Ciência Rural, Santa Maria, v.53:4, e20210790, 2023
http://doi.org/10.1590/0103-8478cr20210790
ISSNe 1678-4596
FOOD TECHNOLOGY

Sex and slaughter weight on carcass traits and non-carcass components of horses

Pedro Hernández-Briano[1] Octavio Carrillo-Muro[1*] Alejandro Rivera-Villegas[1] Marco Antonio López-Carlos[1] Fabiola Méndez-Llorente[1] Jairo Iván Aguilera-Soto[1] Carlos Fernando Aréchiga Flores[1]

[1]Unidad Académica de Medicina Veterinaria y Zootecnia, Universidad Autónoma de Zacatecas, General, Enrique Estrada, 98500, Zacatecas, México. E-mail: octaviocm@hotmail.com. *Corresponding author.

ABSTRACT: *The study evaluated the effect of sex and slaughter weight on carcass traits and non-carcass components of 1,489 horses (739 geldings and 750 females, classified into eight groups according to their weight). Data were analyzed under a completely randomized design. Geldings had a higher (P < 0.05) hot carcass yield (HCY) and cold carcass yield (CCY) than females; however, fat yellowness values (b*) were greater (P < 0.05) in females. Slaughter weight (SW) affected the carcass characteristics. Hot carcass weight (HCW), cold carcass weight (CCW), HCY, and CCY increased (P < 0.05) in accordance with slaughter weight, while cool loss percentage (CL%) was lower (P < 0.05) in horses weighing more than 300 kg. In addition, the non-carcass components decreased (P < 0.05) as the weight of the horses increased. In conclusion, sex and body weight are factors to consider in the production of equine meat since they affect carcass characteristics and non-carcass components.*
Key words: *Horsemeat, carcass weight, carcass yield, meat color, non-carcass components.*

Sexo e peso de abate sobre as características de carcaça e componentes não-carcaça de cavalos

RESUMO: *O estudo teve como objetivo avaliar o efeito do sexo e do peso ao abate sobre as características de carcaça e componentes não-carcaça de 1.489 cavalos (739 machos castrados e 750 fêmeas, classificados em oito grupos de acordo com o peso). Os dados foram analisados em um desenho inteiramente casualizado. Os semeadores apresentaram maior rendimento de carcaça quente (HCY) e fria (CCY) do que as fêmeas, porém o amarelecimento da gordura (b*) foi maior nas fêmeas. O peso ao abate (SW) afetou as características de carcaça. HCW, CCW, HCY e CCY aumentaram de acordo com o peso de abate, enquanto CL% foi menor em equinos com peso superior a 300 kg. Além disso, os componentes não-carcaça diminuíram com o aumento do peso dos cavalos. Em conclusão, sexo e peso corporal são fatores a serem considerados na produção de carne equina, uma vez que afetam as características da carcaça e seus componentes.*
Palavras-chave: *Carne de cavalo, sexo, peso corporal, características de carcaça.*

INTRODUCTION

Horsemeat is classified as meat of excellent quality (TATEO, 2008; LORENZO et al., 2010; STANCIU, 2015). However, the consumption of pork, chicken and beef is higher than that of horsemeat (GILL, 2005; LOMBARDI-BOCCIA et al., 2005). *Per capita* horsemeat consumption is difficult to estimate; however, BELAUNZARAN et al. (2015) have reported a world average of 0.10 kg. Moreover, LORENZO & CARBALLO (2015) mentioned that part of the horsemeat consumed worldwide comes from horses that ended their productive life.

Horses have advantages over other meat-producing species, due to their high carcass yields (60 to 70%) composed principally by the muscle (70%) but low in fat (10%) and bone (20%) (SARRIÉS & BERIAIN, 2005; LANZA et al., 2009). Previous research reports described that sex, age, breed, and production system affect carcass traits and meat quality (JUÁREZ et al., 2009; FRANCO et al., 2011, CITTADINI et al., 2021). However, there are few research reports on the factors that affect carcass and meat characteristics of horses slaughtered in America. Thus, this study evaluated effects of sex and slaughter weight on carcass traits and non-carcass components of horses.

MATERIALS AND METHODS

Protocols for care and animal handling were carried out following the official Mexican standards:

Received 11.04.21 Approved 05.18.22 Returned by the author 06.23.22
CR-2021-0790.R2
Editors: Rudi Weiblen Rubén Domínguez

NOM-024-ZOO-1995, NOM-033-SAG/ZOO-2014, NOM-051-ZOO-1995, and NOM-062-ZOO-1999. In addition, the techniques and procedures were carried out following the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, E.U. Directive 2010/63/EU for animal experiments.

Animals

A sample of 1,489 Quarter Horses and their crosses owned by the packing plant "Empacadora de Carnes Fresnillo S.A. de C.V." located in Zacatecas, México was used. Daily visits were made for 4 weeks to the slaughterhouse until the sample was completed. Horses were classified according to their sex in gelding (739) or female (750). Slaughter weight (SW) was measured before slaughter using an electronic scale (model PG, Torrey, México), and they were classified into eight groups according to SW: 150 to 200 kg, 201 to 250 kg, 251 to 300 kg, 301 to 350 kg, 351 to 400 kg, 401 to 450 kg, 451 to 500, and > 500 kg.

Slaughter and carcass data collection

The slaughter procedures were performed following the Mexican Official Standard NOM-033-SAG/ZOO-2014. After slaughter, non-carcass components (Head, skin, heart, lungs, stomach, caecum, spleen, liver, small intestine, and large intestine) and hot carcass weight (HCW) were obtained. Internal organs were individually removed and weighed. The organ mass was expressed as a percentage of empty slaughter weight (BW). To obtain cold carcass weight (CCW) and dressing percentage, carcasses were stored for 24 h at 4 °C and 98% of relative humidity. Cooling loss (CL) was calculated from the difference between HCW and CCW, and expressed as percentage.

Color determination (L^*, a^*, b^*) in fat (subcutaneous and abdominal) and muscle (*semitendinosus*) was carried out 45 minutes *post-mortem* directly on the carcass using a portable spectrophotometer (CR-400, Konica Minolta Sensing Inc., Japan).

Statistical analyses

A normality test of the data was performed with UNIVARIATE procedure of the SAS University Edition software (SAS Institute, Cary, NC, USA). Data were analyzed as a completely randomized design using the GLM procedure. The model included the sex and slaughter weight as fixed effects. A multiple comparison was made whit option MEANS Tukey in SAS. Main effects significance was declared at $P < 0.05$. Results were presented as least square means ± SEM.

RESULTS

Sex effects on carcass characteristics are shown in table 1. It was observed that sex affected ($P < 0.05$) the HCY and CCY, being higher in geldings. The HCW, CCW and CL were unaffected ($P > 0.05$) by sex. Regarding the *semitendinosus* muscle color, the L^* value was not affected ($P > 0.05$), but the a^* value was higher ($P < 0.05$) in geldings than in females. However, the b^* *value* was higher ($P < 0.05$) in females. Regarding abdominal and subcutaneous fat color, the L^* and a^* values were not affected ($P > 0.05$), but the b^* value was higher ($P < 0.05$) in females than in geldings. Concerning body components, geldings had a higher ($P < 0.05$) head percentage than females; however, other body components were unaffected ($P > 0.05$).

SW affected ($P < 0.05$) HCW and CCW. Similar behavior was observed in HCY and CCY, observing that horses weighing more than 400 kg had higher dressing ($P < 0.05$) concerning those of lower weight (Table 2). The SW in horses also affected CL%, observing that in horses weighing more than 300 kg, CL% is lower ($P < 0.05$) with respect to those of lower weight. Additionally, the percentage of non-carcass components decreased as the SW increases ($P < 0.05$). Color parameters in the *semitendinosus* muscle (L^*, a^*, and b^* *values*) were unaffected by SW ($P > 0.05$). However, color fat was affected by SW, in abdominal fat L^* was less in horses over 450 kg, the opposite was observed in a^*, where it is higher in horses over 300 kg ($P < 0.05$). In subcutaneous fat, it was observed that b^* increase as the SW increases ($P < 0.05$).

DISCUSSION

Different studies have described that horsemeat characteristics are affected by various factors. Among them breed (JUÁREZ et al., 2009; LANZA et al., 2009; FRANCO et al., 2013, CITTADINI et al., 2021), age (SARRIÉS & BERIAIN, 2006; FRANCO et al., 2011, DOMINGUEZ et al., 2015, RUIZ et al., 2017), live weight and feed (SARRIÉS & BERIAIN, 2006; FRANCO et al., 2013; FRANCO & LORENZO, 2014), production system (FRANCO et al., 2013) as well as the type of muscle evaluated (TATEO et al., 2008; LORENZO et al., 2013).

Regarding the sex of the animals, it has been described that it influences carcass characteristics (JUÁREZ et al., 2009). Different authors conclude

Table 1- Effect of sex on carcass traits and non-carcass components in equines.

	Female	Gelding	SEM	*p- value*
N	750	739		
----------Carcass characteristics----------				
HCW, kg	221	222	59	P > 0.05
HCY, %	59[b]	60[a]	1	P < 0.05
CCW, kg	215	216	58	P > 0.05
CCY, %	57[b]	58[a]	1	P < 0.05
CL, %	2.7	2.8	1.5	P > 0.05
----------*Semitendinosus* muscle----------				
L^*	32	33	2	P > 0.05
a^*	15[b]	17[a]	1	P < 0.05
b^*	6[a]	4[b]	0.5	P < 0.05
----------Abdominal fat----------				
L^*	63	60	2	P > 0.05
a^*	13	14	1	P > 0.05
b^*	30[a]	25[b]	2	P < 0.05
----------Subcutaneous fat----------				
L^*	75	76	1	P > 0.05
a^*	6	5	1	P > 0.05
b^*	26[a]	23[b]	3	P < 0.05
----------*Non-carcass components, %*----------				
Head	3.7[b]	3.8[a]	0.5	P < 0.05
Skin	3.8	3.8	1	P > 0.05
Heart	0.6	0.6	0.1	P > 0.05
Lungs	0.9	0.8	0.4	P > 0.05
Stomach	0.4	0.4	0.1	P > 0.05
Caecum	0.6	0.6	0.2	P > 0.05
Spleen	0.3	0.3	0.1	P > 0.05
Liver	1	1	0.3	P > 0.05
Small intestine	1.5	1.5	0.4	P > 0.05
Large intestine	0.8	0.8	0.3	P > 0.05

[abc] Different letters between columns indicate significant differences (P < 0.05). 1 Color CIE space, L^* = lightness, a^* = red to green, b^* = yellow to blue. 2 Non-carcass components are represented in percentage of empty body weight. 3 SEM = standard error of the mean.

that the sex effect on carcass characteristics is related to the fat in the carcass (HORCADA et al., 1998; DÍAZ et al., 2003). For their part, SARRIÉS & BERIAIN (2005) reported a CCW of 270 kg in males, which is higher when compared to the averages observed in females and males in this study.

In this sense, NIVIA et al. (2014) reported greater weight and performance of the carcass in males. Similarly, HERNÁNDEZ et al. (2018) conducted a study in donkeys in which they observed greater CCW and CCY in geldings than in females. However, different investigations mentioned that the sex in horses does not have a significant effect on growth, weight, and carcass performance (MARTIN-ROSSET & DULPHY, 1987; FURTADO et al., 2011).

At this point, it should be noted that the differences between the animals evaluated in this study and those evaluated in European countries

Table 2- Effect of slaughter weight on carcass traits and non-carcass components in equines.

	150-200	201-250	251-300	301-350	351-400	401-450	451-500	> 500	SEM	p-value
N	137	175	252	295	279	186	151	14		
----------Carcass characteristics----------										
HCW, kg	127^{h}	158^{g}	189^{f}	223^{e}	259^{d}	307^{c}	339^{b}	378^{a}	16	P < 0.05
HCY, %	55^{d}	56^{d}	58^{c}	59^{b}	61^{b}	64^{a}	65^{a}	65^{a}	4	P < 0.05
CCW, kg	122^{h}	153^{g}	184^{f}	218^{e}	252^{d}	299^{c}	331^{b}	370^{a}	18	P < 0.05
CCY, %	53^{d}	54^{d}	56^{d}	58^{dc}	60^{c}	63^{a}	64^{a}	63^{a}	3	P < 0.05
CL, %	3^{a}	2.8^{a}	2.9^{a}	2.6^{b}	2.7^{b}	2.5^{b}	2.2^{b}	1.9^{b}	0.5	P < 0.05
----------*Semitendinosus* muscle----------										
L^*	36	33	34	32	34	32	34	32	3	P > 0.05
a^*	17	17	16	16	15	16	14	16	2	P > 0.05
b^*	5	5	4	5	4	4	5	5	1	P > 0.05
----------Abdominal fat----------										
L^*	70^{a}	67^{a}	63^{a}	64^{a}	63^{a}	60^{a}	54^{b}	56^{b}	3	P < 0.05
a^*	11^{b}	11^{b}	10^{b}	15^{a}	13^{a}	13^{a}	16^{a}	15^{a}	2	P < 0.05
b^*	33	32	30	33	33	28	28	28	3	P > 0.05
----------Subcutaneous fat----------										
L^*	74	76	78	77	77	78	75	75	2	P > 0.05
a^*	4	4	4	4	4	3	4	4	1	P > 0.05
b^*	19^{b}	21^{b}	20^{b}	20^{b}	18^{b}	22^{b}	32^{a}	33^{a}	3	P < 0.05
----------*Non-carcass components, %*----------										
Head	4.6^{a}	4.2^{b}	3.9^{c}	3.7^{d}	3.5^{e}	3.3^{f}	3.2^{f}	2.9^{g}	0.3	P < 0.05
Skin	6^{a}	5^{a}	4^{b}	3^{b}	3^{b}	3^{b}	2^{c}	2^{c}	0.5	P < 0.05
Heart	2.2^{a}	2.3^{a}	2.1^{a}	2.1^{a}	2.1^{a}	2.1^{a}	2^{a}	1.6^{b}	0.5	P < 0.05
Lungs	3.5^{a}	3.5^{a}	3.2^{a}	3.1^{a}	3.1^{a}	2.9^{b}	2.6^{b}	2.3^{b}	0.7	P < 0.05
Stomach	0.8^{a}	0.5^{b}	0.5^{b}	0.4^{b}	0.4^{b}	0.3^{c}	0.3^{c}	0.3^{c}	0.1	P < 0.05
Caecum	1.0^{a}	0.8^{a}	0.7^{b}	0.6^{b}	0.5^{b}	0.4^{c}	0.4^{c}	0.3^{c}	0.2	P < 0.05
Spleen	1.5^{a}	1.8^{a}	1.1^{b}	1^{b}	1.1^{b}	1^{b}	0.9^{b}	0.7^{b}	0.2	P < 0.05
Liver	4^{a}	4^{a}	4^{a}	4^{a}	4^{a}	4^{a}	3^{b}	3^{b}	0.2	P < 0.05
Small intestine	2.1^{a}	1.9^{a}	1.6^{b}	1.4^{b}	1.3^{b}	1.1^{b}	1.1^{b}	0.8^{c}	0.3	P < 0.05
Large intestine	1.3^{a}	1.1^{a}	0.9^{b}	0.7^{b}	0.7^{b}	0.6^{c}	0.5^{c}	0.5^{c}	0.2	P < 0.05

^{abc} Different letters between columns indicate significant differences (P < 0.05). 1 Color CIE space, L^* = lightness, a^* = red to green, b^* = yellow to blue. 2 Non-carcass components are represented in percentage of empty body weight. 3 SEM = standard error of the mean.

are mainly due to the different breeds to which they belong, as well as the age and production system (TATEO et al., 2008; FRANCO et al., 2011). In horses, the effect of age and production system on carcass characteristics has been previously described (SARRIÉS & BERIAIN, 2006) in their study, they observed that carcass yield was higher in 24-month-old males and females compared to 16-month-olds, which are superior to the yields in horses observed in our investigation. In relation to the above, LORENZO et al. (2014) observed that carcass weight and dressing percentage were lower in horses from extensive production systems, compared to horses from semi-extensive and supplemented semi-extensive systems. Likewise, a relationship between the breed, age and the type of feeding in horses

finished with different diets is documented (RUIZ et al., 2017, CITTADINI et al., 2021). Being its final weight and the characteristics of the carcass superior regarding the horses slaughtered in Mexico.

Results showed that SW affected CL, values registered in this study are consistent with those reported by FRANCO et al. (2013) and LORENZO et al. (2013a) which range between 2 and 3%. Which is in agreement with RODRÍGUEZ et al. (2013) who described the effect of the production system on carcass yield and CL, mentioned that at higher weight and body condition there was lower CL in bovines. This coincides with what was mentioned by FISHER et al. (1983), due to changes in weight and the amount of fat that covers the carcass. Furthermore, (HERNÁNDEZ et al., 2018) observed that as body weight increased, CL decreased in donkeys. Furthermore, in their study sex affected CL, being greater in females, attributing it to fat percentage in the carcass. In horses, CL ranges from 2 to 2.5% have been reported (FURTADO et al., 2011), these percentages are similar to those observed in this research.

There is little scientific information describing the performance of non-carcass components in horses. However, results in this study showed that there is an effect of SW on the performance of the non-carcass component. In this regard, differences in visceral mass have been described in pigs slaughtered at different SW (SANTOS-RICALDE et al. 2011). Likewise, other authors reported that SW affected red viscera such as the heart, liver, lungs, and kidneys; and body components such as the head, skin and legs are also affected (PÉREZ-MELÉNDEZ et al., 2007). Conversely, our results showed that equine sex did not affect non-carcass components, except head.

Meat color is an important characteristic in fresh meat (MANCINI & HUNT, 2005), and genetics, age, sex, feed system, and slaughter method are factors that could affect meat color (PRIOLO et al., 2002; RIPOLL et al., 2012). For their part, SARRIÉS & BERIAIN (2006) observed differences in meat color between female and male horses of 16 and 24 months of age, respectively. Reporting similar values for L^*, a^* and b^* to those reported in this study. However, in younger foals, DOMINGUEZ et al. (2015) did not observe differences in the color of *longissimus dorsi* in foals slaughtered at 8 and 11 months of age.

Myoglobin content in meat is related to luminosity and red coloration and influenced by the production system and feeding (POLIDORI et al., 2015). In addition, intramuscular fat content and water in muscle were related to meat color (LORENZO et al., 2015). In relation to the above, in lambs, it has been described that heavy and old animals showed differences in color, related to a greater amount of intramuscular fat than light and young animals, even when they received the same diet (OKEUDO & MOSS, 2007).

CONCLUSION

Data from this study indicated that geldings have a heavier and higher-yielding carcass and a lower yellowness color in abdominal and subcutaneous fat than females.

SW affected the carcass characteristics and the percentage of non-carcass components. As body weight increased, carcass weight and dressing also increased. Horses weighing more than 400 kg presented a higher carcass yield. The opposite happened with the non-carcass components, since the proportion of these had to increase the slaughter weight.

ACKNOWLEDGEMENTS

The authors would like to thank the meat packing plant “Empacadora de Carnes Fresnillo S.A. de C.V.” and staff for the facilities to carry out this work.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS’ CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

REFERENCES

BELAUNZARAN, X., et al. Horse-meat for human consumption –current research and future opportunities. **Meat Science**, v.108, p.74-81, 2015. Available from: <https://doi.org/10.1016/j.meatsci.2015.05.006>. Accessed: Jun. 20, 2021. doi: 10.1016/j.meatsci.2015.05.006.

CITTADINI, A., et al. Effect of breed and finishing diet on growth parameters and carcass quality characteristics of Navarre autochthonous foals. **Animals**, v.11: 488, p.1-13, 2021. Available from: <https://doi.org/10.3390/ani11020488>. Accessed: Apr. 20, 2022. doi: 10.3390/ani11020488.

DÍAZ, M. T., et al. Physico-chemical characteristics of carcass and meat Manchego-breed suckling lams slaughtered at different

weights. **Meat Science**, v.65, p.1085-1093, 2003. Available from: <https://doi.org/10.1016/S0309-1740(03)00032-9>. Accessed: Jun. 20, 2021. doi: 10.1016/S0309-1740(03)00032-9.

DOMINGUEZ, R., et al. Effect of slaughter age on foal carcass traits and meat quality. **Animal**, v.9:10, p.1713-1720, 2015. Available from: <https://doi.org/10.1017/S1751731115000671>. Accessed: Apr. 20, 2022. doi: 10.1017/S1751731115000671.

FISHER, A. V., BAYNTUN J. A. Weight loss from beef sides during storage post mortem and its effects on carcass composition. **Meat Science**. v.9 (2). p.121-129, 1983. Available from: <https://doi.org/10.1016/0309-1740(83)90022-0>. Accessed: Sep. 12, 2021. doi: 10.1016/0309-1740(83)90022-0.

FRANCO, D.; LORENZO, J. M. Effect of muscle and intensity of finishing diet on meat quality of foals slaughtered at 15 months. **Meat Science**, v.96, p.327–334, 2014. Available from: <https://doi.org/10.1016/j.meatsci.2013.07.018>. Accessed: Feb. 20, 2022. doi: 10.1016/j.meatsci.2013.07.018.

FRANCO, D., et al. Carcass quality of Galician Mountain foals. Centro Tecnológico de la Carne. San Cibrao das Viñas. **Archivos de Zootecnia**, v.60, n.231, p.385-388, 2011. Available from: <https://dx.doi.org/10.4321/S0004-05922011000300017>. Accessed: Sep. 12, 2021. doi: 10.4321/S0004-05922011000300017.

FRANCO, D., et al. Effect of crossbreeding and amount of finishing diet on growth parameters, carcass and meat composition of foals slaughtered at 15 months of age. **Meat Science**, v.93, p.547–556, 2013. Available from: <https://www.sciencedirect.com/science/article/pii/S0309174012003798>. Accessed: Feb. 20, 2022. doi: 10.1016/j.meatsci.2012.11.018.

FURTADO, C. E., et al. Influência do peso vivo, da idade e do sexo sobre características de carcaças de equinos. **Revista Brasileira de Zootecnia**. v.39, n.12, p.2683-2686, 2011. Available from: <https://doi.org/10.1590/S1516-35982010001200018>. Accessed: Jun. 20, 2021. doi: 10.1590/S1516-35982010001200018.

GILL, C.O. Safety and storage stability of horse meat for human consumption. **Meat Science**. v.71, p.506–513, 2005. Available from: <https://doi.org/10.1016/j.meatsci.2005.04.030>. Accessed: Jun. 22, 2021. doi: 10.1016/j.meatsci.2005.04.030.

HERNÁNDEZ, B. P., et al. Gender and live weight on carcass and meat characteristic of donkeys. **Ciência Rural**. v.48, n.04, p.1-7, 2018. Available from: <https://doi.org/10.1590/0103-8478cr20170889>. Accessed: Sep. 15, 2021. doi: 10.1590/0103-8478cr20170889.

HORCADA, A., et al. Effect of sex on meat quality of Spanish lamb breeds (Lancha and Rasa Aragonesa). **Journal of Animal Science**, v.67, p.541-547, 1998. Available from: <https://doi.org/10.1017/S1357729800032975>. Accessed: Sep. 12, 2021. doi: 10.1017/S1357729800032975.

JUÁREZ, M., et al. Breed effect on carcass and meat quality of foals slaughtered at 24 months of age. **Meat Science**, v.83, p.224–228, 2009. Available from: <https://doi.org/10.1016/j.meatsci.2009.04.022>. Accessed: Sep. 12, 2021. doi: 10.1016/j.meatsci.2009.04.022.

LANZA, M., et al. Meat quality and intramuscular fatty acid composition of Sanfratellano and Haflinger foals. **Meat Science**, v.81, p.142–147, 2009. Available from: <https://www.sciencedirect.com/science/article/pii/S0309174008002349>. Accessed: Sep. 15, 2021. doi: 10.1016/j.meatsci.2008.07.008.

LOMBARDI-BOCCIA, G., et al. Aspects of meat quality: trace elements and B vitamins in raw and cooked meats. **Journal Food and Composition Analysis**, v.18, p.39-46, 2005. Available from: <https://doi.org/10.1016/j.jfca.2003.10.007>. Accessed: Jul. 15, 2021. doi: 10.1016/j.jfca.2003.10.007.

LORENZO, J. M., et al. Intramuscular fatty acid composition of "Galician Mountain" foals breed: Effect of sex, slaughtered age and livestock production system. **Meat Science**, v.86, p.825–831, 2010. Available from: <https://www.sciencedirect.com/science/article/pii/S0309174010002792>. Accessed: Jun. 18, 2021. doi: 10.1016/j.meatsci.2010.07.004.

LORENZO, J. M., et al. Carcass characteristics, meat quality and nutritional value of horsemeat: A review. **Meat Science**, v.96, p.1478–1488, 2014. Available from: <https://doi.org/10.1016/j.meatsci.2013.12.006>. Accessed: Jun. 18, 2021. doi: 10.1016/j.meatsci.2013.12.006.

LORENZO, J. M.; PATEIRO, M. Influence of muscle type on nutritional value of foal meat. **Meat Science**, v.93, p.630–638, 2013. Available from: <https://www.sciencedirect.com/science/article/pii/S0309174012003683>. Accessed: Jan. 31, 2022. doi: 10.1016/j.meatsci.2012.11.007.

LORENZO, J. M., CARBALLO, J. Changes in physic-chemical properties and volatile compounds throughout the manufacturing process of dry-cured foal loin. **Meat Science**, v.99, p.44-51, 2015. Available from: <https://doi.org/10.1016/j.meatsci.2014.08.013>. Accessed: Jun. 20, 2021. doi: 10.1016/j.meatsci.2014.08.013.

MANCINI, R. A.; HUNT, M. C. Current research in meat color. **Meat Science**, v.71(1), p.100–121, 2005. Available from: <https://doi.org/10.1016/j.meatsci.2005.03.003>. Accessed: Jan. 30, 2022. doi: 10.1016/j.meatsci.2005.03.003.

MARTIN-ROSSET, W., DULPHY, J. P. Digestibility interactions between forages and concentrates in horses: influence of feeding level – comparison with sheep. **Livestock Production Science**, v.17, p.263-276, 1987. Available from: <https://doi.org/10.1016/0301-6226(87)90071-6>. Accessed: Sep. 20, 2021. doi: 10.1016/0301-6226(87)90071-6.

NIVIA, O. A., et al. Determination of the slaughter volume and evaluation of quantitative variables of horses sacrificed in a slaughterhouse. **Zootecnia Tropical**, v.32, n.1, p.83-89, 2014. Available from: <http://www.scielo.org.ve/scielo.php?pid=S0798-72692014000100009&script=sci_arttext>. Accessed: May. 20, 2021.

NOM-024-ZOO, 1995. Especificaciones y características zoosanitarias para el transporte de animales, sus productos y subproductos, productos químicos, farmacéuticos biológicos y alimenticios para uso en animales o consumo por éstos. Available from: <https://www.sinec.gob.mx/SINEC/>. Accessed: May. 10, 2021.

NOM-051-ZOO, 1995. Trato humanitario en la movilización de animales. Available from: <https://www.sinec.gob.mx/SINEC/>. Accessed: May. 10, 2021.

NOM-062-ZOO, 1999. Especificaciones técnicas para la producción, cuidado y uso de animales de laboratorio. Available from: <https://www.sinec.gob.mx/SINEC/>. Accessed: May. 10, 2021.

NOM-033-SAG/ZOO, 2014. Métodos para dar muerte a los animales domésticos y silvestres. Available from: <https://www.sinec.gob.mx/SINEC/>. Accessed: May. 10, 2021.

OKEUDO, N. J.; MOSS, B. W. Intramuscular lipid and fatty acid profile of sheep comprising four sex-types and seven slaughter weights produced following commercial procedure. **Meat Science**, v.76(2), p.195–200, 2007. Available from: <https://doi.org/10.1016/j.meatsci.2006.08.017>. Accessed: Jan. 30, 2022. doi: 10.1016/j.meatsci.2006.08.017.

PÉREZ-MELÉNDEZ, P., et al. Effect of Slaughter Weight and Sex on the Carcass of Suffolk Down x German Merino Precocious Suckling Lambs. **Revista Científica**, FCV-LUZ, v.17, n.6, p.621-626, 2007. Available from: <http://ve.scielo.org/scielo.php?script=sci_abstract&pid=S079822592007000600010&lng=en&nrm=iso&tlng=en>. Accessed: Jun. 20, 2021.

POLIDORI, P., et al. A comparison of the carcass and meat quality of Martina Franca donkey foals aged or 12 months. **Meat Science**, v.106, p.6-10, 2015. Available from: <https://doi.org/10.1016/j.meatsci.2015.03.018>. Accessed: May. 20, 2021. doi: 10.1016/j.meatsci.2015.03.018.

PRIOLO, A., et al. Effect of grass or concentrate feeding system on lamb carcass and meat quality. **Meat Science**, v.62, p.179-185, 2002. Available from: <https://doi.org/10.1016/S0309-1740(01)00244-3>. Accessed: Jul. 25, 2021. doi: 10.1016/S0309-1740(01)00244-3.

RIPOLL, G., et al. Influence of alfalfa grazing-based feeding systems on carcass fat color and meat quality of light lambs. **Meat Science**, v.90, p.457-464, 2012. Available from: <https://doi.org/10.1016/j.meatsci.2011.09.007>. Accessed: Jul. 20, 2021. doi: 10.1016/j.meatsci.2011.09.007.

RODRÍGUEZ, E. M. E., et al. Calidad de la carne de bovinos engordados en un sistema silvopastoril intensivo en dos épocas del año. **Tropical and Subtropical Agroecosystems**. v.16, p.235–241, 2013. Available from: <https://www.redalyc.org/articulo.oa?id=93928324010>. Accessed: Aug. 10, 2021.

RUIZ, M., et al. Relationship between carcass traits, prime cuts and carcass grading from foals slaughtered at the age of 13 and 26 months and supplemented with estándar and linseed-rich feed. **Animal**. p.1-9, 2017. Available from: <https://www.sciencedirect.com/science/article/pii/S1751731117002555>. Accessed: May. 18, 2022. doi:10.1017/S1751731117002555.

SANTOS-RICALDE, R., et al. Carcass yield and thoracic and abdominal viscera growth from 25 to 45 kg in creole hairless Pigs. **Revista Científica**, FCV-LUZ, v.21, n.5, p.396–402, 2011. Available from: <http://200.74.222.178/index.php/cientifica/article/view/15663/15637>. Accessed: Sep. 18, 2021.

SARRIÉS, M. V.; BERIAIN, M. J. Carcass characteristics and meat quality of male and female foals. **Meat Science**, v.70, p.141–152, 2005. Available from: <https://doi.org/10.1016/j.meatsci.2004.12.006>. Accessed: Sep. 18, 2021. doi: 10.1016/j.meatsci.2004.12.006.

SARRIÉS, M. V.; BERIAIN, M.J. Color and texture characteristics in meat of male and female foals. **Meat Science**, v.74, p.738–745, 2006. Available from: <https://doi.org/10.1016/j.meatsci.2006.06.005>. Accessed: Sep. 18, 2021. doi: 10.1016/j.meatsci.2006.06.005.

STANCIU, S. Horse meat consumption – between scandal and reality. **Procedia Economics and finance**, v.23, p.697-703, 2015. Available from: <https://doi.org/10.1016/S2212-5671(15)00392-5>. Accessed: Sep. 18, 2021. doi: 10.1016/S2212-5671(15)00392-5.

TATEO, A., et al. Physicochemical properties of meat of Italian Heavy Draft horses slaughtered at the age of eleven months. **Journal of Animal Science**, v.86, n.5, p.1205-2014, 2008. Available from: <https://doi.org/10.2527/jas.2007-0629>. Accessed: Sep. 20, 2021. doi: 10.2527/jas.2007-0629.