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The impact of pig breed on stress levels and meat quality: a study on mangalita purebred and Duroc x Landrace crossbred pigs in Romania

[*O impacto da raça suína nos níveis de estresse e na qualidade da carne: um estudo em porcos Mangalita puro-sangue e Duroc x Landrace cruzados na Romênia*]

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ABSTRACT

This study aimed to investigate the impact of pig breed on stress levels and meat quality in two commercial pig farms in the north-eastern part of Romania. One farm raised 52 Mangalita pure-bred pigs and the other 82 Duroc x Landrace crossbred pigs. Serum cortisol, a biomarker of stress, and serum glucose were measured before and after slaughtering, while meat pH was measured at 45 minutes and 24 hours post-mortem. Results showed that the Duroc x Landrace crossbred pigs had higher serum cortisol and glucose values before and after slaughtering compared to the Mangalita purebred pigs. The meat pH values of the two breeds were similar, with the pH45 and pH24 values being 6.67 and 5.48 for Duroc x Landrace crossbred and 6.53 and 5.52 for Mangalita purebred, respectively. These results suggest that pig breed can have an impact on stress levels and meat quality, with Duroc x Landrace crossbred pigs showing higher stress levels and meat quality being not affected by the breed of pig. Further research is needed to confirm these findings and to understand the underlying mechanisms.

Keywords: stress; cortisol, purebred, crossbred, Mangalita, Duroc, Landrace

RESUMO

Este estudo teve como objetivo investigar o impacto da raça suína nos níveis de estresse e na qualidade da carne em duas fazendas comerciais de suínos, no nordeste da Romênia. Uma fazenda criou 52 suínos puros Mangalita, e a outra 82 suínos mestiços Duroc x Landrace. O cortisol sérico, um biomarcador de estresse e a glicose sérica foram medidos antes e após o abate, enquanto o pH da carne foi medido aos 45 minutos e 24 horas post mortem*. Os resultados mostraram que os suínos mestiços Duroc x Landrace apresentaram valores séricos de cortisol e de glicose mais elevados, antes e após o abate, em comparação com os suínos puros Mangalita. Os valores de pH da carne das duas raças foram semelhantes, sendo os valores de pH45 e pH24 de 6,67 e 5,48 para o mestiço Duroc x Landrace e de 6,53 e 5,52 para o puro sangue Mangalita, respectivamente. Esses resultados sugerem que a raça suína pode ter um impacto nos níveis de estresse e na qualidade da carne, com os porcos mestiços Duroc x Landrace apresentando níveis mais altos de estresse e a qualidade da carne não sendo afetada pela raça do porco. Mais pesquisas são necessárias para confirmar esses achados e entender os mecanismos subjacentes.*

Palavras-chave: estresse, cortisol, raça pura, mestiça, Mangalita, Duroc, Landrace

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INTRODUCTION

Pig farming is an important industry in Romania, and the selection of pig breeds for commercial production is a crucial decision for farmers. This study aimed to investigate the impact of pig breed on stress levels and meat quality in two commercial pig farms in the north-eastern part of Romania. Previous studies suggest that pig breeds can affect the welfare of the pig, but the impact on meat quality still must be assessed. Purebred pigs have a consistent set of characteristics and traits that are typical of that breed. The main advantage of purebred pigs is that their genetics are well-known and predictable, allowing for accurate selection of animals for specific traits, such as meat quality or disease resistance (Millet *et al*., 2005).

On the other hand, crossbred pigs inherit traits and characteristics from both of their parent breeds. The main advantage of crossbreeding is that it can increase genetic diversity and improve growth, reproduction, disease resistance and adaptability to different environments.

Pig welfare and meat quality are important factors in the pig industry as they have a direct impact on the cost of production and the final product. Cortisol, glucose, and pH values are commonly used as indicators for stress and meat quality. Cortisol is a hormone associated with the stress response, and high cortisol levels can lead to negative impacts on pig health, productivity, and meat quality. Glucose is an important energy source for muscles, high levels of glucose can indicate a high level of stress, energy metabolism and muscle activity. Meat pH is an indicator of muscle metabolism and is associated with meat quality (Dalla Costa *et al*., 2019).

It is important to note that, besides genetic factors, there are other variables that can affect the stress levels and meat quality in pigs, such as the environment, management practices and handling procedures of the pig farm. Therefore, it is important to evaluate these factors in conjunction with the pig breed to optimize pig welfare and meat quality (Isbrandt *et al*., 2022).

The most common stressors are associated with microclimate and slaughtering stress, two different types of stress that can affect pigs.

Microclimate stress, on the other hand, refers to the stress caused by the environment in which pigs are kept, including temperature, humidity, air quality, and ventilation. Pigs are sensitive to changes in the microclimate and can suffer from heat stress or cold stress if the conditions are not optimal. Microclimate stress can have negative impacts on pig health and productivity, such as reduced feed intake, impaired immune function, and increased mortality (Gentry *et al*., 2004).

An important environmental factor that can lead to intense stress may be associated with noise levels which are known for the negative effects on pigs. The loud noise, vibrations and sudden movements generated by the machinery could cause distress and disrupt the pigs' natural behavior, leading to increased levels of cortisol, a hormone associated with stress. Additionally, the machinery can contribute to poor air quality, which can also affect the pigs' respiratory systems, leading to stress. This can include dust and debris in the air, as well as the release of gases and other pollutants. Moreover, if the design and layout of the pig farm is not well thought out, the pigs may feel crowded, restricted, and unable to move around freely, leading to stress (Talling *et al*., 1996).

Properly maintaining and operating the equipment and providing good ventilation, along with considering the pigs' natural behavior and needs, can help mitigate the potential stress caused by industrial machines and equipment in a pig farm. It's also important to train employees on best practices for handling and caring for pigs, and providing proper training on the handling, maintenance, and operation of the machinery (Talling *et al*., 1996).

Slaughtering stress in pigs is a well-known issue in the livestock industry that can have negative impacts on animal welfare, meat quality, and economic outcomes. Slaughtering stress refers to the stress experienced by pigs during the process of being slaughtered for meat. This stress can be caused by various factors, including transportation, handling, confinement, and separation from social groups. The consequences of slaughtering stress can be significant for both animal welfare and economic outcomes. Stressed pigs may suffer from physical injuries, impaired immune function, and reduced growth and productivity. In addition, slaughtering stress can

also affect meat quality, such as increasing the pH and reducing the water-holding capacity of the meat, which can lead to reduced palatability and shelf life (McKay and Cidlowski, 2003; Rusu *et al.*, 2021).

MATERIAL AND METHODS

The study was conducted over a period of six months between June-December 2022 on two commercial pig farms in the north-eastern part of Romania, one with 82 Duroc x Landrace crossbred pigs (Farm A) and one with 52 Mangalita purebred pigs (Farm B), 3 to 4 months old, weighting between 80 – 110 kg, both males and females, to investigate stress levels and the quality of the carcass in terms of pH values. Pigs were housed in the indoor finishing facility, on partially slatted floors (Duroc x Landrace crossbred) or reared with access to outdoor (Mangalita). Pigs were provided with feed and water ad libitum. The inclusion criteria considered clinically healthy swine, without any expressed pathology.

Samples have been collected twice, ante- and post-slaughter, to determine serum cortisol and blood glucose levels.

Biochemistry was performed in an accredited laboratory, having determined the serum cortisol and blood glucose levels. Blood samples were collected from the jugular vein in vacutainers with clot activators inside using a sterile needle and syringe. The animals were handled with care and without causing excessive stress during the collection process. The collected blood samples were allowed to coagulate and then centrifuged to separate the serum from the blood cells.

Post-slaughter processing and carcass evaluation were carried out in accordance with meat industry regulations.

The pH was measured in the longissimus lumborum (LL) 45 min after bleeding (pH45) and after 24 hours of carcass chilling (pH24). The parameters, pH45 and pH24, were determined with the WTW 3310 pH meter and combination electrode (WTW-Wissenschaftlich-Technische Werkstaetten GmbH, Weilheim, Germany) and calibrated with the same standard solutions of pH 4.01 and 7.00 at 20ºC.

The sound levels were recorded for both farms using the dBadge2 noise dosimeter, specifically designed for noise exposure measurements. The device was placed 2 meters inside from the entrance in the housing facility, to measure noise levels over a 180-day period. A daily and general average was calculated for both farms.

The statistical interpretation was performed using MS Excel 2019, using Fisher`s exact test, Student and ANOVA tests.

RESULTS AND DISCUSSION

Stress is a complex physiological response to a perceived threat or challenge, and it is associated with several negative effects on the pig's physiology and behavior. Stress can suppress the immune system, making the animals more susceptible to disease. Stress can also reduce growth and reproductive performance, leading to lower productivity and profitability (McKay and Cidlowski, 2003).

Pigs are widely used in agriculture for meat production and are commonly housed in group housing systems (Driessen *et al*., 2020). However, these systems can be a source of stress for pigs, as they are exposed to a variety of environmental stressors, including noise, temperature fluctuations, and overcrowding (Hoffman *et al*., 2003). These stressors can have several negative effects on pig physiology and behavior, including reduced growth and reproductive performance, increased aggression, and compromised immune function (Dalla Costa *et al*., 2019; Rusu *et al*. 2021; Malancus *et al*., 2022). The stress response in pigs is mediated by the hypothalamic-pituitary-adrenal (HPA) axis and is characterized by the release of stress hormones such as cortisol (Rusu *et al*, 2021).

The results presented in table 1 showed that the Duroc x Landrace crossbred pigs had significantly higher mean serum cortisol values before and after slaughtering (6.66µg/dL and 7.28µg /dL, respectively) compared to the Mangalita purebred pigs (5.98µg/dL and 6.23µg/dL, respectively). The mean serum glucose values before and after slaughtering were also higher in the Duroc x Landrace crossbred pigs (132.78mg/dL and 146.31mg/dL, respectively) compared to the Mangalita purebred pigs (122.38mg/dL and 145.21mg/dL, respectively).

Table 1. Serum cortisol and glucose levels before and after slaughtering

Result	Serum cortisol (µg/dl)				Blood glucose (mg/dl)			
	Farm A (Duroc x Landrace crossbred)		Farm B (Mangalita purebred)		Farm A (Duroc x Landrace crossbred)		Farm B (Mangalita purebred)	
	Before	After	Before	After	Before	After	Before	After
Mean	6.66	7.28	5.98	6.23	132.78	146.31	122.38	145.21
Min.	6.23	7.04	5.66	5.98	111	131	99	128
Max.	7.01	7.6	6.34	6.46	153	163	144	160
CI mean	[6.61-6.71]	[7.25-7.32]	[5.93-6.04]	[6.19-6.27]	[130.06-135.50]	[144.21-148.42]	[118.95-125.82]	[142.34-148.07]

The results show a very significant statistical correlation between serum cortisol and blood glucose mean values before and after slaughtering at farm A ($p<0.05$) while for farm B, there is no correlation between the two parameters before and after slaughtering ($p>0.05$), with increased mean blood glucose levels post slaughtering. This may be associated with an increased transportation or handling stress (Averos *et al*., 2003; Choe and Kim, 2014) for the swine population of farm B.

Also, higher values in terms of cortisol and blood glucose levels have been associated with increased noise levels (Talling *et al*., 1996). Noise is considered to be a major environmental stressor for pigs and has been shown to increase stress hormone levels and disrupt normal physiological and behavioral processes. Research has shown that noise levels above 90 decibels can cause hearing loss in pigs, as well as increased stress levels. High noise levels can also disrupt normal feeding and social behavior patterns, leading to changes in appetite and group dynamics (Talling *et al*., 1996).

High noise levels can also lead to increased aggressive behavior in pigs. This can be a problem in group housing systems, where high noise levels can lead to increased competition for resources and fighting among pigs. Aggressive behaviors can also lead to injury, both to the aggressive pig and to the pig being targeted (Talling *et al*., 1996).

To understand if there is any relationship between pre- and post-slaughter stress, an environmental parameter that may impact the entire pig population within a farm has been assessed. Noise levels recorded for both farms revealed daytime average values higher than 80 decibels (82 dB) for the farm housing Duroc x Landrace crossbred pigs while for the farm housing Mangalita pigs, the recorded noise levels were close to 70 decibels (71 dB). The recorded values are presented in Table 2.

Table 2. Daytime and overall noise levels recorded for studied pig farms

Parameter	Daytime Average	Overall average
Noise levels in Duroc x Landrace farm (dB)	82±7.3	49±4.9
Noise levels in Mangalita farm (dB)	71±6.9	47±3.3

The results show a very significant direct correlation between the serum cortisol values and blood glucose with the daytime average noise levels in the two farms, with $p<0.05$.

The meat pH values were similar for both breeds, with the pH45 and pH24 values being 6.67 and 5.48 for Duroc x Landrace crossbred, and 6.53 and 5.52 for Mangalita purebred pigs, as shown in Table 3.

Table 3. Post slaughtering pH45 and pH24 values

Parameter	pH45		pH24	
	Farm A (Duroc x Landrace crossbred)	Farm B (Mangalita purebred)	Farm A (Duroc x Landrace crossbred)	Farm B (Mangalita purebred)
Mean	6.67	6.53	5.48	5.52
Min.	6.35	6.33	5.32	5.41
Max.	6.99	6.71	5.61	5.64
CI mean	[6.63-6.72]	[6.50-6.56]	[5.46-5.50]	[5.50-5.54]

The samples of longissimus lumborum (LL) obtained from all the pigs in the current study could be regarded as normal and were defined as good quality, according to meat classification standards based on pH24 (5.48 - 5.60) with slightly lower values for Duroc x Landrace crossbred pigs. However, Mangalita pigs showed better results as a reduced impact of stress on this breed given their genetical advantages in terms of resistance to diseases (Rusu *et al*., 2021; Malancus *et al*., 2022). These results suggest that while pig breed may have an impact on stress levels, it does not affect the overall meat quality, as other studies also concluded (Averos *et al*., 2003; Peres *et al*., 2014).

To compare pH (Table 3), one way ANOVA test was used, with a confidence level of 0.05. A p-value < 0.05 was obtained, which means that the averages between pH45 and pH24 at the two farms are significantly different.

Long-term preslaughter stress, such as fighting, cold weather, fasting and transit, which occurs 12 to 48 hours prior to slaughter depletes muscle glycogen, resulting in meat which has a higher pH, darker color, and is drier (Hambrecht *et al*., 2004; Lebret *et al*., 2014). Short-term acute stress, such as excitement or fighting immediately prior to slaughter, produces lactic acid from the breakdown of glycogen (Malancus *et al*., 2022; Sather *et al*., 1997). This results in meat which has a lower pH, lighter color, reduced water binding capacity, and is possibly tougher (Grandin, 2021).

Pigs are highly social and intelligent animals that are sensitive to changes in their environment. Environmental stressors, such as noise, temperature fluctuations, and overcrowding, can have a significant impact on pig physiology and behavior.

The results of this study indicate that the Duroc x Landrace crossbred pigs have a higher stress response than Mangalita purebred pigs, as shown by the higher cortisol and glucose values before and after slaughtering. This can be partly explained by genetic factors as well as the environment of the farm, as Duroc x Landrace crossbred pigs have been selected for growth rate and lean meat percentage, which are the desirable traits for commercial pig farming (Čobanović *et al*., 2020, Zahan *et al*., 2009). However, the stress response does not affect the meat quality, as the pH values of the two breeds were similar, indicating that both breeds had a similar rate of muscle metabolism.

Excessive noise can also have an impact on the overall welfare of the pig. Studies have shown that high noise levels can lead to poor sleep quality and disturbance, and chronic noise exposure can lead to chronic sleep deprivation in the animal which can reduce their overall health and productivity (Talling *et al*., 1996; Li *et al*., 2021).

Overall, high noise levels can have significant negative effects on the physiology and behavior of pigs, with stress being one of the most significant impacts. By understanding these effects and implementing effective management strategies, we can improve the welfare of pigs and support the overall productivity and profitability of the industry (Choe and Kim, 2014).

CONCLUSION

The results of this study suggest that the breed of pig can have an impact on stress levels in pigs, but it does not affect the meat quality. These findings have implications for pig farmers and breeders, who should consider the welfare and stress response of pigs when choosing breeds for commercial production.

However, further research is needed to confirm these findings, as the studies were conducted on a small number of farms and pigs, and more research is needed to understand the underlying mechanisms and other welfare parameters such as growth rate, carcass quality and disease resistance. Additionally, studies conducted on different geographical locations and using different breeds of pigs would also help to provide a more comprehensive understanding of the relationship between pig breed and welfare and meat quality.

REFERENCES

AVEROS, X.; HERRANZ, A.; SANCHEZ, R. *et al*. Serum stress parameters in pigs transported to slaughter under commercial conditions in different seasons. *Vet. Med. Czech*., v.52, p.333-342, 2003.

CHOE, J.H.; KIM, B.C. Association of blood glucose, blood lactate, serum cortisol levels, muscle metabolites, muscle fiber type composition, and pork quality traits. *Meat Sci*., v.97, p.137-142, 2014.

ČOBANOVIĆ, N.; STANKOVIĆ, S.D.; DIMITRIJEVIĆ, M. *et al*. Identifying physiological stress biomarkers for prediction of pork quality variation. *Animals*, v.10, p.614, 2020.

DALLA COSTA, F.A.; DALLA COSTA, O.A.; DI CASTRO, I.C. *et al*. Ease of handling and physiological parameters of stress, carcasses, and pork quality of pigs handled in different group sizes. *Animals*, v.9, p.798, 2019.

DRIESSEN, B.; VAN BEIRENDONCK, S., BUYSE, J. Effects of housing, short distance transport and lairage on meat quality of finisher pigs. *Animals*, v.10, p.788, 2020.

GENTRY, J.G.; MCGLONE, J.J.; MILLER, M.F. *et al*. Environmental effects on pigs performance, meat quality, and muscle characteristics. *J. Anim. Sci*., v.82, p.209-217, 2004.

GRANDIN, T. Cattle and pigs are easy to move and handle will have less preslaughter stress. *Foods*, v.10, p.2583, 2021.

HAMBRECHT, E.; EISSEN, J.J.; NOOIJEN, R.I.J. *et al*. Preslaughter stress and muscle energy largely determine pork quality at two commercial processing plants. *J. Anim. Sci*., v.82, p.1401-1409, 2004.

HOFFMAN, L.C.; STYGER, E.; MULLER, M. *et al*. The growth and carcass and meat characteristics of pigs raised in a free-range or conventional system. *S. Afr. J. Anim. Sci*. v.33, p.166-175, 2003.

ISBRANDT, R.; WIEGARD, M.; MEEMKEN, D. *et al*. Impact of procedures and human-animal interactions during transport and slaughter on animal welfare of pigs: a systematic literature review. *Animals*, v.12, p.3391, 2022.

LEBRET, B.; DOURMAD, J.Y.; MOUROT, J. *et al*. Production performance, carcass composition, and adipose tissue traits of heavy pigs: Influence of breed and production system. *J. Anim. Sci*., v.92, p.3543-3556, 2014.

LI, J.; LI, X.; LIU, H. *et al*. Effects of music stimulus on behavior response, cortisol level, and horizontal immunity of growing pigs. *J. Anim. Sci.*, v.99, n.5, 2021.

MALANCUS R.N.; RUSU, O.R.; ARSENOAIA, V.N. *et al*. Stress levels of mangalita, large white, and pietrain pigs reared in different housing systems in south eastern Europe. *Arq. Bras. Med. Vet. Zootec*., v.74, p.1161-1165, 2022.

MCKAY, L.I.; CIDLOWSKI J.A. Pharmacokinetics of corticosteroids. In: KUFE, D.W.; POLLOCK, R.E.; WEICHSELBAUM, R.R. *et al*. (Eds.). *Holland-frei cancer medicine*. 6.ed. Hamilton, New Zealand: BC Decker, 2003.

MILLET, S.; RAES, K.; VAN DE BROECK, W. *et al*. Performance and meat quality of organically versus conventionally fed and housed pigs from weaning till slaughtering. *Meat Sci*., v.69, p.335-341, 2005.

PERES, L.M.; BRIDI, A.M., SILVA, C.A. *et al*. Effect of low or high stress in pre-slaughter handling on pig carcass and meat quality. *Rev. Bras. Zootec*., v.43, p.363-368, 2014;

RUSU, R.O.; AILINCAI, L.I.; MALANCUS, R.N. Stress induced by pre-slaughter farm conditions in pigs. *Arq. Bras. Med. Vet. Zootec*., v.73, p.1357-1360, 2021.

SATHER, A.P.; JONES, S.D.M.; SCHAEFER, A.L. *et al*. Feedlot performance, carcass composition and meat quality of free-range reared pigs. *Can. J. Anim. Sci.*, v.77, p.225-232, 1997.

TALLING, J.C.; WARAN, N.K.; WATHES, C.M. *et al*. Behavioural and physiological responses of pigs to sound. *Appl. Anim. Behav. Sci*., v.48, p.187-201, 1996.

ZĂHAN, M.; RAICA, P.; MICLEA, V. *et al*. Results concerning genetic characterization of Mangalita breed using microsatellite markers. *Lucrări Ştiinţ. Zooteh. Biotehnol. Timişoara*, v.42, p.136-140, 2009.