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Influence of Horse Age on Carcass Tissue Composition and Horsemeat Quality: Exploring Nutritional and Health Benefits for Gourmets

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Abstract: The aim of this study was to show the influence of the age of horses currently in use in Poland on the tissue composition of carcasses and the quality of horsemeat. To conduct a detailed dissection and analysis of horsemeat quality, 12 half carcasses of foals and young horses, 14 half carcasses of adult horses, and 14 half carcasses of older horses were selected. A highly significant difference was demonstrated between the linear measurements of the carcasses of foals and young horses compared with those of adult animals. A significantly higher dressing percentage was observed in foals compared with older horses ($p \leq 0.05$). Compared with the carcasses from older horses, the foal carcasses provided a significantly higher amount of meat in class I ($p \leq 0.05$). Meat obtained from foal carcasses, when compared with the raw material from other age groups of animals, was characterized by a higher number of points for individual qualitative characteristics in the sensory evaluation. The physicochemical properties of horsemeat were dependent on the age of the horses. Compared with the oldest horses, foal meat was characterized by the lowest ability to bind and retain water. The significantly highest content of protein and fat was found in the meat of adult horses compared with the meat of foals. The horsemeats consumed today, compared with those from the 1980s and 1990s, are characterized by a much lower degree of fat deposition in the carcasses, and a higher dressing percentage index and carcass meatiness. This may result in a greater popularization of horsemeat, both among processors of this raw material and the consumers themselves. This can be a very important advantage, pointing to new aspects of food quantity and quality, especially for gourmets of this type of product.

Keywords: horsemeat; tissue composition; dressing percentage; chemical composition; sensory evaluation; physicochemical properties

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1. Introduction

Horsemeat has a strictly defined group of consumers, and the demand for this food varies depending on the country and region. Currently, in Europe, the consumption of horsemeat holds significant importance in countries such as Spain, Belgium, France, and Italy [1]. The quality of the slaughter material obtained at collection centers is highly diverse, which is attributable, in part, to a large age range of the horses (from foals to horses over 20 years of age) and a significant variation in the ante-slaughter weight of horses. Taking into account the characteristics of horse carcasses and meat quality, as well as nutritional value and fatty acid composition, foals are the most extensively studied slaughter category. Numerous research studies [2–18] demonstrated the effect of horse age on the slaughter value and quality of horsemeat. It should be emphasized that the age of horses contributes significantly to the diversification of the obtained raw material.

As an animal ages, not only does the tissue composition of the obtained carcasses change, but the structure of the proteins in muscle and connective tissues, as well as the quality of adipose tissue, also varies [5]. Moreover, the content of basic components in horsemeat is influenced by the age of the animal; specifically, as animals age, the water content in the meat decreases, while the protein and fat content increases [5].

In comparison with other conventional types of meat, such as beef, chicken, or pork, horsemeat consumption is marginal [19,20]. Although horsemeat is commercialized in a minority market, it boasts excellent nutritional properties [8]. These properties include low levels of fat and cholesterol; very high contents of protein, vitamins, and minerals; and relatively high concentrations of *n*-3 fatty acids and heme iron. These attributes suggest that the consumption of horsemeat may offer health benefits [10,14,16,21–28].

In recent years, few studies in the literature have focused their attention on the evaluation of the slaughter value of horses, the tissue composition of carcasses, and the quality of horsemeat in terms of the age of the animal. Most of the research work on the evaluation of the slaughter value of horses and the quality of horsemeat dates back 20 years and some studies in this area are even older [7,29–40]. It should be noted that over the course of these years, the environmental, nutritional, and genetic conditions could have changed. These changes could, in turn, result in the differentiation of the characteristics of the slaughter value, as well as the tissue and chemical composition of this raw material [35,38,41,42].

Given that Poland is a large exporter of horsemeat, the usefulness of Polish horse breeds, compared with other foreign breeds, in terms of slaughter value and chemical composition of the meat may prove to be more favorable [5,38].

In this context, the aim of this study was to show the influence of the age of horses in contemporary use in Poland on the tissue composition of carcasses and the quality of horsemeat. This will make it possible to demonstrate new nutritional and health aspects of horsemeat, especially for gourmets of this type of product.

2. Materials and Methods

2.1. Experimental Material

The experimental material consisted of foals and young horses with an antemortem weight of 240–320 kg (280 ± 20 kg), adult horses with an antemortem weight of 500–560 kg (530 ± 30 kg), and older animals with an antemortem weight of 550–650 kg (600 ± 50 kg). For a detailed dissection and analysis of horsemeat quality assessment, 12 half carcasses of foals and young horses, 14 half carcasses of adult horses, and 14 half carcasses of older horses were used. Horses purchased in Poland are characterized by a large age range (from foals to horses over 20 years old). The horses were divided into three experimental age groups: group I—foals and young horses up to 2 years of age, group II—adult horses from 2 to 10 years of age, and group III—older horses from 10 to 20 years of age. Data on the ages of the animals were obtained in meat plants based on the collected documentation. The animals were divided into these three age groups because the age of the horses significantly determines the tissue composition of carcasses, slaughter value, and quality of horsemeat. The animals were purchased in southeastern Poland. Malopolska and Silesian Horses were used in the experiment. In each age group of horses, an equal distribution of individuals by breed and sex was maintained. All animals were in a normal condition. According to the BCS method developed by Henneke [43] for assessing the body condition of a horse, the horses qualified for the tests in this publication were rated on a scale from 1 to 5. Assessment of the normal condition of the horse according to the BCS method included:

- Shoulder evenly covered with muscle tissue and slightly palpable fat.
- Neck and withers—a nice, flexible neck with a proper layer of fat. The crest of the neck rounds it, joining smoothly with the soft arch of the withers.
- Ribs are invisible but easily felt under the fingers.
- Back does not appear sunken, with a moderate amount of fat. Processes are still palpable but not protruding.

- Base of the tail is covered with spongy fat with the dock palpable.

The horses were kept in a medium-intensive stable-pasture rearing system where the animals were confined for part of the year, and for the other part—especially in summer—they were allowed to graze on pasture. In the case of the horses, a mixed feeding system was used, in which roughage and concentrated feed were included, amounting to at least 15–20% of the total feed ratio. The horses were given low-volume feed rations with a high concentration of nutrients. Animals were fed using a semi-individual system. This system consisted of individual dosing of concentrated feed (mainly cereal grains) and feeding roughly equal amounts of dry and succulent roughage (forage—from permanent grassland and field crops, silage, root crops, hay, straw, chopped straw) to a group of horses with similar body weight, physiological condition, and workload. Pasture grass was used in ad libitum feeding; hay was used less frequently. For foals, concentrates and hay were mainly used after weaning in winter. During summer, in addition to concentrates, animals were grazed on pasture. The concentrates mainly consisted of cereal grains, including oats, barley, and corn. While in the warehouses, the animals were provided with access to clean water. The horses were transported to an abattoir by road over short distances (up to 4 h), with animal welfare being maintained during this process. During transport, the animals were kept in separate boxes to prevent injury. After transportation, they were kept separately in warehouses for about 24 h.

2.2. Slaughter, Evaluation of Slaughter Value, and Carcass Dissection

All activities related to the slaughter of animals and postslaughter classification of half carcasses were performed in accordance with the methodology described by Znaniecki [44]. Horses were slaughtered in an abattoir, following the specifications outlined in European legislation [45]. All carcasses were classified as U (conformation) and 2 (fat cover) according to the community scale for the classification of carcasses of adult bovine animals [46]. This classification was used, as there is no specific classification system for horses at the EU level (Table S3, go to the Supplementary Material).

The obtained carcasses were divided into two halves by cutting through the center of the vertebral column and the pelvic bone at the pubic symphysis, exposing the medullary canal. During postslaughter processing, the tail was cut off from the right half carcass. The perirenal fat was torn off and the kidneys were removed. Subsequently, the obtained half carcasses were weighed with an accuracy of 1 kg to determine the warm carcass weight, up to 2 h after slaughter. This weight was used to calculate the "warm" dressing percentage index. On the hanging right half carcass, dissection measurements were made, which indicated the muscle tone and fatness of the carcasses. After these measurements, the carcasses were sent to a cold store [44].

Linear measurements were carried out in accordance with the recommended methodology [44]. These measurements were taken to determine the following: the length and width of the carcass, the thickness of the sirloin, hind circumference and length, the color of fat and external deposition of fat on the carcass, nape fat thickness, and cross-sectional area of the longest dorsal muscle.

The length of the carcass was measured with a tape measure, extending from the cephalic edge of the pubic bone to the middle of the cephalic edge of the first rib, with an accuracy of 1 cm. The carcass width was measured from the spinous process of the last thoracic vertebra to the outer edge of the sternum, using a line perpendicular to the spine and maintaining an accuracy of 1 cm. The hind circumference was measured at three-quarters of its length, with an accuracy of 1 cm. The length of the hind was taken from the cephalic edge of the pubic symphysis to the cut-off point in the ankle joint, with an accuracy of 1 cm. The thickness of the sirloin was determined using a depth gauge at the mid-section of the carcass, measured at the height of a straight line running from the lower edge of the pubic bone to the tangent of the cervical vertebrae, between the fifth and sixth ribs, with an accuracy of 0.1 cm. The thickness of the nape fat (also referred to as the mane flap or the nape fold) was measured at its thickest point, with an accuracy of 0.1 cm.

External (subcutaneous) fat disposition was assessed visually, assigning scores on a scale of 1–3 points (1 point indicating low fat and 3 points indicating strong fat). The color of the fat was rated on a scale of 1–5 points (1 point for a light cream color, 2 points for a cream color, 3 points for yellow, 4 points for yellowish-orange, and 5 points for orange). The cross-sectional area of the longest dorsal muscle was determined based on a tracing paper outline, which was made on the cross-section of the right half carcass between the last and penultimate thoracic vertebrae. The contour was measured with a planimeter three times, and the mean value in cm^2 was calculated (Table S2, go to the Supplementary Material).

The obtained half carcasses were cooled using the air-flow method and stored at a temperature of 0–4 °C. After 48 h of storage, the half carcasses were weighed to determine the cold half carcass weight.

Dissection was performed on the right half of the carcasses, during which the basic elements were cut out and subsequently divided into morphological components, i.e., meat, fat, bones, tendons, and blood meat.

The meat was divided into two classes: I—lean, nonsinewy meat and II—fatty, slightly sinewy meat. The blood meat was weighed and collected separately [44].

On the other hand, fat was categorized based on its location within the half carcass. The first group consisted of subcutaneous and intermuscular sebum, which was obtained during the division into basic elements and anatomical muscles. Intramuscular fat is situated in the perimysial space between the muscle fibers, while subcutaneous fat is located beneath the skin. The second group encompassed the cervical fat, which was removed in one piece from the half carcass before its division. The third group consisted of the perirenal tallow, lining the abdominal cavity. The percentage of each component in the carcass was determined based on its weight in relation to the weight of the cold half carcass. The meat-to-fat ratio was calculated as the weight of meat (kg) per 1 kg of fat, and the meat-to-bone ratio was calculated as the weight of meat (kg) per 1 kg of bone.

2.3. Methods of Meat Quality Assessment

The research material used to determine the quality of the meat consisted of samples of the *M. longissimus thoracis*, with each weighing approximately 700 g and taken from the level of the 13th–14th thoracic vertebrae. Subsequently, the external fat, connective tissue, and tendons were removed from the samples during the cleaning process. To determine the chemical composition of the horsemeat, the following components were analyzed: water content, protein content, fat content, and ash content.

The water content was determined in accordance with PN-ISO 1442:2000 [47]. The protein content was determined using the Kjeldahl method, according to which the measured nitrogen content was converted into the protein content in accordance with PN-75/A-04018 [48]. The fat content was determined using the Soxhlet method, following the recommendations of PN-ISO 1444:2000 [49]. The total ash content was determined in accordance with the guidelines contained in PN-ISO 936:2000 [50].

The sensory properties of horsemeat samples were evaluated as described by Baryłko-Pikielna and Matuszewska [51]. Briefly, 100 g samples were steamed at 95 °C until their internal temperature reached 80 ± 2 °C, as measured using a digital thermometer with a needle probe (Sous Vide Thermapen; MERA, Warsaw, Poland). Before the sensory evaluation, the samples were cooled down to 20 ± 2 °C and cut perpendicular to the fibers into 1.5 cm thick slices. These slices were stored in disposable plastic boxes with lids, individually coded, and offered in a random order to the evaluation panel, which consisted of six members (three males and three females, aged 26–46 years). These members were experienced in evaluating meat and its products. Each sample was assessed in triplicate by the panel. The sensory analysis was conducted by an evaluation team, who were tested for sensitivity and sensory fitness according to ISO 8586-2:2008 [52] and ISO 8587:2006 [53]. A five-point scale with defined value limits according to the sensory assessment chart (Table 1, Table S1, go to the Supplementary Material) was applied. The evaluation was conducted in a specific laboratory that met the relevant standard requirements [54]. Before testing each sample, the evaluators took a 30 s break and washed their mouths with mineral water. The evaluation was conducted across 10 sessions, and 12 samples were assessed in each session.

Table 1. Sensory assessment chart.

Pkt	Flavor	Juiciness	Tenderness	Tastiness
1	Very negative	Very dry	Very dry, very fibrous	Very negative
2	Negative	Dry	Hard, fibrous	Negative
3	Neutral	Slightly juicy	Slightly tender	Neutral
4	Desirable	Juicy	Tender	Desirable
5	Very desirable	Very juicy	Very tender	Very desirable

The pH of the cooled meat was determined using an OSH 12-01 electrode and a CPC-411 pH meter (produced by ELMETRON, Zabrze, Poland), with an accuracy of up to 0.01. The device was calibrated based on buffers with pH values of 4.00 and 7.00. The determinations were made directly in the meat at various time points: 15 min (pH_1) after slaughter, and then at 24, 48, 72, 96, and 120 h after slaughter. The pH was measured in the middle section of the harvested muscle.

Meat marbling was determined using the point method on a scale from 1 to 5 points, according to the standards of intramuscular fatness of beef (1 point—slight fatness, 2 points—small fatness, 3 points—medium fatness, 4 points—big fatness, and 5 points—strong fatness). This assessment was performed on a 1.5–2 cm thick slice of meat cut from the sample, in daylight, and in a location not exposed to direct sunlight [5,7,32,33]. Marbling was determined in the middle section of the harvested muscle.

To further determine the physicochemical characteristics, i.e., the thermal drip and water retention capacity, meat samples were minced twice in a laboratory wolf (HENDI, Warsaw, Poland) using sieves with holes of 4.0 mm in diameter. The obtained meat mass was mixed thoroughly to homogenize the sample.

Thermal drip was determined according to Janicki and Walczak [44]. The size of the thermal drip (20 g meat samples were subjected to heating in a water bath at a temperature of 85 °C for 10 min) was calculated according to the following equation:

$$\mathrm{Td}(\%)\frac{\mathrm{WI}-\mathrm{WII}}{\mathrm{WI}}\times 100\%$$

where Td refers to the thermal drip rate (%), WI refers to the weight of the sample before the heat treatment (g), and WII refers to the weight of the sample after cooling down (g).

To determine the water retention capacity of the meat, a ground sample (approximately 300 mg) was placed on Whatman No. 1 filter paper. The paper, along with the sample, was then inserted between two glass plates and subjected to a pressure of 2 kg for 5 min. After the designated extrusion time, the boundaries of the surface occupied by the meat sample and the drip of meat juice were outlined on the paper. These outlined areas were subsequently planimetered. The measure of the water retention capacity of the meat juice was determined by the difference between these two surfaces. This difference represented the water absorption of the meat in cm^2, with a higher value indicating lower water absorption by the meat.

2.4. Statistical Analyses

All experiments were performed in triplicate. All obtained results were segregated and subjected to statistical and mathematical calculations, yielding arithmetic means and standard error values. The data were verified for normality using the Kolmogorov–Smirnov test. The homogeneity of variance was verified using the Brown–Forsythe test. Tukey’s test was used to identify the significance of differences between the means in the groups at the 95% (α = 0.05) confidence level. Differences were considered significant if $p \leq 0.05$. To determine the significance of the influence of horse age on the characteristics of the slaughter value, the tissue composition of carcasses, and the quality of horsemeat, the method of one-way analysis of variance (ANOVA) was used. The significance of the differences between the means was determined using Tukey's post hoc HSD test for different numbers (ANOVA; STATISTICA v. 10; StatSoft, Krakow, Poland).

3. Results and Discussion

The age of an animal is one of the basic factors that influence the level of most traits related to the slaughter value of animals. It also determines the postslaughter yield, the tissue composition of carcasses, and the physical and chemical qualities of the raw material. This, in turn, differentiates the directions of the culinary and processing uses of meat [2,3,5,11,16,29,55,56]. Proper determination of an animal's slaughter value, in addition to its use in breeding work, is essential in the relationship between breeders/producers and meat plants in order to objectively determine the price for animals delivered for slaughter. The postslaughter evaluation of the slaughter value of horses is conducted based on detailed linear measurements, calculation of the slaughter yield index, and dissection with the separation of individual tissue components of the carcass. Horses exhibit significant differences in terms of slaughter value, and this depends on several factors that shape the quantity and quality of essential raw materials, namely, meat and fat. These factors primarily include performance type, sex, nutrition, and age. A higher preslaughter weight of horses positively affects the slaughter value of their carcasses. The slaughter value evolves as animals age, and the nature of these changes is a result of two physiological processes: growth and development. Growth is expressed by the increasing weight of the animal until it reaches physiological maturity. Development, on the other hand, can be defined as changes in the shape, structure, and function of individual tissues and organs. Development occurs concurrently with growth, and the achievement of maturity by the animal is a product of both these processes.

The evaluation of the slaughter quality of horses is based, among other factors, on the determination of the dressing percentage, the degree of muscularity, and the body fat content of the animals. Simplified and quick methods for this evaluation include mass measurements and linear measurements [5,44].

The results concerning the slaughter value of foals and other horses obtained in this research are presented in Table 2. The analysis of the dressing percentage showed that in all three age groups, a similar value of this feature was obtained, ranging from 63.6% to 67.2%. A higher dressing percentage was demonstrated in foals compared with old horses ($p \leq 0.05$). To compare the obtained results, one should cite the studies by Deskur and Doroszewski [57] and other authors [7,29–31,34], who obtained a lower dressing percentage of foals. The dressing percentage in foals, at the level of 67.2% shown in our research, was related to the live weight of the animals. The relationship between the live weight of animals and the dressing percentage index was also confirmed by the results of other studies [4,32,33]. A high dressing percentage in foals was demonstrated by other authors [6,11,58,59]. The decrease in dressing percentage with age/weight is usually associated with increases in noncarcass fat. Tomczyński et al. [35], in their study on the dressing percentage of adult horses, showed values for this index ranging from 52.1% to 62.8%. Taking into account the formation of the dressing percentage in horses in various age groups (3–7, 8–13, and 14–20 years), Zin et al. [7] found that this parameter was the lowest in the oldest group of horses, which amounted to 61.5%. This, in comparison with the results of our research, indicates a higher value of this parameter in older horses. Additionally, the study of Catalano and Martuzzi [32] indicates a higher dressing percentage of adult horses compared with the results of our study (60.0%). Manfredini et al. [30] also showed a higher level of this parameter compared with the results of our research, ranging from 59.8% to 60.9%.

Table 2. Slaughter value of horses depended on age.

Component	Group I (up to 2 Years Old)	Group II (from 2 to 10 Years Old)	Group III (from 10 to 20 Years Old)	p
Number (n)	12	14	14	
Age (Years)	$1.5^{c} \pm 0.5$	$7.5^{b} \pm 0.8$	$15.5^{a} \pm 0.6$	0.001
Warm carcass weight (kg)	188.16 ± 6.5	342.91 ± 12.55	381.60 ± 14.45	0.1
Cold carcass weight (kg)	186.28 ± 6.0	339.49 ± 11.67	377.79 ± 13.76	0.11
Dressing percentage, warm (%)	$67.2^{a} \pm 3.8$	64.7 ± 4.2	$63.6^{b} \pm 3.5$	0.03
Carcass length (cm)	$122.3^{b} \pm 5.1$	$145.8^{a} \pm 5.7$	$148.1^{a} \pm 4.9$	0.01
Carcass width (cm)	$65.3^{b} \pm 3.2$	$72.5^{a} \pm 3.2$	$73.7^{a} \pm 2.5$	0.034
Circumference of hind (cm)	$90.0^{b} \pm 5.1$	$102.3^{a} \pm 4.9$	$99.8^{a} \pm 4.6$	0.039
Hind length (cm)	$73.5^{b} \pm 4.4$	76.8 ± 3.9	$78.8^{a} \pm 3.1$	0.041
Sirloin thickness (cm)	$4.2^{b} \pm 0.5$	$5.6^{a} \pm 0.4$	$5.7^{a} \pm 0.5$	0.016
Nape fat thickness (cm)	$4.3^{b} \pm 0.4$	$8.0^{a} \pm 0.8$	$8.9^{a} \pm 0.4$	0.0018
External fat deposition (points)	$1.1^{b} \pm 0.2$	$1.9^{a} \pm 0.3$	$2.2^{a} \pm 0.3$	0.0029
Cross-sectional area of the longest dorsal muscle (cm^2)	$92.3^{c} \pm 7.5$	$115.1^{a} \pm 6.6$	$109.0^{b} \pm 6.4$	0.025

a, b, c: Means with different superscript letters in the same row differed significantly at $p \leq 0.05$; means with missing letters or having the same superscript letters in the same row did not significantly differ at $p \leq 0.05$.

The research results cited, along with our research, indicate higher values of the dressing percentage index for the breeds and utility types of horses used today. This increase is observed in both foals and older horses when compared with the results achieved in the 1980s and 1990s.

Additionally, our research (Table 2) showed statistically significant differences between the linear measurements of the carcasses of foals and adult horses. The analysis of these results showed that the foal half carcasses were significantly smaller compared with those of adult horses. This was a result of the lower anteslaughter weight and the weights of the obtained half carcasses. It can be assumed that the length of the carcass may have an impact on the preslaughter weight, while the weight of slaughtered animals significantly affected the increase in the cross-sectional area of the longest dorsal muscle and nape fat thickness. Therefore, it is believed that this factor affected not only the shape but also the musculature of the carcass, as well as the quantity of meat and fat obtained. On the other hand, the analysis of linear measurements in two groups of adult horses showed a great similarity in terms of their length and width. The study conducted by Litwińczuk et al. [4] showed a significant increase ($p \leq 0.05$) in the linear measurements of half carcasses of horses with the increase in the live weight of animals. Similar dependencies were demonstrated in the research conducted by Szmulik [32], where, in this case, as the slaughter weights increased, the length and width of the carcass, as well as the circumference and length of hind limbs, also increased.

Another feature that relates to the quality of the obtained slaughter material is its fat content. The results in Table 2 show that the amount of fat under the skin that covered the half carcass was significantly higher ($p \leq 0.05$) in adult horses compared with foals. The index increased from 1.1 points in foals to 1.9 in young horses and to 2.2 points in older horses. This evidence indicates that in foals, the external fat deposition on the carcasses was clearly the lowest. Similar relationships were found in the thickness of the nape fat between the foals and the other two groups of horses. In foals, this fold was 4.3 cm thick, while in the groups of young and old horses, it was significantly higher ($p \leq 0.05$), amounting to 8.0 and 8.9 cm, respectively. This distribution of results shows that the horses became increasingly fat with age, not only on the surface of the carcass but also in other parts of the body. The results presented in Table 3 confirm this relationship, indicating higher fat contents in the animals in groups II and III. The proportion of adipose tissue obtained after the dissection of adult horse half carcasses was significantly higher ($p \leq 0.05$) and amounted to 8.2 and 8.3%, respectively. In contrast, the lowest percentage of fat content was found in foals, at 4.1%. This distribution of results can be explained by the fact that the progressive development of each of the body's tissues with age is not uniform, but follows a certain regularity. This progression is expressed in the developmental sequence of individual tissues: nerve tissue develops first, followed by bone, then muscle, and finally fat. Hence, the proportions of the animal's body and the tissue components within it change with age. As the weight of a horse increases, especially after it reaches the age of 2–3 years, the adipose tissue grows more intensively, not only on the surface of the carcass but also in other parts of the body. In the case of horses aged 6–30 months, Martin-Rosset et al. [34] showed the total fat content to be at the level of 9.4% to 14.2%, which, compared with the results of our research, indicates much greater fatness of the horse half carcasses. A higher fat content in the half carcasses of foals aged 6–18 months, ranging from 12.84% to 19.98%, was also demonstrated by Palo et al. [11]. Campodoni et al. [59] showed a fat content of 16.43% in foals aged approximately 8 months. Additionally, in the study by Catalano and Martuzzi [36] involving foals (6–15 months) and adult horses, a higher fat content in the half carcasses was demonstrated at levels of approximately 9.6% and 13.4%, respectively.

Table 3. Tissue composition of horse carcasses and fat color in different age groups (%).

Component	Group I (up to 2 Years Old)	Group II (from 2 to 10 Years Old)	Group III (from 10 to 20 Years Old)	p
Total meat contents, namely:	69.6 ^{a} ± 8.8	68.2 ± 6.9	67.2 ^{b} ± 5.6	0.035
– →meat of class I $^{\#}$	39.7 ^{a} ± 3.1	37.6 ± 4.1	35.8 ^{b} ± 3.5	0.039
– →meat of class II $^{\#}$	29.9 ± 4.0	30.6 ± 3.9	31.4 ± 3.5	0.7
Total fat contents, namely:	4.1 ^{b} ± 1.6	8.2 ^{a} ± 2.1	8.3 ^{a} ± 2.2	0.0017
– →nape fat	0.6 ± 0.1	0.7 ± 0.1	0.8 ± 0.1	0.81
– →external and intramuscular fat deposit	2.1 ^{b} ± 0.8	4.8 ^{a} ± 1.1	4.7 ^{a} ± 1.0	0.0025
perirenal fat	1.4 ^{b} ± 0.3	2.7 ^{a} ± 0.7	2.8 ^{a} ± 0.8	0.0032
Content of bones and tendons	25.2 ^{a} ± 3.9	21.5 ^{b} ± 3.5	22.7 ^{b} ± 2.9	0.027
Content of bloody raw product	1.2 ^{a} ± 0.3	0.5 ^{b} ± 0.1	0.7 ^{b} ± 0.1	0.0031
Ratios:				
– →meat-to-fat	15.92 ^{a} ± 0.9	8.15 ^{b} ± 0.6	7.55 ^{b} ± 0.5	0.0029
– →meat-to-bone	2.50 ± 0.3	3.00 ± 0.3	2.76 ± 0.2	
Fat color (points)	1.5 ^{b} ± 0.3	3.1 ± 0.6	4.2 ^{a} ± 0.3	0.0021

a, b: Means with different superscript letters in the same row differed significantly at $p \leq 0.05$; means with missing letters or having the same superscript letters in the row did not significantly differ at $p \leq 0.05$. $^{\#}$ meat of class I—lean, nonsinewy meat; meat of class II—fatty, slightly sinewy meat.

The color of adipose tissue in the postmortem evaluation also plays an important role from both a technological and consumption perspective [5]. Deposits of subcutaneous and perirenal sebum present in horse carcasses are not valuable culinary or technological raw materials, while intramuscular fat contributes to the marbling of the horse and determines the juiciness and tenderness of the meat. Horse fat from young animals is generally white, and from older animals, especially those kept on pasture, it is intensely yellow due to the carotene contained in the grass. The color of the fat with increasing age takes on a yellowish or even orange shade. The amount of carotene in 100 g of horse fat ranges from 0.1 to 0.7 mg. The intensity of the color of the horse fat increases throughout the summer to a maximum in October, then gradually lightens to a minimum in May [5,37,39]. The distribution of the numerical value of this feature indicates that with increasing age of the animals, the color intensity of the fat covering the half carcass increased, reaching a yellowish-orange color in the group of old horses (4.2 points). The value of this feature in the case of young horses was assessed at 3.1 points, which should be interpreted as light yellow. The lightest color of adipose tissue was found in foals and it was defined as light cream (1.5 points). Statistically significant differences in the values of this feature were noted between the fat from the foal carcasses and that from the adult horse carcasses. The studies conducted by Zina et al. [7]

and Zina and Znamirowska [29] also showed a similar relationship between the age of the animal and the color of the adipose tissue. The aforementioned authors described the color of adipose tissue in the foal as light cream (1.89 points). On the other hand, the values of this feature in the case of carcasses obtained from adult animals aged 8–13 and 14–20 years were assessed at the levels of 3.06 points and 3.36 points, respectively, which can be interpreted qualitatively as yellow. The obtained figures show that the currently obtained half carcasses of horses, especially those from older animals (group III), were characterized by a noticeably darker color of fat compared with the samples studied by the cited authors.

Another indicator that allows for the assessment of the slaughter value and meatiness of a carcass is the measurement of the cross-sectional area of the longest dorsal muscle. For a long time, the cross-sectional area of the longissimus muscle has been considered a very good indicator of muscularity and fatness in livestock. As the cross-sectional area of the longissimus muscle increases, intramuscular fat also increases, which is important for the culinary value of meat. The correlation between the cross-sectional area of the longissimus dorsi muscle and the amount of meat in the basal cuttings was estimated to be relatively high. In group I, this index was 92.3 cm^2 and was lower ($p \leq 0.05$) than in group II (115.1 cm^2) and group III (109.0 cm^2). A similar size of the cross-sectional area of the longest dorsal muscle in foals, at the level of 91.6 cm^2, was demonstrated by Zin et al. [7], and Zin and Znamirowska [29]. These cited authors showed that in young horses aged 3–7 years, this index was higher, determined at the level of 96.0 cm^2. However, in the subsequent age groups, i.e., 8–13 and 14–20 years, the cross-sectional measurements of the longest dorsal muscle were lower than in young horses, amounting to 94.9 and 95.5 cm^2, respectively. On the other hand, Litwińczuk et al. [4] showed a significant increase in the cross-sectional area of the longest dorsal muscle in horses aged 10 years (±3.7), correlating with an increase in the live weight of the horses. It is noteworthy that, in all of the cited studies, the results concerning the cross-sectional area of the longest dorsal muscle in the case of adult horses were lower compared with the results of our research on this feature.

The tissue composition of a carcass is an important indicator that determines the quality of a carcass, and it changes as the weight of the animal increases. As the weight of the animal continues to increase, the percentage of fat increases, while the percentage of meat and bone decreases significantly. The slaughter value of an animal is determined primarily by the main slaughter raw materials, namely, meat and fat. The higher the percentage of an animal's body weight, the higher its slaughter value. Meat is the raw material of particularly high value and consumer preference. Ideally, the percentage of bone should be as low as possible. An important feature in assessing the slaughter value of horses is the percentage of meatiness. The highest content of this tissue was found in foal carcasses, where the meat content was 69.6% (Table 3). In contrast, in carcasses obtained from older horses, a decrease ($p \leq 0.05$) in meat content to 67.2% was observed. In other studies, Zin et al. [7] and Zin and Znamirowska [29] reported the meatiness of foals to be approximately 60.0%. In the remaining age groups, the amount of the obtained raw material, in terms of percentage, was lower in the research carried out by these cited authors. Specifically, 59.1% of meat was obtained from young horses aged 3–7 years, while 55.4% of this raw material was obtained from the oldest horses aged 14–20 years. Martin-Rosset et al. [34], depending on the age of foals (6–24 months), reported a meat content ranging from 57.4% to 64.9%. The results of studies by other authors [36,58,59] indicate a lower meat content in foal half carcasses in comparison with the results of our study (63.68–69.3%). The analysis of the results of our research on the meatiness of horse half carcasses shows that compared with the results of the research obtained in the 1980s and 1990s, the value of the studied feature increased. On the other hand, considering the tissue composition of the studied animals at the beginning of the 21st century, Lorenzo et al. [10] showed mean values of 69.6% muscle, 10.4% fat, and 17.4% bone in the tissue composition of horse carcasses. These numerical values suggest that horse half carcasses were highly fleshy compared with our research, where the meat content of 69.6% was obtained only from foal half carcasses. In the case of adult horses, the amount of meat obtained was slightly lower. However, these values indicate a lower proportion of adipose tissue compared with the results of the previously cited authors.

Even more important information about the quality of the obtained raw material is provided by the analysis of the results concerning the yield of meat tissue in individual quality classes (Table 3). The carcasses of foals provided the highest amount of meat in class I compared with carcasses from old horses ($p \leq 0.05$). This suggests that the amount of high-quality horsemeat in the carcass (class I meat) is strongly influenced by the age of the animal. The presented results also show that as animals age, the amount of class II horsemeat, which is sinewy and harder, clearly increases; however, the differences were not statistically significant. As animals age, not only does the quantity of muscle tissue change but so does its quality, which determines the nutritional value. This change is largely related to the properties of muscle fibers. Their number throughout the body is genetically determined and is essentially fixed at the birth of the animal. With the development and growth of the organism, only the width and length of the fibers increase, reaching their maximum size, which is typical of the breed, species, and even the individual at maturity. However, the achievement of maximum fiber size depends on the nutritional status of the animal. As the animal ages, the number of muscle fibers decreases, which is compensated, to some extent, by an increase in their thickness.

More detailed information about the slaughter value of the tested animals is provided by the analysis of the ratio of meat to fat and bone. The data in Table 3 show that in the carcasses of foals, 1 kg of fat has an average of −15.92 kg of meat, and 1 kg of bone has an average of 2.50 kg of meat. The first index is very important in this analysis, as it confirmed the higher ($p \leq 0.05$) dietary value of foal carcasses in comparison with those of adult horses. In the carcasses of adult horses, unfavorable results regarding the ratio of meat to fat and bone were observed, as these ratios were respectively 8.15 and 3.00 for carcasses of adult horses and 7.55 and 2.76 for carcasses of older horses. As the weight of the animal progressively increased, changes in the meat-to-bone ratio were also observed. For example, a 10 kg increase in the weight of a cattle carcass increased the meat-to-bone ratio by 0.031 [44].

The decisive factor in the chemical composition of horsemeat was the age of the animal [7,33]. National studies conducted by Deskur and Doroszewski [38] and Zina and Znamirowska [39] indicated that foal meat is characterized by a high content of protein (ranging from 21.16% to 22.44%) and water (ranging from 73.05% to 75.51%) and a low amount of fat (ranging from 0.86% to 2.0%). In other studies, the following numerical values were presented to characterize the basic chemical composition of the longest dorsal muscle: dry matter content ranging from 25.47% to 27.52%, water content ranging from 72.48% to 74.53%, protein content ranging from 19.94% to 22.50%, and fat content ranging from 1.56% to 4.65% [57]. On the other hand, Tomczyński [60] states that foal meat is characterized by a protein content ranging from 12.8% to 21.4% and a fat content ranging from 3.7% to 6.2%.

According to many authors, as horses age, their meat contains decreasing amounts of water, with increasing amounts of fat and minerals [5,29,37,61,62]. Korzeniowski et al. [37] reported that the water content in horsemeat is 74.1%, protein content is 21.5%, and fat content is 2.6%.

The results of the chemical composition analysis of the meat of foals, as well as young and old horses, are presented in Table 4. The meat of young animals generally contains less protein and fat and more water compared with the meat from older animals. This fact was confirmed by the study presented in this paper. Statistically significant differences were observed depending on the age of the horses, specifically in relation to water, protein, and fat contents. It should be noted that the highest ($p \leq 0.05$) water content in the meat was found in foals (76.38%) and young horses (72.99%) compared with the meat of old horses (70.94%). The highest ($p \leq 0.05$) protein content was found in the groups of adult horses compared with group I. The amount of fat in the meat increased statistically significantly with the age of the horses. However, no statistically significant differences were found between age and ash content. The level of this component ranged from 1.01% (group II) to 1.19% (group III). The obtained distribution of numerical values confirmed the generally occurring regularity that with the age of horses (especially after 2–3 years), muscle tissue grows more intensively, and only later does fat tissue grow, which causes a simultaneous decrease in the amount of water in the meat in favor of the protein and fat content of this raw material.

Table 4. Chemical composition of horsemeat depended on age (%).

Component	Group I (up to 2 Years Old)	Group II (from 2 to 10 Years Old)	Group III (from 10 to 20 Years Old)	*p*
Water content	$76.38^{a} \pm 1.56$	$72.99^{b} \pm 1.13$	$70.94^{c} \pm 1.05$	0.016
Protein content	$20.02^{c} \pm 0.68$	$21.57^{b} \pm 0.45$	$21.99^{a} \pm 0.25$	0.035
Fat content	$2.55^{c} \pm 0.24$	$4.29^{b} \pm 0.35$	$5.54^{a} \pm 0.32$	0.0016
Ash content	1.01 ± 0.04	1.06 ± 0.02	1.19 ± 0.03	0.9

a, b, c: Means with different superscript letters in the same row differed significantly at $p \leq 0.05$; means with missing letters or having the same superscript letters in the same row did not significantly differ at $p \leq 0.05$.

Taking into account the chemical composition of horses in different age groups, a higher intramuscular fat (IMF) content in the meat of foals should be noted in the studies by Sarriés and Beriain [6] and Tateo et al. [13]. In these studies, the cited authors showed the content of the analyzed component in the range from 3.1% to 4.23%. However, numerous research results [8,63–65] indicate the content of IMF in the meat of foals ranges from 0.1% to 0.36%; Lanza et al. [64] and Juárez et al. [1] showed a similar fat content in the meat of foals compared with the results of these studies. On the other hand, in the case of the meat of adult horses aged 6–10 years, Badiani et al. [65] showed a higher content of intermuscular fat at the level of 6.63%.

Numerous studies [8–10,14,21–23,63] indicated that horsemeat is characterized by a high protein content (22.5%) and a low fat content (2.9%). Compared with the results of our research, these findings indicate a higher protein content and a lower fat content. When considering the protein content in foal meat, numerous studies [1,6,8,13,15,63,66,67] also suggested a higher content of this component in the analyzed raw material.

The demonstrated mean water content in foal meat, at the level of 76.38%, was higher compared with the studies by Franco et al. [8], who showed the content of this component at 75.43%, and other authors [1,6,13,15], who, in the meat of foals aged 15–24 months, reported a water content ranging from 68.34% to 75.43%. Taking into account the water content in the meat of adult horses aged 3–5 years, Badiani et al. [65] showed the content of this component at the level of 70.9%, which suggests a lower content of this component compared with the results of our research.

Data on the sensory evaluation of heat-treated horsemeat are presented in Table 5. Raw meat is a source of flavor precursors, and only to a small extent of flavor and aroma-active compounds. It is characterized by a taste reminiscent of rawness, similar to the taste of blood. The odor of raw meat is faint, resembling that of industrial lactic acid. In the case of horsemeat, the glycogen content of muscle tissue, at 0.9%, gives the horsemeat a typically sweet taste, which is unfortunately perceived as a significant disadvantage from the consumer's point of view. Muscle tissue is a carrier of flavor precursors that react chemically with each other during thermal processing to form positive, yet differentiated, flavor compounds [68–70]. It should be noted that during the postslaughter maturation of meat, the postslaughter transformations of nucleotides, carbohydrates, proteins, and fats lead to the formation of precursors and even flavor and aroma substances. These include inosinic acid, glucose, inorganic phosphates, lactic acid, free amino acids, free fatty acids, ammonia, electrolytes, and others [69].

Table 5. Sensory properties of horsemeat depended on age (point).

Component	Group I (up to 2 Years Old)	Group II (from 2 to 10 Years Old)	Group III (from 10 to 20 Years Old)	p
Flavor	$3.09^{a} \pm 0.26$	$2.92^{b} \pm 0.22$	$2.90^{b} \pm 0.23$	0.026
Juiciness	$3.25^{a} \pm 0.50$	$3.02^{b} \pm 0.35$	$3.02^{b} \pm 0.38$	0.029
Tenderness	$3.09^{a} \pm 0.33$	$2.88^{b} \pm 0.47$	$2.82^{b} \pm 0.33$	0.031
Tastiness	$4.15^{a} \pm 0.25$	3.98 ± 0.34	$3.95^{b} \pm 0.35$	0.039

a, b: Means with different superscript letters in the same row differed significantly at $p \leq 0.05$; means missing letters or having the same superscript letters in the same row did not significantly differ at $p \leq 0.05$.

Based on the research, it is evident that the sensory quality of horsemeat clearly depended on the age of the slaughtered animals. The foal meat obtained higher ($p \leq 0.05$) point values for all assessed characteristics. The meat obtained from the carcasses of older animals exhibited worse sensory features, with the assigned numerical values for individual features systematically decreasing with age.

In all age groups of animals, the smell of horsemeat was assessed as neutral. Moreover, the raw material was assessed as slightly juicy. Juiciness, which is perceived as the dryness or moistness of the product, is among the characteristics that shape a consumer's sensory evaluation. A positive assessment of juiciness is characterized by meat that is sufficiently moist. The moisture content of meat is influenced by many factors, mainly the water content. It can be assumed that the high water content in foal meat positively influences the perceived juiciness of the tested raw material, which is supported by the higher scores for juiciness assigned to meat samples from foals. The tenderness of the foal meat, as well as meat obtained from the carcasses of young and old horses, could be interpreted qualitatively as somewhat tender, as the score values for this feature ranged between 3.09 and 2.82 points. The age of an animal plays a special role in shaping the tenderness of its muscle tissue. The changes accompanying growth and development render the meat of young individuals more tender than that of older ones. Young animals, due to their relatively thin muscle fibers, are characterized by higher tenderness than older animals. This is attributed, on one hand, to the enlargement of the size of the fibers and the production of thicker bundles of fibers, resulting in greater "meat granularity." On the other hand, changes in the nature of the muscle connective tissue also play a significant role. In addition, an important element that should be paid attention to is the maturity of collagen and its ability to dissolve. With age, the nature of connective tissue changes, as collagen undergoes so-called aging. This involves changes in its structure, which are reflected by a decrease in solubility. In mature and older animals, collagen plays the most important role in shaping the tenderness of the meat.

The tastiness in group I was estimated at 4.15 points, which should be interpreted as desirable. In contrast, the tastiness in the remaining age groups was defined as intermediate between neutral and desirable, with scores of 3.98 points and 3.95 points, respectively. The tastiness of meat is determined by its pH. At higher pH levels, meat exhibits a less intense flavor and aroma, appears less salty, and is perceived as less tasty than at lower pH values in analogous muscles of the same animal. Higher meat pH values are associated with better water absorption and stronger water binding. Flavor precursors dissolved in water are more difficult to release when the meat is chewed, which affects the sensory evaluation of the tested raw material. This is reflected in the lower scores for meat from the oldest animals in terms of the taste and smell of the tested raw material.

It was observed that as the age of the animal increases, there is a tendency to receive a lower score for individual qualitative characteristics in the sensory evaluation. Such a distribution of results shows the significant influence of the animals' age on the sensory quality of the obtained samples.

Pérez et al. [40], in conducting a sensory evaluation of horsemeat using a 10 cm nonstructured scale, reported tenderness at a level of 2.000 cm. The numerical values recorded for juiciness and smell were 3.708 and 5.160 cm, respectively.

Among the many postslaughter factors that determine meat quality, active acidity plays an important role. The acidity of meat is one of the most practical and objective indicators for determining the rate of changes occurring in meat. Moreover, the level of this feature dictates the degree of advancement of the raw material's maturation process. It influences the meat's color, water absorption, tenderness, taste, and durability, thereby shaping the properties that determine its technological and culinary suitability [71,72].

The data obtained in our research on the acidity of the foal meat and other age groups of horses are presented in Table 6. The analysis of the pH measurement results shows that foal meat had the lowest pH (6.73) 45 min after slaughter. This decreased to a value of 5.24 after 48 h of cold storage. In the following days, it remained at a similar level, indicating that this raw material is a durable product suitable for longer storage. The final pH of the foal meat was 5.35 after 120 h. This indicates a long period of maturation and suggests the possibility of further storage if necessary. Statistically significant differences were observed between the pH of foal meat and horsemeat from the third age group. It should be noted that the course of glycolytic processes was similar in all age groups: rapid and substantial decreases in the pH value of the meat during the first few days, and then maintaining this level for an extended period (120 h). Only in foal meat were these changes observed at a slightly lower level. It should be highlighted that the low pH (5.35–5.48) in all age groups of horses indicates that the maturation process had not yet been fully completed, allowing for this raw material to still be stored under refrigeration conditions. For this reason, horsemeat is considered a raw material with a high shelf life. The obtained distribution of results was influenced by the high glycogen content of the horsemeat, which is associated with long-lasting acidification inside the muscles. This is due to the course of anaerobic glycolysis, the final product of which is lactic acid, causing a decrease in the pH of muscle tissue. Unlike meat from other animal species, horsemeat is characterized by a high glycogen content. The results obtained in this study also confirmed the general regularities of glycolytic transformations occurring in muscle tissue; in meat obtained from older animals, the progress of postslaughter maturation processes is slower than in younger animals. It is known that the factors that affect the rate and extent of postslaughter metabolism include the age and weight of the horses. The muscles of horses with lower body weights are generally characterized by a higher glycogen content, while horses with higher body weights have a lower reserve of this compound. Therefore, as a consequence of the postslaughter metabolism, the muscles of horses with lower body weights are characterized by a higher lactic acid content and a more rapid decrease in pH value. In contrast, horses with higher body weights have a lower amount of this compound. The results of this study align with those of other Polish studies, which also confirmed the high initial pH value of horsemeat. Znamirowska [5] and Znamirowska and Stanisławczyk [73] reported high pH values of meat obtained from foals. Lorenzo et al. [59], in the case of foal meat aged for 6–7 months, determined the longissimus dorsi acidity (LD) 24 h after slaughter to be 5.59. Litwińczuk et al. [74], in the case of samples from the *Longissimus dorsi* (*Longissimus lumborum* section (LL)) and semitendinosus (ST) muscles obtained from half carcasses of horses aged an average of 10 years, obtained pH1 (45 min after slaughter) values of 6.79 and 6.73, respectively. In turn, Pérez et al. [40], in the case of *M. Biceps femoris* muscles obtained from postrigor horse half carcasses (24 h after slaughter), showed the acidity of the meat to be at the level of 5.72.

Table 6. Physicochemical properties of horsemeat depended on age.

Component	Group I (up to 2 Years Old)	Group II (from 2 to 10 Years Old)	Group III (from 10 to 20 Years Old)	p
pH_1	$6.73^{b} \pm 0.11$	6.78 ± 0.13	$6.84^{a} \pm 0.10$	0.028
pH_{24}	$5.46^{b} \pm 0.09$	5.51 ± 0.08	$5.63^{a} \pm 0.13$	0.017
pH_{48}	$5.24^{b} \pm 0.12$	5.40 ± 0.12	$5.42^{a} \pm 0.15$	0.019
pH_{72}	$5.31^{b} \pm 0.06$	5.36 ± 0.10	$5.46^{a} \pm 0.13$	0.024
pH_{96}	$5.34^{b} \pm 0.10$	5.44 ± 0.11	$5.48^{a} \pm 0.09$	0.021
pH_{120}	$5.35^{b} \pm 0.09$	5.46 ± 0.12	$5.48^{a} \pm 0.10$	0.026
Marbling (point)	$1.65^{b} \pm 0.38$	$2.68^{a} \pm 0.28$	$2.81^{a} \pm 0.33$	0.008
Thermal drip (%)	$32.09^{a} \pm 2.47$	$30.99^{b} \pm 2.84$	$29.56^{b} \pm 2.93$	0.019
Water retention capacity (cm^2)	$7.14^{a} \pm 0.47$	$5.81^{b} \pm 0.72$	$4.96^{b} \pm 0.64$	0.025

a, b: Means with different superscript letters in the same row differed significantly at $p \leq 0.05$; means with missing letters or the same superscript letters in the same row did not differ significantly at $p \leq 0.05$.

Horsemeat marbling has rarely been considered in meat studies, as it can be observed only in horses characterized by good fattening conditions [5,7,32,33]. In this respect, horsemeat is distinctive because it has muscle fibers intertwined with easily meltable fatty tissue that has a soft consistency and a cream color. In the case of young horses (up to 2 years old), the muscle fibers are thin, delicate, and interspersed with adipose tissue, which ultimately imparts the often-desired marbling effect [5,75,76]. As horses age, there is intensive development of adipose tissue. This tissue is characterized by a specific development pattern that depends on the location and develops according to the following sequence: perirenal fat, intermuscular fat, subcutaneous fat, and intramuscular fat. The latter is particularly preferred since the tenderness of meat is, in part, dependent on the content of intramuscular fat, which is precisely referred to as marbling. As the amount of intramuscular fat in the meat increases, the overall fat content of the carcass increases markedly. This results in a decrease in the proportion of muscle, which is a fact that was confirmed by the research presented in this paper. The numerical values in Table 6 indicate that on a five-point scale, the horsemeat marbling ranged from 1.65 to 2.81 points, and it increased with age. However, a statistically significant difference in the marbling of the horsemeat was found only between foals and adults ($p \leq 0.05$). Such correlations were to be expected, as a general increase in carcass fat content with horse age increases marbling. It is important to note that marbling also influences the brightness and color of the samples, as well as their tenderness and juiciness. Given the marbling of the meat, intensive fattening and an increase in the energy value of the diet at the end of the fattening period lead to stronger fattening of the carcass. This, in turn, improves the marbling of the meat and, consequently, enhances several sensory characteristics of the muscle tissue.

The physical and chemical properties of each meat type depend on its hydration properties, as these affect the juiciness of cooked meat. These specific properties of meat depend on protein fractions, and the interactions of myofibrillar proteins with water are particularly important. They influence, among others, the solubility, the ability to bind and retain water, and the preservation of protein functions during heat treatment at both high and low temperatures [5,77]. It should be noted that water in the muscle is maintained by muscle proteins and is immobilized in the capillary spaces of the muscle.

According to the literature [56,78], immediately after slaughter, meat with a high content of ATP and glycogen shows the highest water retention capacity, which is associated with the high pH level of the muscle tissue. The effect of pH on the hydration properties of meat is explained by the change in the isoelectric point of proteins, which results from the interplay of dissimilar charges. As the environment gradually acidifies, calcium, magnesium, and other ion complexes dissociate from proteins. This significantly reduces the water absorption capacity and solubility of proteins [56]. This fact was confirmed by our research. Based on the results presented in Table 6, the foal meat was characterized by the greatest thermal and water retention capacity. The first of these characteristics was at the level of 32.09%, and the second was at the level of 7.14 cm^2. Considering the results presented in Table 6, it is clear that the thermal and water retention capacity of the meat stored in refrigerated conditions depended on the age of the slaughtered horses. The raw material obtained from animals in the second age group was characterized by lower thermal drip (30.99%) and water retention capacity (5.81 cm^2) compared with the foal meat. As age increased, these characteristics clearly and systematically decreased, producing the following values in the group of old horses: thermal drip of 29.56% and water retention capacity of 4.96 cm^2. It should be noted that the foal meat had the significantly lowest water retention capacity, while the meat obtained from the carcasses of the oldest horses had the highest. The resulting distribution of results was most likely influenced by the progressive increase in preslaughter weight with horse age and the increasing diameter of muscle fibers, which may have had a beneficial effect on the water absorption of fresh meat. The intrinsic water-holding capacity (WHC), which is defined as the forced leakage of meat juice, is a criterion that informs about the technological quality of meat. It is well known that the ability of tissue to retain water is highly dependent on the pH, the functional state of muscle proteins, and muscle conformation. The acidity of all analyzed horsemeat samples was normal and did not reveal any changes in protein degradation.

Lorenzo et al. [63] reported that in the case of foal meat aged for 6–7 months, the thermal drip was at the level of 19.25%. Kwiatkowska [79] showed that 24 h after slaughter, at a temperature of 4 °C, the thermal drip from horse muscles (*L. dorsi*) was 30.9%.

According to Razmaité et al. [80] further additional investigations of age and other factors on meat quality from horses are needed. The obtained information can be used to increase the diversity in meat production and consumption, and it provides new insights for research on the usage of horses. It will be a step toward the development and utilization of horses.

4. Conclusions

In Poland, the ages of horses used for meat production results in a large variety of raw materials obtained. The horses used today are characterized by a much lower degree of fat deposition in half carcasses compared with those from the 1980s and 1990s. They also have a higher dressing percentage index and increased carcass meatiness. However, confirmation of these observations requires further studies involving a larger number of animals. The ages of the horses significantly influenced the chemical composition of the meat, as well as the physicochemical and sensory properties of the tested horsemeat samples. As a result, the findings from these studies may contribute to a broader acceptance and consumption of horsemeat. This could be a major advantage, highlighting the potential nutritional and health aspects of horsemeat, especially for gourmets of such products. Poland, as an exporter of horsemeat and with access to high-quality raw material, is well-positioned to meet the standards and expectations of importing countries where horsemeat is a preferred choice among consumers. With consumer interest in the quality of meat and its impact on health in mind, it is worth noting that horsemeat derived from modern horses aligns well with contemporary consumer trends due to its low fat content and high protein content.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app132011293/s1, Table S1: A five-point scale with defined value limits according to the sensory assessment chart; Table S2: The contour measurement with a planimeter; Table S3: Additional information on the classes of conformation and fat cover of horses carcasses.

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