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EFFECT OF MATURING PROCESS ON CHANGES IN PHYSICO-CHEMICAL PROPERTIES OF COLT MEAT

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Summary. The paper had the objective of determining the physicochemical parameters of colt meat during a five-day long cold storage, tantamount to its turnover period to, or time of its reaching, the western-European countries. Samples of the longest dorsal muscle from 29 colts 1.5-2 years old, from commercial breeding were investigated. Colt meat is characterized by high content of water and protein and low content of fat. That meat requires a longer period for 'maturing' and, with its value pH, indicates a potential for storage in cold condition for at least five days. Moreover, a five day maturing of colt meat in cold storage raises its water holding capacity, usability for processing and improves meat tenderness, as well as causes a dramatic darkening of meat color.

Key words: colt meat, meat quality

INTRODUCTION

Colts constitute approx. 10% of the total slaughter horse supply and provide the most valuable raw meat variety, destined mostly for export in form of half carcasses or meat portions [Segato et al. 1999, Zin and Wojciechowski 1998, Zin and Znamirowska 2001].

Colt meat meets a tremendous interest in Italy, France and Belgium, where consumers prefer colt meat to other meat varieties [Arcos-Garcia et al. 2001, Badiani et al. 1993, Hertrampf 2003, Martuzzi et al. 2001]. On average, colt half carcasses contain 71% of meat, approx. 10% of fat and 19% of bones. A higher content of tallow in colt half carcasses was shown by Catalano and Martuzzi [1986] who found 9.5% of fat in carcasses of 15-month-old colts. A high meat yield from colt carcasses was achieved in Italy, where it was reported at the level of 68.3% to 71.8% [Campodoni et al. 1994, Badiani et al. 1994, Manfredini and Badiani 1993, Manfredini et al. 1992].

The share of forequarters and hindquarters was 55.09% and 44.91%, respectively, compared to the whole half carcass [Deskur and Doroszewski 1966].

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Colt meat is highly appreciated for its taste and other consumption qualities, while low content of fat makes it a dietetic food [Paleari et al. 2003]. Moreover, as reported in the relevant literature [Tomczyński 1982], it exhibits also a satisfactory water holding capacity, good juiciness and light color. Colt meat has a full composition of essential amino acids, surpassing beef in respect of lysine, leucine, tryptophan, phenylalanine and methionine contents [Arcos-Garcia et al. 2001, Deskur and Doroszewski 1972, Palenik et al. 1980].

Colt meat is a valuable Polish export raw product to western European countries. Therefore, the objective of this paper was to determine the physicochemical parameters of that meat quality during its five-day long cold storage, tantamount to its turnover period.

MATERIAL AND METHODS

The study was performed on the premises of horse slaughter plant that is authorized for export deliveries to the EU and in the laboratory of the Department of Agricultural Processing and Commodity Science. Twenty nine 1.5-2 year old colts from commercial breeding were examined. The (pH_1) reaction was measured on the process line 45 minutes after slaughter, with the ESAgl-307W electrode and the Elmetron-Poland microcomputer pH/ION METER CI-316, on the longest dorsal muscle. The measurement was repeated in meat samples every 24 hours. In order to carry out further determinations of physicochemical characteristics of meat at the time of dissection (24 hours after slaughter), samples of 700 g were taken from the area of the longest dorsal muscle (*m. longissimus dorsi*) at the height of the 12-14th thoracic vertebra. Samples were cold stored (at the temperature of 6°C). Meat used for the determinations was cleaned from external fat, connective tissue and sinews.

Water content was determined in accordance with the PN-ISO 1442:2000 [2000] standard. Protein was determined with the Kjedahl method, where the determined value of nitrogen is recalculated to protein according to PN-75/A-04018 [1975] Polish standard. Fat content was determined with the Soxhlet method, as per recommendations in the PN-ISO 1444:2000 [2000] Polish standard, and total ash was determined according to guidelines in PN-ISO 936:2000 [2000].

Meat color was assessed by a score-point method according to masters supplied by Soicarnia, Italy, in a scale from 4 to 8 points (4 score points – for light pink meat, 8 points – for dark red or brown meat). Then, color lightness was also measured (in % of reflection) using the 'Spekol' spectrophotometer with R45/0 reflection attachment at the wavelength of 730 nm [Zin and Znamirowska 2001].

The tenderness of raw meat was determined with 'tenderness meter' (produced by Graf WMP, Poznań), which is an improved and modified version of the Warner-Bratzler shear force instrument [Tyszkiewicz 1969]. Meat marbling was determined by score point method in a scale from 1 to 5 points, in accordance with the beef intramuscular fattening standards.

In order to perform consecutive determinations of physicochemical characteristics i.e. those of water holding capacity and thermal drip, meat samples were minced twice in laboratory grinder and passed through sieve holes of 2.0 mm. Obtained meat mass was mixed thoroughly to homogenize the sample. Water holding capacity (WHC) was

determined according to Grau and Hamm method [1953] by modification Pohja and Niinivaara [1957]. Thermal drip was determined with the Walczak method [1959], in which meat sample was subjected to thermal treatment at the temperature of 85°C for 10 minutes.

Statistical processing was carried out on the basis of the STATISTICA program, version 6.0 [Woźniak 2002].

RESULTS

Table 1 shows the results on physicochemical characteristics of colt meat. The chemical composition of colt meat exhibits high content of water (74.51%) and protein (21.44%) and low content of fat (2.57%). Similar chemical composition was obtained by Deskur and Doroszewski [1972], namely 73.50-75.12%, 21.54-22.16% and 0.86--2.00% for water, protein and fat, respectively. A higher content of protein (22.96%) in meat of cold-blooded young stallions was obtained by Tomczyński [1982] after using various fodder combinations.

Process of changes occurring in that raw meat after slaughter is best reflected with the analysis of active acidity values. Forty five minutes after slaughter, the average pH was found at 6.75. Its value decreased over a further period of cold aging of cooling meat and reached a similar lowest level of values at 48 and 72 hours after slaughter (pH_{48} = 5.33, pH_{72} = 5.32). Final pH after 120 hours of the studied cold aging process was still very low, as it reached the mean value of 5.39. These results show that colt meat requires long 'maturing' period and, if the pH is taken into account, they indicate a possibility of further storage.

The pH of colt meat was also measured for two days after slaughter by Tomczyński [1982], who found the lowest pH at 48 after slaughter. However, as he admits, his results (5.62-5.72) in that study were affected by long transportation. That is why pH assumed higher values than those obtained by us here.

Meat color was estimated visually, as well as with instruments. Twenty four hours after slaughter the studied meat exhibited pink color (score: 4.98 points), after one more day its color darkened slightly (score: 5.50 points), to reach dark red color (6.23 points) after five days. That visual assessment was confirmed by instrumental measurement of color lightness; the respective values were: 32.50%, 25.53% and 23.37%. These results indicate that, as colt meat underwent oxidation of myoglobin, its color darkened.

It is commonly known that meat color depends mainly on the quantity of myoglobin and on percentage of its fraction during meat maturing process. That is why color undergoes changes during cold storage and it is a resultant of red (Mb), light red (MbO_2) and brown (MMb) color, depending on oxygen availability [Krala 2001, Kwiatkowska 2002]. The myoglobin content in horsemeat is very high compared to other meat types [Korzeniowski et al. 1999] whereas there are no research results on myoglobin levels in colt meat. However, if the visual and instrumental assessment of color lightness is taken into account, it is obvious to assume that the myoglobin content is high, if meat obtained of animals so young is dark colored, like that of beef [Zin et al. 1999].

The tenderness of colt meat (meat not subjected to thermal processing) was found as least favorable 24 hrs after slaughter (68.64 $N \cdot cm^{-2}$). The following 24 hrs of colt meat maturing caused an improvement of its tenderness and reduced the value of force

Table 1. Physico-chemical properties of colt meat (n = 29)
Tabela 1. Właściwości fizykochemiczne mięsa źrebiąt (n = 29)

Meat properties – Właściwości mięsa	Average Średnia	Standard deviation Odchylenie standardowe
pH_1	6.75	0.30
pH_{24}	5.51	0.06
pH_{48}	5.33	0.12
pH_{72}	5.32	0.10
pH_{96}	5.37	0.09
pH_{120}	5.39	0.09
Tenderness after 24 hrs, $N \cdot cm^{-2}$ – Kruchość po 24 h, $N \cdot cm^{-2}$	68.64	13.44
Tenderness after 48 hrs, $N \cdot cm^{-2}$ – Kruchość po 48 h, $N \cdot cm^{-2}$	52.12	13.05
Tenderness after 120 hrs, $N \cdot cm^{-2}$ – Kruchość po 120 h, $N \cdot cm^{-2}$	48.28	10.17
Thermal drip after 24 hrs, % – Wyciek termiczny po 24 h, %	31.68	3.71
Thermal drip after 48 hrs, % – Wyciek termiczny po 48 h, %	34.05	2.67
Thermal drip after 120 hrs, % – Wyciek termiczny po 120 h, %	29.02	2.47
Water holding capacity after 24 hrs, % – Zdolność utrzymywania wody po 24h, %	16.50	5.00
Water holding capacity after 48 hrs, % – Zdolność utrzymywania wody po 48 h, %	24.76	4.90
Water holding capacity after 120 hrs, % – Zdolność utrzymywania wody po 120 h, %	23.80	4.73
Color lightness after 24 hrs, % – Jasność barwy po 24 h, %	23.37	1.50
Color lightness after 48 hrs, % – Jasność barwy po 48 h, %	25.53	4.48
Color lightness after 120 hrs, % – Jasność barwy po 120 h, %	32.50	6.15
Color after 24 hrs, points – Barwa po 24 h, pkt	4.98	0.55
Color after 48 hrs, points – Barwa po 48 h, pkt	5.50	0.66
Color after 120 hrs, points – Barwa po 120 h, pkt	6.23	0.48
Marbling, points – Marmurkowatość, pkt	1.67	0.68
Water, % – Woda, %	74.51	1.81
Protein, % – Białko, %	21.44	0.42
Fat, % – Tłuszcz, %	2.57	0.25
Ash, % – Popiół, %	1.00	0.03

necessary to cut/shear the sample by as much as 16.52 $N \cdot cm^{-2}$, whereas extending of maturing period to five days reduced the cutting/shear force by 20.36 $N \cdot cm^{-2}$, compared to tenderness determined at 24 hours after slaughter.

Such distribution of results is connected with pH staying at low levels, i.e. the high content of lactic acid which affects the transformations taking place in muscle proteins and improves the tenderness as well as collagen solubility [Korzeniowski et al. 1991, Korzeniowski et al. 1998, Kwiatkowska 2002, Perez-Chabela and Escalona-Buendia 2003, Pospiech et al. 2003, Wetanabe et al. 1996].

It is evidenced by a significant correlation (Table 2) between pH_{48} and the tenderness obtained 48 hours after slaughter ($r = 0.66$, $P \leq 0.05$), as well as between pH_{120} and the tenderness determined after 120 hours ($r = 0.72$, $P \leq 0.05$).

Table 2. Correlation coefficients (n = 29)
Tabela 2. Współczynniki korelacji (n = 29)

	pH_1	pH_{24}	pH_{48}	pH_{72}	pH_{96}	pH_{120}	Tenderness Kruchość 24 h	Tenderness Kruchość 48 h	Tenderness Kruchość 120 h	Thermal drip Wyciek termiczny 24 h	Thermal drip Wyciek termiczny 48 h	Thermal drip Wyciek termiczny 120 h
pH_{24}	–0.12											
pH_{48}	0.32	**0.89**										
pH_{72}	0.15	**0.85**	**0.91**									
pH_{96}	0.10	**0.92**	**0.90**	**0.90**								
pH_{120}	0.09	**0.88**	**0.93**	**0.94**	**0.92**							
Tenderness after 24 hrs, $N \cdot cm^{-2}$ Kruchość po 24 h, $N \cdot cm^{-2}$	0.02	**0.38**	**0.33**	**0.35**	0.22	0.10						
Tenderness after 48 hrs, $N \cdot cm^{-2}$ Kruchość po 44 h, $N \cdot cm^{-2}$	0.18	**0.37**	**0.66**	**0.48**	0.28	**0.36**	**0.90**					
Tenderness after 120 hrs, $N \cdot cm^{-2}$ Kruchość po 120 h, $N \cdot cm^{-2}$	–0.11	0.12	0.21	0.13	0.45	**0.72**	**0.89**	**0.88**				
Thermal drip after 24 hrs, % Wyciek termiczny po 24 h, %	0.12	**0.39**	0.28	**0.32**	**0.43**	**0.52**	0.22	**0.30**	0.01			
Thermal drip after 48 hrs, % Wyciek termiczny po 48 h, %	**0.54**	**0.41**	**0.72**	**0.54**	**0.57**	**0.48**	0.13	**0.44**	–0.04	**0.90**		
Thermal drip after 120 hrs, % Wyciek termiczny po 48 h, %	**0.32**	0.22	**0.35**	**0.42**	**0.48**	**0.53**	0.01	–0.04	0.22	**0.80**	**0.77**	
WHC after 24 hrs, % Zdolność utrzymywania wody po 24 h, %	–0.11	**–0.54**	**–0.42**	**–0.31**	–0.12	–0.21	**–0.31**	–0.08	0.03	**0.48**	**0.33**	0.18
WHC after 48 hrs, % Zdolność utrzymywania wody po 48 h, %	**–0.3**4	**–0.50**	**–0.74**	**–0.88**	**–0.71**	**–0.68**	–0.25	–0.15	–0.13	0.27	**0.57**	0.13
WHC after 120 hrs, % Zdolność utrzymywania wody po120 h, %	–0.16	–0.22	**–0.35**	–0.25	**–0.51**	**–0.70**	–0.01	–0.16	–0.20	0.12	**0.32**	**0.38**

Table 2 – cont.
Tabela 2 – cd.

Color lightness after 24 hrs, % Jasność barwy po 24 h, %	–0.04	**0.40**	0.20	0.23	0.18	0.25	0.05	0.12	–0.11	–0.10	–0.07	–0.03
Color lightness after 48 hrs, % Jasność barwy po 48 h, %	–0.10	0.15	**0.51**	**0.42**	**0.33**	0.12	0.19	0.24	0.26	–0.04	–0.05	–0.01
Color lightness after 120 hrs, % Jasność barwy po 120 h, %	–0.13	0.18	0.02	0.21	**0.46**	**0.51**	0.01	0.15	0.20	0.01	–0.02	0.01
Color after 24 hrs, points Barwa po 24 h, pkt	0.15	0.12	0.30	0.21	0.11	0.15	0.14	0.13	–0.13	0.04	–0.01	0.05
Color after 48 hrs, points Barwa po 48 h, pkt	0.07	**0.37**	**0.48**	**0.61**	**0.76**	**0.67**	0.02	–0.12	–0.29	–0.03	0.07	0.08
Color after 120 hrs, points Barwa po 120 h, pkt	0.01	0.13	**0.40**	**0.52**	**0.78**	**0.80**	0.15	–0.02	0.01	0.00	0.02	–0.01
Marbling, points Marmurkowatość, pkt	–0.11	**0.38**	**0.45**	**0.43**	**0.30**	**0.40**	**–0.53**	**–0.36**	**–0.67**	–0.03	–0.10	0.02
Water, % – Woda, %	0.23	**–0.43**	**–0.54**	**–0.61**	**–0.55**	**–0.54**	**0.38**	0.13	0.10	**0.60**	**0.52**	0.12
Protein, % – Białko, %	0.03	0.12	0.00	0.12	0.09	0.03	**0.55**	**0.32**	0.08	0.12	–0.22	0.06
Fat, % – Tłuszcz, %	0.12	0.04	0.02	0.13	0.01	0.05	**–0.54**	**–0.50**	–0.22	**0.52**	**0.48**	0.14
Ash, % – Popiół, %	0.01	0.00	0.11	0.08	0.02	0.10	0.20	0.10	0.01	0.04	0.01	0.08
	pH_1	pH_{24}	pH_{48}	pH_{72}	pH_{96}	pH_{120}	Tenderness Kruchość 24 h	Tenderness Kruchość 48 h	Tenderness Kruchość 120 h	Thermal drip Wyciek termiczny 24 h	Thermal drip Wyciek termiczny 48 h	Thermal drip Wyciek termiczny 120 h

Table 2 – cont.
Tabela 2 – cd.

WHC after 48 hrs, % Zdolność utrzymywania wody po 48 h, %	**0.92**												
WHC after 120 hrs, % Zdolność utrzymywania wody po 120 h, %	**0.78**	**0.82**											
Color lightness after 24 hrs, % Jasność barwy po 24 h, %	0.12	0.03	0.18										
Color lightness after 48 hrs, % Jasność barwy po 48 h, %	0.13	0.19	0.15	**0.92**									
Color lightness after 120 hrs, % Jasność barwy po 120 h, %	0.17	0.14	0.09	**0.89**	**0.90**								
Color after 24 hrs, points Barwa po 24 h, pkt	**–0.33**	–0.21	–0.11	**–0.32**	–0.11	–0.08							
Color after 48 hrs, points Barwa po 48 h, pkt	**–0.32**	**–0.64**	**–0.38**	–0.11	**–0.48**	–0.28	**0.93**						
Color after 120 hrs, points Barwa po 120 h, pkt	–0.18	–0.19	–0.20	–0.09	–0.13	**–0.60**	**0.90**	**0.92**					
Marbling, points Marmurkowatość, pkt	**–0.38**	**–0.79**	–0.20	–0.15	–0.13	–0.14	–0.22	–0.25	**–0.33**				
Water, % – Woda, %	**0.37**	**0.44**	–0.03	0.29	**0.34**	0.22	**–0.35**	–0.24	**–0.38**	–0.10			
Protein, % – Białko, %	0.10	–0.28	**–0.32**	**0.40**	**0.32**	**0.31**	0.02	0.05	0.28	**–0.32**	**–0.35**		
Fat, % – Tłuszcz, %	**–0.52**	**–0.50**	**–0.35**	**0.54**	**0.48**	**0.30**	**–0.38**	**–0.48**	**–0.50**	**0.92**	**–0.90**	**–0.60**	
Ash % – Popiół, %	0.05	–0.01	0.12	0.00	0.09	0.08	0.06	–0.01	–0.01	0.02	0.10	0.10	0.10
	WHC Zdolność utrzy-mywania wody 24 h	WHC Zdolność utrzy-mywania wody 48 h	WHC Zdolność utrzy-mywania wody 120 h	Color lightness Jasność barwy 24 h	Color lightness 48 h	Color lightness Jasność barwy 120 h	Color Barwa 24 h	Color Barwa 48 h	Color Barwa 120 h	Marbling Marmurko-watość	Water Woda	Protein Białko	Fat Tłuszcz

Statistically significant correlation, $P \leq 0.05$.
Zależność istotna statystycznie, $P \leq 0{,}05$.

Physicochemical properties of meat depend on its capacity to bind and retain water, because/and they affect the juiciness of obtained meals and meat products. Moreover, colt meat is characterized by low marbling, with its average score of 1.67 points. Our experiment has shown the lowest water retentions capacity at 48 hours after slaughter – 24,76%. Water holding capacity appeared to be highly negatively correlated with pH_{48} and reached $r = –0.74$ for $P \leq 0,05$. Moreover, a significant correlation existed with marbling ($r = –0.79$) and water content ($r = 0.44$). Thermal treatment losses were also at the highest level (34.05%) at 48 hours after slaughter, with similar high correlation to pH_{48} ($r = 0.72$, $P \leq 0.05$). A five-day period of cold maturing improved these colt meat properties, with thermal drip reduced to 29.02%, and the water holding capacity reduced to 23.80%.

CONCLUSION

Colt meat is characterized by high content of water and protein and low content of fat. That meat requires a longer time for maturing and, with its value pH, indicates a potential for storage in cold condition for at least five days. Moreover, a five day 'maturing' of colt meat in cold storage raises its water holding capacity, usability for processing and improves meat tenderness as well as causes a dramatic darkening of meat color.

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WPŁYW PROCESU DOJRZEWANIA NA ZMIANY WŁAŚCIWOŚCI FIZYKOCHEMICZNYCH MIĘSA ŹREBIĄT

Streszczenie. Celem pracy było określenie parametrów fizykochemicznych źrebięciny podczas pięciodniowego składowania chłodniczego, stanowiącego czas obrotu do krajów Europy Zachodniej. Przebadano próbki mięśnia najdłuższego grzbietu z 29 źrebiąt w wieku 1,5-2 lat, pochodzących z chowu masowego. Źrebięcina charakteryzuje się wysoką zawartością wody i białka a niską zawartością tłuszczu. Mięso to wymaga długiego okresu dojrzewania i biorąc pod uwagę wskaźnik kwasowości czynnej można przechowywać je w warunkach chłodniczych co najmniej pięć dni. Ponadto pięciodniowe dojrzewanie w warunkach chłodniczych źrebięciny zwiększa jej wodochłonność, przydatność dla przetwórstwa i poprawia kruchość oraz powoduje zdecydowane pociemnienie barwy mięsa.

Słowa kluczowe: mięso źrebiąt, jakość mięsa

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