Content is avaliable at SCOPUS

Meat Technology — Special Issue 64/2

www.meatcon.rs ▪ www.journalmeattechnology.com

UDK: 636.1.033

ID: 126557705

https://doi.org/10.18485/meattech.2023.64.2.29

Review paper

Horse carcass and meat quality — current knowledge and research gaps

Nikola Čobanović[a], Nevena Grković[a], Branko Suvajdžić[a], Ivan Vićić[a] and Nedjeljko Karabasil[a]*

[a] *University of Belgrade, Faculty of Veterinary Medicine, Bulevar oslobodjenja 18, 11000 Belgrade, Serbia*

ARTICLE INFO

Keywords:
Carcass conformation
Carcass fat cover
Meat colour
Water-holding capacity

ABSTRACT

Horsemeat can be considered a good alternative for conventional meats due to its potential dietetic and health benefits linked with its specific nutritional composition. The aim of this review was to provide information on the carcass and meat quality of horses, as well as methods for their examination based on currently available scientific literature in order to expand knowledge in this field and determine the direction of future research. The most important horse carcass quality indicators are the carcass conformation and carcass fat cover, while the most important horsemeat quality traits are pH, colour, water-holding capacity and texture. However, more research is needed to establish a classification system for horse carcasses as well as threshold values for colour and water-holding capacity traits that might be used for horsemeat classification into quality classes.

1. Introduction

Horsemeat can be considered a good alternative for conventional meats (chicken, pork, sheep or beef) due to its potential dietetic and health benefits linked with high content of protein, iron, minerals (P, Fe, Zn and Cu) and vitamins (A, E, C and B group) (*Lorenzo et al.*, 2014, 2019). This meat type has a low fat content, low cholesterol content and favourable fatty acid profile, with a high content of unsaturated fatty acids relative to saturated acids and provides a large amount of essential amino acids (*Lee et al.*, 2007).

However, horsemeat can only be considered as an alternative for conventional meat types if the production chain is under strict control to guarantee traceability and high quality and safety of raw meat and meat products (*Lorenzo et al.*, 2014, 2019). It is also important to define horse carcass and meat characteristics, appropriate assessment methods and reference ranges for good or poor carcass/meat quality to ensure that product quality meets consumers expectations. Therefore, the aim of this review was to provide information on the carcass and meat quality of horses, as well as methods for their examination based on currently available scientific literature in order to expand knowledge in this field and determine the direction of future research.

2. Carcass characteristics

The horse carcasses exhibit a large degree of variability, which arises from differences in horse origins, slaughter ages, breeds, types and production systems (*Lorenzo et al.*, 2019). However, the unique attributes of the horse carcass are a dark colour that can change to brown or black with a bluish tinge

***Corresponding author:** Nikola Čobanović, *cobanovic.nikola@vet.bg.ac.rs*

Paper received Jun 29th 2023. Paper accepted July 12th 2023.
Published by Institute of Meat Hygiene and Technology — Belgrade, Serbia

upon exposure to air, the absence of significant fatty deposits, and the presence of yellow-coloured fat (*Lorenzo et al.*, 2014, 2019). Certain features, such as neck length, rib number (18 pairs), non-lobulated kidney and bony structures, can help differentiate horse carcasses (*Lorenzo et al.*, 2019). The most important factors that affect horse carcass quality are age, slaughter weight, breed, gender, production system, finishing feeding and anatomical location of measurements (*Franco et al.*, 2011; *Lorenzo et al*, 2013a; *Domínguez et al*, 2015). Horse carcass traits are evaluated by different parameters such as: slaughter weight, carcass weight, dressing percentage, carcass conformation, carcass fat cover and carcass linear measurements (*Lorenzo et al.*, 2014; *Znamirowska*, 2005).

Slaughter weight and dressing percentage are measures of the animal's development and are important for determination of the fattening performance (daily weight gain) (*National Research Council*, 1988). Indirectly, considering that heavier carcasses usually have more musculature, weight can also indicate horse carcass meatiness. In horses, slaughter weight can be determined on a balance scale or with horse weight tape on the farm, at the lairage or, most often, 1 hour before slaughter (*De Palo et al*, 2013). The dressing percentage of horses is mainly the ratio of dressed hot carcass weight to the slaughter weight, expressed as a percentage (hot dressing percentage) (*Lorenzo et al.*, 2014). Extremely high slaughter weight and dressing percentage can be a disadvantage if they are a consequence of the large amount of fat, bones and organs (*National Research Council*, 1988).

A horse carcass is defined as the carcass from which the skin, head, lower legs (separated at the tarsal and carpal joints), tail and all internal organs of the thoracic, abdominal and pelvic cavities (except for the kidneys and renal fat tissue) have been removed during processing (*Polidori et al*, 2015). Carcass weight is usually determined on a balance scale 45 minutes (hot carcass weight) or 24 hours *postmortem* when the internal carcass temperature drops below 7°C (cold carcass weight). Cold carcass weight can also be calculated by reducing hot carcass weight by 2% (*European Commission*, 2008).

Carcass conformation is the most important indicator when classifying carcasses because it directly indicates the amount of meat (*Pečiulaitienė et al*, 2015). It describes the development of carcass profiles, in particular the essential parts, such as legs (round and rump), back and shoulders (chuck), and indicates the sum of muscle and fat in relation to the bones (*Ekiz et al*, 2021). Carcass conformation is visually evaluated at the end of the slaughterline, i.e., immediately after determination of hot carcass weight (45 minutes *postmortem*). The currently available ONIBEV (*Office National Interproffessionnel du Betail et des Viandes*) classification system for horse carcasses, established in 1979 in France, takes into consideration the horse age, carcass conformation, carcass fat cover and the slaughter weight. However, some authors (*Fàbregas and Such*, 2001; *Lorenzo et al.*, 2019; *Cittadini et al,* 2021) consider that the ONIBEV system (1979) for classifying horse carcasses is limited, and therefore, the EUROP standard for beef carcass classification is used as an alternative in commercial conditions and in research studies (*Cittadini et al.*, 2021). Since horsemeat has a regular group of consumers, addressing the issue of objective classification of horses and their carcasses will increasingly gain importance (*Znamirowska*, 2005). The absence of an official classification system for horse carcasses intended for meat consumption in the European Union necessitates the development of such a system to ensure an adequate supply of desired quality meat to meet consumer demands (*Lorenzo et al.*, 2014). The implementation of a standardised classification system would enable comparative analyses of horsemeat across different countries, between time periods and between studies, and the grouping of meat batches for export based on uniform parameters or criteria, neither of which is possible at the moment (*Znamirowska*, 2005). This would also provide positive incentives for primary producers to produce horses of higher quality standards and facilitate crossbreeding efforts aimed at obtaining premium-quality raw meat, for which they could potentially receive higher prices (*Znamirowska*, 2005).

Carcass fat cover is one of the most important parameters in the horse carcass classification, and is usually determined at the same time as the carcass conformation (45 minutes *postmortem*) (*Lorenzo et al.*, 2019). The carcass fat cover describes the amount of fat on the outside of the carcass and in the thoracic cavity (*Ekiz et al.*, 2021). From the carcass quality aspect, favourable fat cover is described when a carcass has uniformly and evenly distributed, continuous, but not too thick layer of fat tissue (*European Commission*, 2008). Sufficient carcass fat cover insulates the carcass and decreases cooling loss (*Albertí et al*, 2022), slowing down surface meat spoilage (Gill, 1983), increases antioxidative stability and improves meat aroma (juiciness, taste and odour) (*Alberti et al*., 2017). The subcutaneous fat on a horse carcass is not abundant, and the kidney fat depots and flank region are relatively lean, even in well-fed animals (*Lorenzo et al*., 2014, 2019). The fat cover of horse carcasses can be determined using the same methodology as for beef carcasses (*Cittadini et al.,* 2021). Five classes are defined, using the visual carcass evaluation on the dorsal side and on thoracic cavity, represented by the incremental scale ranges from 1 (denotes the least fat) to 5 (denotes the most fat) (*European Commission*, 2008).

Carcass linear measurements of horses are can be determined using the same indicators as for beef carcass quality assessment (*De Boer et al*, 1974). These are general indicators, because it is difficult to objectively define the relationship between the carcass morphometric measurements and muscle development in slaughter animals (*Lonergan et al*, 2019). However, linear measurements directly indicate the muscle development in the most valuable anatomical parts (chest, back, shoulders and legs) on the horse carcasses (*Gurgel et al.*, 2021). Horse carcass linear measurements are measured 24 hours *postmortem* in centimetres using a tape and/or calliper in the following order: carcass length, carcass compactness index, chest depth, leg length, leg width, leg circumference and leg compactness index (*Znamirowska*, 2005).

3. Meat quality

Horsemeat has a very dark red colour, yellow fat and high carbohydrate content (intramuscular glycogen) with a typical sweetish smell and taste, which can be considered a significant disadvantage from the consumer's perspective (*Stanisławczyk et al*, 2021a; *Driessen et al,* 2022). The most important factors that affect horsemeat quality are age, slaughter weight, breed, gender, production system and anatomical location of the measurements (*Franco et al.*, 2011; *Lorenzo et al*, 2013b, *Lorenzo et al.*, 2019). Horsemeat quality are evaluated by different traits such as: pH, temperature, colour, water-holding capacity and texture (*Franco et al.*, 2011; *Seong et al.*, 2016; *Lorenzo et al.*, 2014, 2019).

Physicochemical indicators (pH and temperature) are important horsemeat quality traits for monitoring the processes taking place during the *postmortem* conversion of muscle into meat. After slaughter, the horsemeat pH rapidly drops below 6, and the onset of *rigor mortis* starts to take place at 48 hours *postmortem* (*Lorenzo et al.*, 2019). Under normal conditions (without stress), horsemeat reaches pH values between 5.4 and 5.9 within 24–48 hours *postmortem* (*Seong et al.*, 2016; *Walker*, 2017; *Stanisławczyk et al*, 2019). Considering that meat pH also depends on the temperature, the optimal horsemeat temperature ranges from 37.2°C to 38.5°C 45 minutes *postmortem* (*Green et al*, 2005) and from 0 to 7ºC 24 hours after slaughter (*Walker*, 2017). Compared to other meat types, horsemeat has high glycogen and ATP content, and consequently, it is highly resistant to spoilage and is a high durability raw material (*Lorenzo et al.*, 2019; *Stanisławczyk et al.*, 2021a). This can be attributed to the specific *postmortem* changes that occur within the glycogen-rich horse muscles, which involve prolonged anaerobic glycolysis and lactic acid production as the end product (*Stanisławczyk et al.*, 2021a). This results in a sustained acidification within the muscles and, thus, low ultimate horsemeat pH (*Stanisławczyk et al.*, 2021a). The measures of horsemeat pH can be taken at different times, from 45 minutes to 6 days after slaughter (*Sarriés and Beriain*, 2005; *Franco et al*, 2013; *Stanisławczyk et al*, 2020; *Cittadini et al.*, 2021), but in most studies, this physicochemical indicator was determined 24 hours *postmortem* in *Musculus longissimus dorsi*, using a portable pH meter (*Franco et al.*, 2011; *Domínguez et al.*, 2015; *López-Pedrouso et al.*, 2023).

Horsemeat is characterised by a relatively good water-holding capacity (*Stanisławczyk et al.*, 2021a), that ranges from 67.3% to 73.9% (*Strashynskyi and Fursik*, 2020). The good water-holding capacity of horsemeat contributes to low fluid loss during heat treatment, resulting in high yield and good quality final meat products, which indicates that this meat type is a good raw material for producing different meat products (*Stanisławczyk et al.*, 2021a). The following methods are most often used to determine the water-holding capacity of horse meat: (i) (forced) drip loss (*Domínguez et al.*, 2015; *Franco et al.*, 2011; *Lorenzo et al.*, 2013a); (ii) thawing loss (*De Palo et al.*, 2013); (iii) cooking loss (*Franco et al.*, 2011; Lorenzo et al., 2013a; Domínguez et al., 2015; *Seong et al.*, 2016; *Stanisławczyk et al.*, 2020; *López-Pedrouso et al.*, 2023); and (iv) centrifugation (*De Palo et al.*, 2013). In most investigations, horsemeat water-holding capacity was determined 24 hours *postmortem* in *Musculus longissimus dorsi* (*Franco et al.*, 2011, 2013; *Domínguez et al.*, 2015; *Stanisławczyk et al.*, 2020). Unlike pork and poultry meat (*Kralik et al*, 2018; Čobanović et al., 2020), there are no reference values in the available scientific literature for horsemeat that could be used for classification into meat quality classes. Future research should establish cut-off values for horsemeat water-holding capacity to assess whether the meat is of good or low quality.

One quality characteristic that distinguishes horsemeat, even from beef, is its relatively dark-red colour with a subtle brownish hue, which rapidly darkens and turns into a black-brown shade upon exposure to air (*Stanisławczyk et al*., 2021a). This horsemeat property is attributed to its elevated myoglobin content (7.4 mg/g) compared to beef (3.8 mg/g) and pork (ranges from 0.79 to 1.44 mg/g) (*Lorenzo et al.*, 2014, 2019*; Stanisławczyk et al.*, 2021a). The elevated myoglobin concentration in horsemeat facilitates its colour transformation, rendering it more visible to the eye compared to pork or veal, and, thus, fresh horsemeat colour stability is relatively low, shortening the shelf-life (*Lorenzo et al*., 2014, 2019*; Stanisławczyk et al.*, 2021a). It has been reported that horsemeat darkens as the animal ages, while the fat tissue turns yellowish or even orange in colour (*Stanisławczyk et al*, 2021b). However, the myoglobin content in horse muscle tissue increases during the first years two of life, and then decreases during the ten following years (*Lorenzo et al*., 2019). Horsemeat colour can be measured 24 hours *postmortem* in the *Musculus longissimus dorsi* after 30 minutes of blooming time at 4℃ using portable colorimeter based on the colorimetric scale CIE L*, a*, b* (*Franco et al*., 2011, 2013; *Lorenzo et al*., 2013a; *Domínguez et al*., 2015; *Stanisławczyk et al*., 2020). Compared to pork and poultry meat (*Kralik et al.*, 2018*; Čobanović et al.*, 2020), there are no reference values in the available scientific literature for horsemeat colour that could be used for classification into quality classes. Consequently, future research should establish cut-off values for horsemeat colour to assess whether the meat is of good or low quality.

Horsemeat texture is undesirable, as it exhibits extreme stringiness and hardness, particularly in older animals, even after undergoing heat treatment (*Stanisławczyk et al.*, 2021a). This can be attributed to a higher proportion of connective tissue, specifically collagen (3.5% of the total protein content in horsemeat), compared to pork (less than 0.5%) and beef (ranges from 0.49% to 1.0%) (*Stanisławczyk et al.*, 2021a, 2021b). Conversely, horsemeat from younger animals generally displays superior tenderness, surpassing in this aspect other meat types, especially, beef (*Lorenzo et al.*, 2014, 2019; *Stanisławczyk et al*., 2021a). As animals age, connective tissue mechanical stability increases as a consequence of collagen crosslinking (*Stanisławczyk et al*., 2021a, 2021b). Consequently, collagen within the intermuscular connective tissue becomes stiffer, harder and more resistant to heat denaturation, leading to progressive meat toughening and requiring greater force for cutting (*Stanisławczyk et al*., 2021a). Horsemeat texture can be determined 24 hours *postmortem* on cooked samples obtained from *Musculus longissimus dorsi* by using the Warner-Bratzler shear force (WBSF) test (*De Palo et al.*, 2013; *Franco et al.*, 2011, 2013; *Lorenzo et al*., 2013b; *Stanisławczyk et al*., 2020; *Stanisławczyk et al*., 2021b). Based on texture values obtained by using the WBSF test, horsemeat can be classified in the same manner as beef (*Stanisławczyk et al*., 2021a): very tender (WBSF < 3.2 kg), tender (3.2 < WBSF < 3.9 kg), intermediate (3.9 < WBSF < 4.6 kg) and tough (WBSF > 4.6 kg).

4. Conclusion

Based on the analysis of existing scientific literature, it can be concluded that the most important horse carcass quality indicators are the carcass conformation and carcass fat cover, while the most important horsemeat quality traits are pH, colour, water-holding capacity and texture. However, more research is needed to establish a classification system for horse carcasses as well as threshold values for colour and water-holding capacity traits that might be used to classify horsemeat into quality classes.

Disclosure statement: No potential conflict of interest was reported by the authors.

Funding: The study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract number 451-03-47/2023-01/200143).

References

Albertí, P., Campo, M. M., Beriain, M. J., Ripoll, G. & Sañudo, C. (2017). Effect of including whole linseed and vitamin E in the diet of young bulls slaughtered at two fat covers on the sensory quality of beef packaged in two different packaging systems. *Journal of the Science of Food and Agriculture*, 97(3), 753–760, https://doi.org/10.1002/jsfa.7792

Cittadini, A., Sarriés, M. V., Domínguez, R., Indurain, G. & Lorenzo, J. M. (2021). Effect of breed and finishing diet on growth parameters and carcass quality characteristics of Navarre autochthonous foals. *Animals*, 11(2), 488, https://doi.org/10.3390/ani11020488

Čobanović, N., Stanković, S. D., Dimitrijević, M., Suvajdžić, B., Grković, N., Vasilev, D. & Karabasil, N. (2020). Identifying physiological stress biomarkers for prediction of pork quality variation. *Animals*, 10(4), 614, https://doi.org/10.3390/ani10040614

De Boer, H. D. B. L., Dumont, B. L., Pomeroy, R. W. & Weniger, J. H. (1974). Manual on EAAP reference methods for the assessment of carcass characteristics in cattle. *Livestock Production Science*, 1(2), 151–164, https://doi.org/10.1016/0301-6226(74)90055-4

De Palo, P., Maggiolino, A., Centoducati, P. & Tateo, A. (2013). Slaughtering age effect on carcass traits and meat quality of Italian heavy draught horse foals. *Asian-Australasian Journal of Animal Sciences*, 26(11), 1637, https://doi.org/10.5713/ajas.2013.13174

Domínguez, R., Crecente, S., Borrajo, P., Agregán, R. & Lorenzo, J. M. (2015). Effect of slaughter age on foal carcass traits and meat quality. *Animal*, 9(10), 1713–1720, https://doi.org/10.1017/s1751731115000671

Driessen, B., Marlin, D. & Buyse, J. (2022). Horses. In L. Faucitano (Ed.), Preslaughter Handling and Slaughter of Meat Animals (pp. 194-221). Wageningen Academic Publishers, https://doi.org/10.3920/978-90-8686-924-4

Ekiz, B., Kecici, P. D., Ograk, Y. Z., Yalcintan, H. & Yilmaz, A. (2021). Evaluation of the functionality of EUROP carcass classification system in thin-tailed and fat-tailed lambs. *Meat Science*, 181, 108603, https://doi.org/10.1016/j.meatsci.2021.108603

European Commission (2008). EC Regulation No. 1249/2008 of 10 December 2008 laying down detailed rules on the implementation of the Community scales for the classification of beef, pig and sheep carcases and the reporting of prices thereof. ECOJ No. L3373–30.

Fàbregas, X. & Such, X. (2001). Clasificación de canales equines: I. Distribución de clases. *ITEA*, 2, 706–708.

Franco, D., Rodríguez, E., Purriños, L., Crecente, S., Bermúdez, R. & Lorenzo, J. M. (2011). Meat quality of "Galician Mountain" foals breed. Effect of sex, slaughter age and livestock production system. *Meat Science*, 88(2), 292–298, https://doi.org/10.1016/j.meatsci.2011.01.004

Franco, D., Crecente, S., Vázquez, J. A., Gómez, M. & Lorenzo, J. M. (2013). Effect of cross breeding and amount of finishing diet on growth parameters, carcass and meat composition of foals slaughtered at 15 months of age. *Meat Science*, 93(3), 547–556, https://doi.org/10.1016/j.meatsci.2012.11.018

Franco, D. & Lorenzo, J. M. (2014). Effect of muscle and intensity of finishing diet on meat quality of foals slaughtered at 15 months. *Meat Science*, 96(1), 327–334, https://doi.org/10.1016/j.meatsci.2013.07.018

Gill, C. O. (1983). Meat spoilage and evaluation of the potential storage life of fresh meat. *Journal of Food Protection*, 46(5), 444 – 452, doi.org/10.4315/0362-028x-46.5.444

Green, A. R., Gates, R. S. & Lawrence, L. M. (2005). Measurement of horse core body temperature. *Journal of Thermal Biology*, 30(5), 370–377, https://doi.org/10.1016/j.jtherbio.2005.03.003

Gurgel, A. L. C., Difante, G. D. S., Emerenciano Neto, J. V., Fernandes de Araújo, C. G., Costa, M. G., Ítavo, L. C. V.... & Fernandes, P. B. (2021). Prediction of carcass traits of Santa Inês lambs finished in tropical pastures through biometric measurements. *Animals*, 11(8), 2329, https://doi.org/10.3390/ani11082329

Kralik, G., Kralik, Z., Grčević, M. & Hanžek, D. (2018). Quality of chicken meat. In B. Yucel & T. Taskin (Eds.), Animal husbandry and nutrition (pp. 63–94), IntechOpen, https://doi.org/10.5772/intechopen.69938

Lee, C. E., Seong, P. N., Oh, W. Y., Ko, M. S., Kim, K. I. & Jeong, J. H. (2007). Nutritional characteristics of horsemeat in comparison with those of beef and pork. *Nutrition Research and Practice*, 1(1), 70 –73, https://doi.org/10.4162/nrp.2007.1.1.70

Lonergan, S. M., Topel, D. G. & Marple, D. N. (2019). Methods to measure body composition of domestic animals. In S. M. Lonergan, D. G. Topel, and D. N. Marple (Eds.), The Science of Animal Growth and Meat Technology (pp. 125–146), Elsevier, https://doi.org/10.1016/b978-0-12-815277-5.00008-1

López-Pedrouso, M., Lorenzo, J. M., Cittadini, A., Sarries, M. V., Gagaoua, M. & Franco, D. (2023). A proteomic approach to identify biomarkers of foal meat quality: A focus on tenderness, color and intramuscular fat traits. *Food Chemistry*, 405, 134805, https://doi.org/10.1016/j.foodchem.2022.134805

Lorenzo, J. M., Sarriés, M. V. & Franco, D. (2013a). Sex effect on meat quality and carcass traits of foals slaughtered at 15 months of age. *Animal*, 7(7), 1199–1207, https://doi.org/10.1017/s1751731113000189

Lorenzo, J. M., Pateiro, M. & Franco, D. (2013b). Influence of muscle type on physicochemical and sensory properties of foal meat. *Meat Science*, 94(1), 77–83, https://doi.org/10.1016/j.meatsci.2013.01.001

Lorenzo, J. M., Sarriés, M. V., Tateo, A., Polidori, P., Franco, D. & Lanza, M. (2014). Carcass characteristics, meat quality and nutritional value of horsemeat: A review. *Meat Science*, 96(4), 1478–1488, https://doi.org/10.1016/j.meatsci.2013.12.006

Lorenzo, J. M., Maggiolino, A., Sarriés, M. V., Polidori, P., Franco, D., Lanza, M. & De Palo, P. (2019). Horsemeat: Increasing Quality and Nutritional Value. In Lorenzo, J. M., Munekata, P. E., Barba, F. J. & Toldrá, F. (Eds.), More than Beef, Pork and Chicken–The Production, Processing, and Quality Traits of Other Sources of Meat for Human Diet (pp. 31–69), Springer, https://doi.org/10.1007/978-3-030-05484-7_3

National Research Council, (1988). Live animal and carcass composition measurement. In Designing Foods: Animal Product Options in the Marketplace. National Academies Press (US).

ONIBEV, (1979). Catalogue de Classement des Équidés (en carcasse). Office National Interproffessionnel du Betail et des Viandes, Paris Cedex.

Pečiulaitienė, N., Jukna, V., Meškinytė-Kaušilienė, E., Kerzienė, S. & Moleikaitienė, S. (2015). Effects of weight and age on carcass yield and conformation of cattle. *Biotechnology in Animal Husbandry*, 31(1), 73–84, https://doi.org/10.2298/bah1501073p

Polidori, P., Pucciarelli, S., Ariani, A., Polzonetti, V. & Vincenzetti, S. (2015). A comparison of the carcass and meat quality of Martina Franca donkey foals aged 8 or 12 months. *Meat Science*, 106, 6–10, https://doi.org/10.1016/j.meatsci.2015.03.018

Sarriés, M. V. & Beriain, M. J. (2005). Carcass characteristics and meat quality of male and female foals. *Meat Science*, 70(1), 141–152, doi.org/10.1016/j.meatsci.2004.12.006

Seong, P. N., Park, K. M., Kang, G. H., Cho, S. H., Park, B. Y., Chae, H. S. & Van Ba, H. (2016). The differences in chemical composition, physical quality traits and nutritional values of horse meat as affected by various retail cut types. *Asian-Australasian Journal of Animal Sciences*, 29(1), 89–99, doi.org/10.5713/ajas.15.0049

Stanisławczyk, R., Rudy, M., Gil, M. & Duma-Kocan, P. (2019). Influence of cold and frozen storage on the chemical content, hydration properties and texture parameters of horse meat. *Medycyna Weterynaryjna*, 75(4), 242–246, https://doi.org/10.21521/mw.6207

Stanisławczyk, R., Rudy, M. & Gil, M. (2020). Quality characteristics of horse meat as influence by the age of horse. *International Journal of Food Properties*, 23(1*)*, 864–877, https://doi.org/10.1080/10942912.2020.1764579

Stanisławczyk, R., Rudy, M. & Rudy, S. (2021a). The quality of horsemeat and selected methods of improving the properties of this raw material. *Processes*, 9(9), 1672, https://doi.org/10.3390/pr9091672

Stanisławczyk, R., Rudy, M., Gil, M., Duma-Kocan, P. & Żurek, J. (2021b). Influence of horse age, marinating substances, and frozen storage on horse meat quality. *Animals*, 11(9), 2666, https://doi.org/10.3390/ani11092666

Strashynskyi, I. & Fursik, O. (2020, December). Using of horsemeat as an additional source of raw materials for expanding the range of meat products. Poster session presentation at the meeting of the Specialized and multidisciplinary scientific researches, Amsterdam, The Netherlands, pp. 38–40, https://doi.org/10.36074/11.12.2020.v2.10

Walker, B. D. (2017). Impact of carcass chill time on the microbiology of horse meat, University of Alberta, Canada.

Znamirowska, A. (2005). Prediction of horse carcass composition using linear measurements. *Meat Science*, 69(3*)*, 567–570, https://doi.org/10.1016/j.meatsci.2004.10.008