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Review Paper

Pre-slaughter conditions and related effects on welfare and meat quality of slaughter horses: a mini review

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ABSTRACT

In recent years, horsemeat has gained recognition as a valuable dietetic food due to its low caloric content, high-quality protein, rich vitamin and mineral composition and favourable fatty acid profile, making it a suitable alternative meat for individuals with anaemia, obesity, atherosclerosis, hypertension, organ diseases and compromised immunity. As with other livestock species, minimising pre-slaughter stress is essential for ensuring animal welfare and achieving high meat quality, as stress can result in bruising and/or other injuries. Therefore, the aim of this review was to provide insights into the pre-slaughter conditions in the horsemeat production chain and related effects on welfare and meat quality, which will in turn expand knowledge in this area and determine directions for future research. Throughout the pre-slaughter period, horses encounter multiple potential stressors that can compromise their welfare and negatively affect carcass and meat quality. These stressors can arise at various stages, including conditions at the point of purchase, loading, transport, unloading, lairage, stunning and exsanguination. Pre-slaughter welfare conditions are significantly affected by animal characteristics (age, gender, breed, temperament), the infrastructure at both the point of purchase and the slaughterhouse, vehicle design, environmental conditions and the quality of human-animal interactions. Since current recommendations on minimum floor space in transport vehicles are insufficient and also clear guidelines on optimal lairage duration for horses at slaughterhouses are lacking, further research is required to enhance horse welfare across the meat production chain.

1. Introduction

In recent years, horsemeat has gained recognition as a valuable "dietetic" food due to rising demand for alternative meats (*Lorenzo et al*., 2019). It is low in calories compared to other red meats (*Jastrzębska et al*., 2019; *Kołodziejczyk et al*., 2019), rich in protein with a complete amino acid profile, and particularly suitable for immunocompromised individuals (*Stanisławczyk et al*., 2020). High vitamin, mineral and iron content and a favourable fatty acid profile makes horsemeat beneficial for people with anaemia, obesity, atherosclerosis, hypertension and various organ diseases (*Jastrzębska et al*., 2019; *Kołodziejczyk et al*., 2019; *Seong et al*., 2016; *Stanisławczyk et al*., 2020). As a specific product, horsemeat has a specific group of consumers. Italy leads Europe in per capita horsemeat consumption,

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averaging 0.88 kg per person per year, followed by Belgium with about 0.5 kg (*Kołodziejczyk et al*., 2019).

As with other slaughter species, minimising pre-slaughter stress is crucial to ensure animal welfare and obtain high-quality meat, as stress can lead to bruises and/or injuries (*Consortium of the Animal Transport Guides Project*, 2018; *Marlin et al*., 2011; *Pawshe et al*., 2016). During the pre-slaughter period, horses are exposed to numerous potential stressors that adversely affect their welfare and carcass and meat quality, starting from conditions at the point of purchase, loading, transport, unloading, lairaging, stunning and exsanguination (*Driessen et al*., 2022; *EFSA*, 2022). Therefore, the aim of this review was to provide insights into the pre-slaughter conditions in the horsemeat production chain and related effects on welfare and meat quality, which will in turn expand knowledge in this area and determine directions for future research.

2. Place of purchase

Considering that the primary role of most horses is not meat production, acquiring a sufficient number of animals for slaughter transport involves sourcing individuals from various locations—such as farms, auctions, livestock markets and assembly centres—usually through intermediaries, dealers or traders (*Driessen et al*., 2022). To a lesser extent, slaughter horses can originate from farms where they are raised under extensive conditions (e.g., the USA, South America and Spain), but the majority are sport, recreational or working horses sent for slaughter after the end of their productive use, most often due to locomotor disorders (musculoskeletal diseases) or chronic illnesses (*Driessen et al*., 2022).

As a result, horses are frequently transported to slaughter in poor body condition, making it difficult for them to maintain balance during transport, which leads to quick fatigue and increases the risk of developing transport fever (*Driessen et al*., 2022; *EFSA*, 2022). Additionally, horses sourced from different locations can be subclinically infected and act as carriers for various infectious agents, while the mixing animals from diverse origins increases the risk of respiratory diseases (*Driessen et al*., 2022; *EFSA*, 2022). As a consequence of subclinical respiratory infections, *postmortem* examination can reveal lung lesions, which negatively affect carcass and meat quality in slaughter horses (*Čobanović et al*., 2023). Signs of parascarosis in horses are non-specific, can develop over a prolonged period, or may not be clinically apparent at all. However, *postmortem* inspection can reveal scarring in the form of white spots on the liver caused by larval migration of *Parascaris equorum*. These lesions are the result of the liver's fibroplastic response to the presence of these nematodes (*Boyle and Houston*, 2006).

3. Loading

Loading horses into a lorry is one of the most stressful events during pre-slaughter handling, as individuals are transferred from a familiar environment into a new setting, come into direct contact with unfamiliar people, corridors, compartments and vehicles, are subjected to spatial restrictions and are mixed with unfamiliar conspecifics (*Driessen et al*., 2022; *EFSA*, 2022). During this stage, animal welfare can be compromised due to rough handling, exposure to unfavourable climatic conditions (e.g. rain, wind, intense sunlight, noise, etc.) and inadequate infrastructure (*Driessen et al*., 2022). During loading, horses have shown elevated heart rates—on one hand, as a result of increased physical effort while negotiating overly steep loading ramps (>20°), and on the other hand, due to emotional fear triggered by sudden and unfamiliar sounds and visual stimuli, which can cause horses to stop, back away, sidestep or flee (*Driessen et al*., 2022; *Tateo et al*., 2012; *Waran*, 1993). This reaction is even more pronounced in farmed slaughter horses, who, unlike sport or recreational horses, have little or no previous experience with transport (*Driessen et al*., 2022). Excessive use of force during loading, including the use of whips, electric prods, sticks and dogs, causes fear and distress in horses, which can lead to slipping, falling and injury (*Dai et al*., 2021; *Grandin*, 1999; *Nivelle et al*., 2020).

4. Transport

The transport of horses can negatively impact their health, welfare and performance, as well as carcass and meat quality (*Čobanović et al*., 2023; *Driessen et al*., 2022; *EFSA*, 2022). During transit, horses face multiple stressors, including vehicle design (e.g. flooring, compartmentalisation, restraint), feed and water deprivation, driving style, ambient conditions, floor space, transport duration, season, and social disruption due to mixing of unfamiliar individuals (*Driessen et al*., 2022; *EFSA*, 2022).

Within the EU (*European Commission*, 2005), unbroken horses can be transported for a maximum

of eight hours and only in small groups (≤4 per compartment), considering their poor adaptation to restraint and novel environments. Both excessively long and short transport durations have been shown to induce stress responses—elevated levels of cortisol, lactate, glucose, and creatine kinase—and compromise welfare through increased carcass bruising (*Driessen et al*., 2022; *EFSA*, 2022; *Werner & Gallo*, 2008). Insufficient floor space (e.g. 1.28 m²/horse) increases the risk of loss of balance, slipping, falling, fighting and carcass bruising (*Collins et al*., 2000; *Iacono et al*., 2007; *Knowles et al*., 2010). Furthermore, high loading densities (>200 kg/m²) during transport impair welfare, particularly in stallions, who display heightened stress responses and more bruising than geldings (*Božić Jovanović et al*., 2024). These conditions also negatively affect meat quality, resulting in higher ultimate pH and darker meat colour (*Božić Jovanović et al*., 2024).

Recommended floor space allowances for long-distance transport (>8 hours) of adult slaughter horses vary (e. g. 1.75 m²/horse in the EU vs. 1.2 m² in Australia) (*Australian Animal Welfare Standards and Guidelines*, 2021; *European Commission*, 2005), but are often not adhered to in commercial practice, where overloading is common to increase profit (*Driessen et al.*, 2022; *EFSA*, 2022). No consensus currently exists on the optimal floor space in lorries, considering animal size, age, weight, transport duration and environmental conditions, that would simultaneously ensure profitability, animal health and welfare, and especially high carcass and meat quality (*Driessen et al*., 2022; *EFSA*, 2022). Data on how these factors influence horsemeat quality remain scarce, highlighting the need for further research. During transport, slaughter horses from different groups are often mixed, which disrupts the social hierarchy and can lead to fighting (biting and kicking) as animals attempt to establish new social structures, resulting in carcass bruising (*Driessen et al*., 2022; *EFSA*, 2022). Council Regulation No 1/2005 (*European Commission*, 2005) mandates separate transport for horses of different sizes, ages or sexes (especially stallions and mares), unless reared together. Stallions are more difficult to manage during transportation than mares and geldings (*Roy et al*., 2015), while foals are especially vulnerable to transport stress and unfamiliar social contact (*Driessen et al*., 2022; *EFSA*, 2022).

Ambient temperature, humidity, solar radiation and wind speed inside the lorry also affect horse behaviour, health and welfare during transport (*Driessen et al*., 2022). When temperatures deviate from the thermoneutral zone (5–25 °C), horses expend additional energy to maintain homeostasis (*Morgan*, 1998). Cold stress (<5 °C) leads to shivering or huddling, while heat stress (>25 °C) triggers skin vasodilation, sweating and panting (*Consortium of the Animal Transport Guides Project*, 2018; *Luz et al.*, 2015). In commercial conditions, heat and cold stress during transit can only be detected through close observation of horses by trained personnel (*Driessen et al*., 2022).

5. Unloading

The unloading of horses has been largely overlooked in scientific research, despite being one of the most stressful events on the day of slaughter. Exposure to an unfamiliar environment and unknown handlers during this phase can induce stress, adversely affecting animal welfare and carcass and meat quality (*Driessen et al*., 2022; *EFSA*, 2022). The welfare of horses during unloading can be compromised due to inadequate conditions at the slaughterhouse (e.g. steep unloading ramps, corridor design, lighting, unloading equipment), poor human-animal interactions and exposure to adverse weather conditions (e.g., snow, rain, wind, intense sunlight) (*Driessen et al*., 2022; *EFSA*, 2022).

During unloading, horses should be given sufficient time to explore the unfamiliar environment (e. g. the unloading ramp) and exit the lorry calmly, to minimise the risk of injuries (*Messori et al*., 2016). It has been found that excessively steep unloading ramps (>20°) can cause stress (evidenced by elevated concentrations of lactate, glucose and cortisol) and increased heart rate (*Tateo et al*., 2012; *Werner & Gallo*, 2008). Improper handling of horses during unloading, such as yelling, whistling, sudden movements, hitting with hands or feet and the use of whips, electric prods, sticks or dogs, leads to fear and distress in the animals, which can result in slipping, falling, and injuries to both the horses and slaughterhouse personnel (*Driessen et al*., 2022; *EFSA*, 2022).

6. Lairage

Lairage is the holding area in slaughterhouses where animals are temporarily kept prior to slaughter to ensure a continuous slaughter line and to allow recovery from the stress of loading, transport and unloading, thereby increasing meat quality (*Driessen et al*., 2022; *EFSA*, 2022). While intended to

provide rest and protection from adverse weather, lairage can also negatively impact animal welfare and carcass and meat quality if not properly managed. It is, therefore, essential to avoid errors at this stage that could undermine welfare improvements achieved during earlier production phases (*Driessen et al*., 2022; *EFSA*, 2022).

During lairage, attention should be paid to pen design, duration of stay, feed and water deprivation and mixing of animals from different groups (Driessen et al., 2022). Currently available scientific literature provides very limited data on the recommended optimal lairage duration for horses at slaughterhouses (*Driessen et al*., 2022; *EFSA*, 2022; *Farm Animal Welfare Council*, 2003). Under commercial conditions, horses can either be slaughtered immediately upon arrival or kept in lairage for several hours (~six hours), overnight or for several days (*Werner & Gallo*, 2008; *Driessen et al*., 2022). However, from an animal welfare standpoint, some authors advocate for immediate slaughter, as extended lairage could elevate stress levels (e. g. due to noise, fear, thirst, hunger), ultimately compromising meat quality (*Werner & Gallo*, 2008). Lower horse meat quality arises as a consequence of severe stress, bruising or injuries sustained during extended lairage periods (C*onsortium of the Animal Transport Guides Project*, 2018; *Nivelle et al*., 2020; *Pawshe et al*., 2016). In addition, it has been found that mixing horses from different origins during lairage leads to fights for the establishment of new social hierarchies and for limited resources in the lairage pens (e. g. space, feed and water), which results in carcass bruising and consequently lower meat quality (*Miranda-de la Lama et al.*, 2021).

7. Stunning

The process of moving horses from lairage to the stunning box, as well as the stunning itself, can induce significant stress, thereby compromising animal welfare and carcass and meat quality. To minimise stress, careful attention must be given to the stunning box design, animals' temperament, stunning method and slaughterhouse personnel training (*Driessen et al*., 2022). Restraint within the stunning box can provoke agitation, fear and stress; therefore, the duration of restraint should be minimised. Horses should not be led into the box until the operator responsible for stunning and bleeding is fully prepared to perform the procedure without delay (*Driessen et al*., 2022). Extended restraint in the stunning box has been associated with behavioural signs of distress—such as nervousness, muscular rigidity and tremors—as well as elevated blood concentrations of lactate and creatine kinase at exsanguination (*Werner & Gallo*, 2008).

In Europe and South America, stunning is typically performed using a penetrating captive bolt (powered by compressed air or explosive cartridges), while in Canada, a long rifle is used (*Algers & Atkinson*, 2014; *Gibson et al*., 2015). Malfunction of cartridge-fired captive bolts can occur due to damp cartridges (*Grandin*, 2015), and pneumatic devices can be compromised by inadequate air pressure (*Bulens et al*., 2013), both resulting in ineffective stunning and serious animal welfare issues. When using firearms for stunning horses, risks such as ricochet necessitate strict adherence to safety protocols, including correct operator positioning (*Gallo et al*., 2022; *Hultgren*, 2022; *Needham & Hoffman*, 2022; *Shearer & Ramirez*, 2013).

8. Exsanguination

Delayed or improper exsanguination can compromise horse welfare and negatively affect meat quality (*Werner & Gallo*, 2008). The procedure is typically performed using a sharp, rigid, long-bladed knife to sever the jugular veins, carotid arteries and trachea (*Woods & Shearer*, 2015). To enhance bleeding efficiency, thoracic sticking—severing major vessels near the heart, such as the brachiocephalic trunk and artery—can also be employed (*Woods & Shearer*, 2015). To ensure animal welfare and optimal bleeding, exsanguination should occur within 60 seconds of stunning (*Werner & Gallo*, 2008).

During the interval between stunning and exsanguination, and throughout the bleeding process, horses must be monitored for signs of inadequate stunning, including the presence of the corneal reflex, spontaneous blinking, rhythmic breathing and righting reflex (*Bulens et al*., 2013). Carcass processing and *postmortem* inspection can only proceed once the absence of vital signs has been confirmed (*Bulens et al*., 2013). *Werner and Gallo* (2008) reported that in 95.2% of horses, the interval between stunning and bleeding exceeded one minute (range: 1–4 minutes), and 57.2% of animals exhibited signs of sensibility post-stunning and bleeding. The most frequent signs of sensibility were rhythmic breathing (47.6%), eye movement (42.7%), vocalisation (14.7%), head lifting (12.2%) and attempts

to rise (9.5%) (*Werner & Gallo*, 2008). Additionally, elevated blood concentrations of lactate, glucose, creatine kinase and cortisol were observed under conditions of delayed or ineffective exsanguination, indicating stress and compromised welfare (*Werner & Gallo*, 2008).

9. Conclusion

The welfare of horses can be compromised at any stage of the meat production chain – from the place of purchase, through loading, transport, and unloading, to lairage and the slaughter process itself. Animal characteristics, infrastructure at the point of purchase and slaughterhouse, vehicle design, environmental factors, and the quality of human-animal interactions significantly influence pre-slaughter welfare conditions. Considering that the current recommendations on minimum floor space in transport vehicles are inadequate, and that there are no clear guidelines regarding the optimal lairage duration for horses at slaughterhouses, further research is needed to improve horse welfare throughout the meat production chain.

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