FBW (P > 0,05). Los machos presentaron mejores valores en todos los indicadores productivos que las hembras (excepto en FC). Bajo las condiciones de este estudio, el comportamiento productivo de corderos en crecimiento alojados ya sea en RP o en GL fue similar.

Information

Cronología del artículo.
Recibido/Received: 15.11.2019
Aceptado/Accepted: 24.09.2020
On-line: 15.10.2020
Correspondencia a los autores/Contact e-mail:
gamo_688@hotmail.com

INTRODUCTION

The housing of growing lambs is an important factor in intensive fattening systems due to its influence on productive performance and animal welfare (Muñoz-Osorio et al., 2019). In this sense, the literature has demonstrated the beneficial effects of enriched housing with bedding materials on animal welfare and the maintenance of the production level of the systems (Muñoz-Osorio et al., 2019). In fattening lamb

production, a good housing system can improve biological functioning, as well as welfare (Aguayo-Ulloa et al., 2014; Aguayo-Ulloa et al., 2015). However, in the warm sub-humid tropical region of Mexico, the most traditional housing systems used is intensive feedlot at ground level (GL) without any material used as bedding (Muñoz-Osorio et al., 2015; Muñoz-Osorio et al., 2016), which has an unfavorable environment for lambs without comfort (Teixeira et al., 2012; Teixeira et al., 2014; Teixeira et al., 2015). Thus, the raised pens (RP) offer probably an alternative solution for this problem (Muñoz-Osorio et al., 2015; Muñoz-Osorio et al., 2016; Muñoz-Osorio et al., 2017).

RP is commonly used in intensive feeding operations and research settings to minimize the labour and costs associated with bedding and manure removal from animal pens (Færevik et al., 2005; Jaborek et al., 2016). This system has advantages such as a clean and healthy environment, reduced exposure to parasites, increases protection from predators, and reduces energy expenditure from animals (Lupton et al., 2007; Hernández-Cortazar et al., 2014). RP has been promoted in the tropical regions of Mexico as a housing system that improves the productivity of growing lambs for male and female lambs and shows high acceptance among farmers (Muñoz-Osorio et al., 2015; Muñoz-Osorio et al., 2016). However, in a recent review it was shown that RP, per se, does not seem to improve the productive performance of lambs, due to the interaction of various factors such as management, breeding, nutrition, health, among others (Muñoz- Osorio et al., 2019). Therefore, our research group has hypothesized that under controlled conditions (free of parasites, similar genotypes, adequate housing conditions, including elevated roofs and clean environment), the productive performance of lambs housed in RP and at GL could be similar (Muñoz-Osorio et al., 2017). Besides, male and female lambs are managed under the same conditions, either for housing or feeding (Muñoz-Osorio et al., 2015). These strategies, however, seems to be inadequate because males have higher food consumption and achieve higher weight gain compared to females (Bello et al., 2016).

There is a lack of studies about RP and the environmental enrichment of fattening intensive systems (Muñoz-Osorio et al., 2019). However, Mexican consumers are interested in animal welfare issues and their ethical, sociological, and economic implications (Miranda-de la Lama et al., 2017). The studies of enriched housing with bedding materials such as woodchip, considering a productive point of view, is a research area that needs to be addressed in the tropical regions of Mexico (Muñoz-Osorio et al., 2019). Likewise, it is necessary to continue research on RP to clarify with scientific evidence if they improve the productive performance of growing male and female lambs compared to pens with environmental enrichment (Muñoz-Osorio et al., 2019). This study aimed to compare the productive performance of growing male and female lambs housed on RP or GL enriched with woodchip as bedding material.

MATERIAL AND METHODS

The trial was conducted between March and June at a sheep farm located in the center of Yucatán, Mexico (21 ° 14′ N, 89 ° 07′ W), with warm sub-humid climate and summer rainfalls. There are two seasons during the year, dry season (December-May) and rainy season (June-November) (INEGI, 2013).

Thirty-two lambs (hair sheep crossbreed), 15 males and 17 females, born and weaned in the same farm, with an average initial live weight and age of 10.54 ± 1.89 kg and 66.54 ± 22.43 days, respectively, were distributed into two housing systems: 1) RP and 2) GL, with a similar number of male and female lambs per system. Lambs were housed in 12 pens (6 RP and 6 GL pens) with two or three lambs each (1 m² per lamb). The study lasted ten weeks, two of adaptation and eight of the experimental period.

The RP was build of an expanded metal floor. The RP was daily cleaned and dried. The floor of GL was made of concrete covered with woodchips (approximately 10 cm in height) (**Figure 1**). New bedding material was added or replaced during the experiment when necessary. Pens had roof that provided shade for the lambs all the time, as well as feeders and troughs. The roof was 3.90 m in height, and the RP was 80 cm above the ground. The lambs were fed twice a day (8:30 and 16:00 h). The amount of feed supplied daily was adjusted, considering at least 15% rejection of feed offered. Samples from both feed supplied and rejected were taken once a week for dry matter analysis. The food was commercial brand concentrate containing 12% humidity, 14.5% crude protein, 2.8% fat, 3.1% crude fiber, 5.0% ash, and 62.60% nitrogen-free extract (according to the manufacturer's information). Water consumption was *ad libitum*. Seven days before starting the experiment, all lambs were dewormed with Levamisol 12% at doses of 16 mg/ kg BW.

The lambs were weighed at 8:00 in the morning every 14 days, with a digital scale, previously fasting of 12 h. Body weight change was calculated as follows BWC = final body weight (FBW) – initial body weight (IBW). The dry matter intake (DMI, kg day-1) was estimated as the difference, on dry basis, between the concentrate suppled and the concentrate refused. Daily weight gain (DWG, g day-1) was calculated as the difference between IBW and FBW divided by the whole fattening period (70 days). The feed conversion on dry basis (FC, kg DM kg-1) was estimated as DMI/BWC.

The data were analyzed by the General Linear Model procedure of SAS version 8 (SAS, 1999). In order to determine the effects of housing systems (RP and GL) and sex (male and female) on DWG, DMI, FC, and

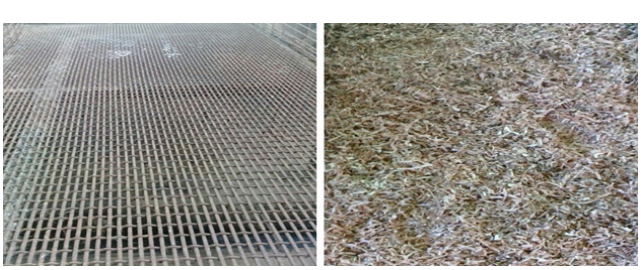

Figure 1. Pens made of expanded metal floor (RP, left side) and pens at ground level enriched with woodchip as bedding material (GL, right side) (Corral elevado con piso construido de metal expandido (RP, lado izquierdo) y corral a nivel del suelo enriquecido con viruta de madera como material de cama (GL, derecha)**.**

FBW analysis of variance were performed. The model included simple interactions between fixed effects; however, as there no significant interaction, they were removed from the final model. Differences between means were assessed by Tukey test. Resulting data were tabulated using Least Square Means (LSM) and their associated Standard Error of Means (SEM). Besides, an overall relationship between time and live weight for males and females was assessed using linear regression, and the DWG means (regression slopes) were compared using GraphPad Prism 5 (2007).

RESULTS

Overall means and SEM for DWG, DMI, FC and FBW were 231.7 ± 10.0 g, 951.4 ± 17.9 g/d, 4.5 ± 0.35 kg/kg and 26.8 ± 0.8 kg, respectively. The LSM ± SEM of productive performance for the different housing systems are shown in **Table I**. No significant differences between RP and GL were found for DWG, DMI, FC, and FBW ($P > 0.05$).

The LSM ± SEM of the variables of productive performance, according to the sex, is shown in **Table I**. The males showed differences of 59.0 g, 108.25 g, and 4.9 kg for DWG, DMI, and FBW, respectively, higher than females ($P < 0.05$), while the FC was not statistically different between sexes ($P > 0.05$).

DISCUSSION

Results on the DWG and FC agree with those reported by Escalera et al. (2017), but DWG was lower than that reported by Muñoz-Osorio et al. (2017). To our knowledge, no studies have compared RP and GL enriched with woodchip as bedding material. However, the literature shows other studies that also found no significant differences between different housing systems on the productive performance of lambs. Escalera et al. (2017), reported similar DWG and FC between lambs housed in RP compared to GL of concrete. Day et al. (2006), found higher DWG on lambs allocated in pens with plastic slats compared to straw bedding pen.

Rescently, Muñoz-Osorio et al. (2017), in a retrospective study (using 1213 productive data of lambs registered for three years), found differences in favor of the RP compared to GL of metal or plastic slats flooring only for the first year, but in the second year, these indicators presented similar values, regardless of the housing type. These authors suggest that the productive performance of lambs can vary due to diverse factors such as feeding, housing, climatic conditions, preventive and bio-security factors as well as production objectives. Besides, it is probable that their environmental adaptation or tolerance of hair sheep lambs to warm conditions, it allows a good productive performance regardless of the housing system (Do Prado et al., 2013; Correa et al., 2013).

Flooring type may affect animal behavior and growth performance if the flooring material causes stress to the animal (Jaborek et al., 2016). In the present study, the lamb behavior or welfare was not evaluated. It would have been interesting to evaluate the resting area or time resting on the different housing systems during the experimental period. For example, Teixeira et al. (2013) in a study, analyzing lamb's choices of different types of bedding materials and cement floor area (available during the fattening period), observed that the lambs preferred sawdust bedding with an occupancy rate of 47% compared to an area without cement bedding material 21%. Lambs on the sawdust bedding were lying longer (80%) than standing (20%), which suggests lower energetic waste for movements and better use of food for growth. So, bedding material (woodchip) incorporated into the GL system could have favored the productive performance of the animals, as reported by Wolf et al. (2010). A study in ewes showed clear preferences for resting on the solid floor rather than slatted floors during the cold season (Jørgensen et al., 2017).

Assessment of the sex effect in this study was important because farmers use RP for both male and female lambs. Results showed that males have higher production efficiency than females, which has been reported before (Partida et al., 2009; Macías-Cruz et al., 2010; Rodríguez et al., 2011; De Vargas Junior et al., 2014; Escalera et al., 2017). These differences could be explained because of higher feed intake in males compared with females (Macías-Cruz et al., 2010) and for increased muscle-fat ratio in the composition of gain weight by the males. Males deposit more muscle and less fat than females (Partida et al., 2009). On the other hand, overall cumulative weight gain (WG) during the experimental period was described by the

Table I. Daily weight gain, feed intake, feed conversion and final weight of lambs for the housing system and sex (Ganancia diaria de peso, consumo de alimento, conversion alimenticia y peso final de corderos por sistema de alojamiento y sexo).

Variables	Housing system		Sex	
	RP	GL	Male	Female
Daily weight gain (g)	238.7 ± 14.2[a]	224.7 ± 14.1[a]	261.2 ± 14.6[a]	202.2 ± 13.7[b]
Feed intake (g/d)	940.8 ± 25.4[a]	962.1 ± 25.3[a]	1005.6 ± 26.2[a]	897.3 ± 24.6[b]
Feed conversion (kg/kg)	4.5 ± 0.5[a]	4.5 ± 0.5[a]	4.4 ± 0.5[a]	4.6 ± 0.4[a]
Final weight (kg)	27.3 ± 1.1[a]	26.2 ± 1.1[a]	29.2 ± 1.2[a]	24.3 ± 1.1[b]

RP = Raised pens made of expanded metal floor; GL = Pens at ground level enriched with woodchip as bedding material. Values are expressed as least square means (±SE). Different letters indicate significant differences (a<b, $P < 0.05$) (RP – Corral elevado con piso construído de metal expandido; GL - Corral a nivel del suelo corral a nivel del suelo enriquecido con viruta de madera como material de cama (GL, derecha), . Los valores se expresan como medias al cuadrado (±SE). Diferentes letras indican diferencias significativas (a<b, $P < 0.05$)).

following equations: Males WG (kg) = 10 (± 0.75) + 0.26 (± 0.018)*No. days and Females WG (kg) = 9.9 (± 0.43) + 0.20 (± 0.010)*No. of day. The slope of the regression was different between males and females ($P < 0.004$), and DWG differed from 28th day onwards ($P < 0.05$) (**Figure 2**). The model included simple interactions between housing systems and sex; however, there was no significant interaction between them. These results suggest that females and males should be managed different during the finishing phase of fattening.

CONCLUSIONS

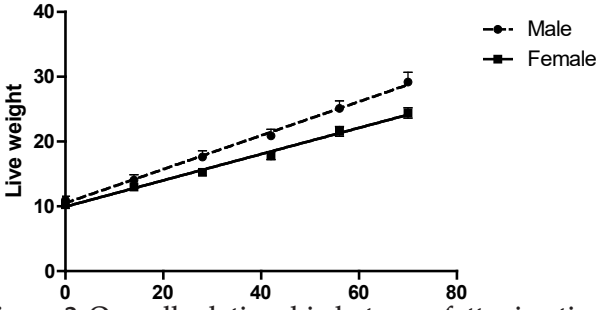

Figure 2. Overall relationship between fattening time (days) and live weight (kg) for males and females (Relación general entre el tiempo de engorde (días) y el peso vivo (kg) para machos y hembras**).**

It is concluded that the RP system did not improve the productive performance of growing lambs compared with GL enriched with woodchip as bedding material. These results are of great interest for sheep farmer because the inversion of capital in RP is higher than in GL, and this is directly related to the profitability of the system. However, these results should be taken with caution due to the small number of replicates used in the current study. It is essential to continue with these studies considering higher number of lambs and environmental factors such as building temperature, speed, and air movement. On the other hand, the assessments of these housing systems regarding lamb welfare and meat quality are necessary.

ACKNOWLEDGMENTS

The first author would like to thank the Consejo Nacional de Ciencia y Tecnologia (CONACYT-México) for the scholarship granted for Ph.D. studies at the Universidad Autónoma de Yucatán, México.

BIBLIOGRAPHY

Aguayo-Ulloa, LA., Miranda-de la Lama, GC, Pascual-Alonso, M, Olleta, JL, Villarroel, M, Sañudo, C, & María, GA 2014, ´Effect of enriched housing on welfare, production performance and meat quality in finishing lambs: The use of feeder ramps´, *Meat Science*, vol. 97, pp. 42–48. http://dx.doi.org/10.1016/j.meatsci.2014.01.001

Aguayo-Ulloa, LA, Pascual-Alonso, M, Olleta, JL, Sañudo, C, Miranda-de la Lama, GC, & María, GA 2015a, ´Effect of a screen with flaps and straw on behaviour, stress response, productive performance and meat quality in indoor feedlot lambs´, *Meat Science*, vol. 105, pp. 16–24. http://dx.doi.org/10.1016/j.meatsci.2015.02.008

Bello, JM, Mantecón, AR, Rodriguez, M, Cuestas, R, Beltran, JA, & Gonzalez, JM 2016, ´Fattening lamb nutrition. Approaches and strategies in feedlot´, *Small Ruminant Research*, vol. 142, pp. 78-82. https://doi.org/10.1016/j.smallrumres.2016.04.006

Correa, MPC, Dallago, BSL, Paiva, RS, Canozzi, AME, Louvandini, H, Barcellos, JJ, & McManus, C 2013, ´Multivariate analysis of heat tolerance characteristics in Santa Inês and crossbred lambs in the Federal District of Brazil´, *Tropical Animal Health and Production*, vol. 45, pp. 1407-1414. https://doi.org/10.1007/s11250-013-0378-3

Day, JP, Boland, TM, & Crosby, TF 2006, ´The effects of plastic slatted floor or straw bedding on performance, liver weight and liver copper concentrations in intensively reared lambs´, *Livestock Science*, vol. 100, pp. 270–275. https://doi.org/10.1016/j.livprodsci.2005.09.007

De Vargas Junior, FM, Martins, CF, dos Santos Pinto, G, Ferreira, MB, de Almeida Ricardo, H, Leão, AG, Fernandes, ARN, & Teixeira, A 2014, ´The effect of sex and genotype on growth performance, feed efficiency, and carcass traits of local sheep group Pantaneiro and Texel or Santa Inês crossbred finished on feedlot´, *Tropical Animal Health and Production*, vol. 46, pp. 869-875. https://doi.org/10.1007/s11250-014-0579-4

Do Prado Paim, T, Borges, BO, de Mello Tavares Lima, P, Gomes, EF, Dagallo, BSL, Fadel, R, De Menezes, AM, Louvandini, H, Canozzi, MEA, Barcellos, JOJ, & McManus, C 2013, ´Thermographic evaluation of climatic conditions on lambs from different genetic groups´, *International Journal of Biometeorology*, vol. 57, pp. 59-66. https://doi.org/10.1007/s00484-012-0533-y

Escalera, VF, Martínez, GS, Carrillo, DFB, Salgado, MSM, Ávila, RF, Gómez, GA, & Lenin, LOJ 2017, ´Uso del piso de rejilla como método físico de control de parásitos gastrointestinales en corderos recién destetados´, *Investigación y Ciencia*, vol. 25, núm. 72, pp. 12-19.

Færevik, G, Andersen, IL, & Bøe, KE 2005, ´Preferences of sheep for different types of pen flooring´, *Applied Animal Behaviour Science*, vol. 90, pp. 265–276. https://doi.org/10.1016/j.applanim.2004.08.010

GraphPad Prism 2007, ´Prism 5, versión 5.01 for windows´, GraphPad software Inc. www.graphpad.com

Hernández-Cortázar, HB, Jiménez-Coello, M, Acosta-Viana, KY, Guzmán-Marín, E, Torres-Acosta, JFJ, Rodríguez-Buenfil, JC, & Ortega-Pacheco, A 2014 ´Comparing the dynamics of *Toxoplasma gondii* seroconversion in growing sheep kept on raised slatted floor cages or floor pens in Yucatan, Mexico´, *Small Ruminant Research*, vol. 121, pp. 400-403. https://doi.org/10.1016/j.smallrumres.2014.06.011

INEGI 2013, ´Instituto Nacional de Estadística y Geografía´, Anuario estadístico y geográfico por entidad federativa / Instituto Nacional de Estadística y Geografía. México: INEGI, c2013. 744 p. ISBN En trámite.

Jaborek, JR, Lowe, GD, & Fluharty, FL 2016, ´Effects of pen flooring type and bedding on lamb growth and carcass characteristics´, *Small Ruminant Research*, vol. 144, pp. 28–34. https://doi.org/10.1016/j.smallrumres.2016.07.013

Jørgensen, GHM, Johanssen, JRE, & Bøe, KE 2017, ´Preference in shorn sheep for different types of slatted flooring at low ambient temperatures´, *Small Ruminant Research*, vol. 153, pp. 17-22. https://doi.org/10.1016/j.smallrumres.2017.05.002

Lupton, CJ, Huston, JE, Craddock, BF, Pfeiffer, FA, & Polk, WL 2007, ´Comparison of three systems for concurrent production of lamb meat and wool´, *Small Ruminant Research*, vol. 72, pp. 133-140. https://doi.org/10.1016/j.smallrumres.2006.10.002

Macías-Cruz, U, Álvarez-Valenzuela, FD, Rodríguez-García, J, Correa-Calderón, A, Torrentera-Olivera, NG, Molina-Ramírez, L, & Avendaño-Reyes, L 2010, ´Crecimiento y características de canal en corderos Pelibuey puros y cruzados F1 con razas Dorper y Katahdin en

confinamiento´, *Archivos de Medicina Veterinaria*, vol. 42, pp. 147-154. http://dx.doi.org/10.4067/S0301-732X2010000300005

Miranda-de la Lama, GC, Estévez-Moreno, LX, Sepúlveda, WS, Estrada-Chavero, MC, Rayas-Amor, AA, Villarroel, M, & María, GA 2017, ´Mexican consumers' perceptions and attitudes towards farm animal welfare and willingness to pay for welfare friendly meat products´, *Meat Science*, vol. 125, pp. 106-113. https://doi.org/10.1016/j.meatsci.2016.12.001

Muñoz-Osorio, GA, Aguilar-Caballero, AJ, Sarmiento-Franco, LA, Wurzinger, M, & Cámara-Sarmiento, R 2015, ´Descripción de los sistemas intensivos de engorda de corderos en Yucatán, México´, *Nova Scientia*, vol. 7, pp. 207-226. DOI: 10.21640/ns.v7i15.346

Muñoz-Osorio, GA, Aguilar-Caballero, AJ, Sarmiento-Franco, LA, Wurzinger, M, & Cámara-Sarmiento, R 2016, ´Technologies and strategies for improving hair lamb fattening systems in tropical regions: a review´, *Ecosistemas y Recursos Agropecuarios*, vol. 3, pp. 267-277. http://ri.ujat.mx/bitstream/20.500.12107/1064/1/1058-724-A.pdf

Muñoz-Osorio, GA, Aguilar-Caballero, AJ, Sarmiento-Franco, LA, Wurzinger, M, & Gutiérrez-Reynoso, GA 2017, ´The effect of two housing systems on productive performance of hair-type crossbreed lambs in sub-humid Tropic of Mexico´, *Journal of Applied Animal Research*, vol. 45, pp. 384-388. DOI: 10.1080/09712119.2016.1200979

Muñoz-Osorio, GA, Aguilar-Caballero, AJ, & Cámara-Sarmiento, R 2019 ´Influencia del tipo de alojamiento sobre el comportamiento productivo y bienestar de corderos en sistemas de engorda intensivos´, *Tropical and Subtropical Agroecosystems*, vol. 22, pp. 1-11. http://www.revista.ccba.uady.mx/urn:ISSN:1870-0462-tsaes.v22i1.2777

Partida, PJA, Braña, VD, & Martínez, RL 2009, ´Desempeño productivo y propiedades de la canal en ovinos Pelibuey y sus cruzas con Suffolk o Dorset´, *Técnica Pecuaria México*, vol. 47, pp. 313-322.

Rodríguez, AB, Bodas, R, Landa, R, López-Campos, Ó, Mantecón, AR, & Giráldez, FJ 2011, ´Animal performance, carcass traits and meat characteristics of Assaf and Merino × Assaf growing lambs´, *Livestock Science*, vol. 138, pp. 13-19. https://doi.org/10.1016/j.livsci.2010.11.020

SAS 1999, ´Statistical Analysis System Version 8´, SAS Institute Inc., Cary, NC, USA.

Teixeira, DL, Miranda-de la Lama, GC, Villarroel, M, García-Belenguer, S, Sañudo, C, & María, GA 2012, ´Effect of straw on lamb welfare, production performance and meat quality during the finishing phase of fattening´, *Meat Science*, vol. 92, pp. 829-836. http://dx.doi.org/10.1016/j.meatsci.2012.07.009

Teixeira, DL, Miranda-de la Lama, GC, Pascual-Alonso, M, Aguayo-Ulloa, L, Villarroel, M, & María, GA 2013, ´A note on lamb's choice for different types of bedding materials´, *Journal of Veterinary Behavior*, vol. 8, pp. 175-179. http://dx.doi.org/10.1016/j.jveb.2012.06.007

Teixeira, DL, Miranda-de la Lama, GC, Villarroel, M, Escós, J, & María, GA 2014, ´Lack of straw during finishing affects individual and social lamb behavior´, *Journal of Veterinary Behavior*, vol. 9, pp. 177-183. http://dx.doi.org/10.1016/j.jveb.2014.02.008

Teixeira, DL, Miranda-de la Lama, G, Villarroel, M, Olleta, JL, García-Belenguer, S, Escós, J, & María, GA 2015, ´Effects of alternative bedding substrates on lamb welfare, productive performance, and meat quality during the finishing phase of fattening´, *Journal of Veterinary Behavior*, vol. 10, 171–178. http://dx.doi.org/10.1016/j.jveb.2014.12.011

Wolf, BT, Molloy, HRB, Trayte, MJ, & Rose, MT 2010, ´Behaviour of growing lambs housed on straw or woodchip bedding materials and their preference for floor type´, *Applied Animal Behaviour Science*, vol. 124 pp. 45–50. DOI:10.1016/j.applanim.2010.01.011