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The effect of sex and age at slaughter on the physicochemical properties of baby-beef meat

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ABSTRACT

The aim of this study was to determine the effect of sex and age at slaughter on the physicochemical properties and quality of Simmental baby-beef. The research was conducted on 1,200 livestock, of which 600 were male and 600 female. Male cattle were slaughtered at the age of 13 to 14 months, 15 to 16 months and 17 to 18 months, while female cattle were slaughtered at the age of 12 to 13 months, 14 to 15 months and 16 to 17 months. Physicochemical properties associated with the quality of meat (pH, EC and meat colour parameters) were measured 24 hours *post mortem* on the m. longissimus dorsi. While sex significantly influenced the physicochemical properties associated with the quality of baby-beef ($P<0.001$), different age at slaughter had little effect on the physicochemical properties associated with the quality of meat ($P>0.05$), thus indicating the possibility of increasing the slaughter age of male and female Simmental cattle up to 18 and 17 months respectively, without a substantial negative impact on the physicochemical properties associated with the quality of baby-beef.

Key words: sex; age; slaughter; physicochemical properties; baby-beef

Introduction

Consumers are placing more and more emphasis on the quality of food and generally form their impressions on meat quality on the basis of its colour. It has long been believed that dark meat and meat striped with yellow-coloured fat tissue comes from old and sick

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animals (MUCHENJE et al., 2009). Great emphasis, during the production of baby-beef, is therefore placed on the control and sustainability of meat colour. Since dark meat represents one of the leading problems in the sale of baby-beef and causes the meat industry millions in losses, it has been the subject of numerous studies.

The dynamics of glycolysis and pH changes in muscles influence the quality of meat in two ways. If the pH falls quickly, the meat will be pale, soft and exudative (PSE), while a slow and incomplete drop of pH, 24 hours after slaughter, causes dry, firm and dark meat (DFD). The incidence of PSE meat in young cattle is very rare. PAGE et al. (2001) stated that according to the 1997 United States Department of Agriculture (USDA) standards, all beef carcasses with pH_{24} higher than 5.80 are classified as dark. Dark meat has a low L* value, which represents lightness and varies from 0 (black) to 100 (white). The water holding capacity (WHC) is another important feature associated with meat quality. It refers to the ability of meat to retain water post-mortem. This occurs spontaneously and under the influence of external factors, such as gravity or heat treatment (HUFF-LONERGAN, 2005). Electrical conductivity (EC) is the measure of the ability to bind or lose water (BYRNE et al., 2000). PAGE et al. (2001) reported that electrical conductivity measures the conductivity of electrical current through the muscle tissue and is associated with the amount of unbound water in the muscles.

The quality of meat is determined by a variety of endogenous (breed, sex, age at slaughter) and external factors (fattening technology, transport, slaughter, meat storage conditions, etc.) (RENAND et al., 2001; ČUBIĆ et al., 2011; MARENČIĆ et al., 2012). A significant number of studies have indicated that breed, sex, age at slaughter and nutrition affect the weight gain of young cattle, and carcass yield (FRENCH et al., 2001; VESTERGAARD et al., 2000). Even though many studies have examined the effect of sex and age at slaughter on the colour of meat (MURAMOTO et al., 2003; PLESSIS and HOFFMAN, 2007; MOJTO et al., 2009; SARGENTINI et al., 2010), they have primarily focused on dairy and older beef breeds (over 18 months of age).

The aim of this study was to determine the impact of the age at slaughter and sex on the physicochemical properties and quality of Simmental breed meat.

Materials and methods

Experimental animals. The biological part of our research was carried out on 1,200 randomly selected Simmental livestock, 600 of whom were male and 600 female. The fattening of young cattle was carried out on three fattening farms. Young cattle were kept in large covered pens, each holding about 10 young cattle and measuring 61 m^2 in size. The young cattle were fattened by applying a common fattening technology. They were fed once a day, following a total mixed ration (TMR) method. The meals provided were uniform throughout the year and available to the cattle at will. An average TMR meal consisted of 6.5 kg of corn silage (30% dry matter), 5.5 kg of high moisture corn (~

70% dry substance), 650 g of straw (~ 35% dry matter) and 1.4 kg of concentrated feed containing 34% crude protein. Each meal had an average nutritional value of ~ 76 MJ/kg of ME and 950 gr/kg of crude protein. With regard to the slaughter age, male and female cattle were divided into three groups. Male cattle were slaughtered at an age ranging from 13 to 14 months (n = 200), 15 to 16 months (n = 200) and 17 to 18 months (n = 200), while female cattle were slaughtered at an age ranging from 12 to 13 months (n = 200), 14 to 15 months (n = 200) and 16 to 17 months (n = 200). In accordance with applicable legislation (ANON., 2005), young cattle were transported to the slaughterhouse in the early morning and the transport itself lasted about 265 minutes. The slaughter and processing of carcasses were performed in the export slaughterhouse of PIK Vrbovec (HR 10). The slaughter was carried out according to the standard procedure. Young cattle were first rendered unconscious using a captive bolt pistol (Schermer), whose pointed bolt penetrated their brain. After the cattle were stunned, their blood vessels were severed at the brachiocephalic artery (truncus brachiocephalicus). The cattle were exsanguinated in a hanging position. After the outflow of blood, they were decapitated and their carcasses processed according to the standard procedure (ANON., 2004). Processed carcasses were placed in cold storage, at a temperature of 4 °C. All procedures used in this research were in compliance with the European guidelines for the care and use of animals in research (Directive 2010/63/EC).

Slaughter characteristic of meat. The company Agroinspekt d.o.o. provided us with relevant data on the slaughter characteristics of carcasses (slaughter weight, degree of fatty tissue coverage) and we calculated the net daily gain ourselves (weight of chilled halves/age × 1000).

Technological properties of meat. Parameters of colour, electrical conductivity and pH related to meat were monitored at the anatomical position of the area at the intersection of the *m.* longissimus dorsi, at the height of the 6th and 7th ribs, on the right half of each carcass. The monitored parameters (colour, pH and electrical conductivity) were measured 24 hours post-mortem, namely after the bloom time (80 minute long exposure of MLD to aeration), when the colour of the meat had stabilized. The colour of the meat was determined in accordance with the CIE standard (Comission Internationale de l'Eclairage), using a Minolta CR-410 Chroma Meter (Minolta Co., Ltd., Japan) with a 50 mm measuring aperture for a colour-opponent space, with the dimensions L* (lightness) a* (redness) b* (yellowness) C* (chroma) and h* (hue). The colour spectrum was determined using a standard D65 illuminant. The concentration of hydrogen ions (pH) was measured with Eutech's CyberScan pH 310 instrument. Electrical conductivity was measured in millisiemens/cm using a LF-Control system device (Würthinger, Pettenbach, Austria).

We analysed the results obtained by monitoring the relevant quality parameters using the SAS statistical software (SAS Institute, 1999) and applying the GLM procedure. We used the ANOVA multivariate linear model to analyse the impact of sex and age

at slaughter on the quality of meat, and Tukey's HSD test to determine the significance of differences between the examined groups. The classification of meat based on pH was performed in line with the recommendations published by PAGE et al. (2001), that consider all carcasses with a pH greater than 5.8 dry, firm and dark meat (DFD), while the levels of significance were determined by applying the Pearson's chi-squared test.

Results

Slaughter characteristics and technological properties. The significance of differences in the carcasses' slaughter characteristics (slaughter weight, net daily gain, degree of fatty tissue coverage) between the sexes and the quality of baby-beef meat (pH, EC and colour parameters: L*, a*, b*, C* and h*) are shown in Table 1.

Table 1. Descriptive statistics, significance of difference of carcass slaughter characteristics and quality of baby-beef, of male and female Simmental cattle

Parameters	Sex	Mean	SD	SE	Min	Max	CV
Carcasses' slaughter characteristics							
Slaughter weight (kg)	male	363.05[a]	40.71	1.65	207.00	456.00	11.21
	female	272.23[b]	21.42	0.69	195.00	392.00	7.87
Net daily gain (kg)	male	0.771[a]	0.11	0.01	0.379	1.099	14.25
	female	0.635[b]	0.08	0.01	0.370	0.854	12.72
Degree of fatty tissue coverage	male	3.00[a]	0.53	0.02	2.00	4.00	17.60
	female	3.21[b]	0.48	0.02	2.00	5.00	14.90
Quality of baby-beef							
pH	male	5.61[a]	0.13	0.01	5.45	6.73	2.24
	female	5.57[b]	0.07	0.01	5.41	6.28	1.27
EC	male	7.28[a]	1.38	0.06	2.60	12.40	18.96
	female	4.80[b]	1.19	0.04	1.50	11.80	24.79
L*	male	42.07[a]	2.64	0.11	33.17	54.89	6.27
	female	43.60[b]	2.06	0.07	35.44	51.45	4.71
a*	male	29.35[a]	1.75	0.07	22.01	34.79	5.95
	female	28.76[b]	1.57	0.05	21.75	35.25	5.45
b*	male	11.45[a]	1.33	0.05	6.74	14.78	11.64
	female	11.71[b]	1.00	0.03	7.74	15.03	8.53
C*	male	31.50[a]	2.09	0.08	23.36	37.66	6.62
	female	31.06[b]	1.77	0.66	23.61	38.00	5.70
h*	male	21.26[a]	1.53	0.06	12.23	32.23	7.19
	female	22.09[b]	1.21	0.04	10.52	29.46	5.47

Values presented in the same column of the table that are labelled by different letters are significantly different ($P<0.001$).

Table 2 shows the effect of sex on the baby-beef quality grades with regard to pH value. It is evident that sex has a significant effect on the incidence of DFD meat (P<0.001). The effects of age at slaughter on the carcasses' slaughter characteristics and the quality of baby-beef are shown in Table 3. In view of the slaughter characteristics of carcasses of young male cattle of different ages at slaughter, we found a significant difference for the recorded net daily gain and degree of fatty tissue coverage parameters (P<0.001), and only a negligible difference for the slaughter weight parameters (P>0.05). Table 4 shows that the age at slaughter had only a small effect on the quality classes of meat originating from young male and female cattle (P>0.05).

Table 2. Effect of sex on distribution of baby-beef quality grades (number of livestock, %)

Group	Desirable (pH_{24} < 5.8)	DFD (pH_{24} >5.8)	Chi-test
Male	559 (93.17%)	41 (6.83%)	***
Female	584 (97.33%)	16 (2.67%)	

DFD - dark, firm and dry meat; ***P<0.001

Table 3. Effect of age at slaughter on carcass slaughter characteristics and quality of baby-beef

Parameters	Male			SE	Female			SE
	13 - 14 month	15 - 14 month	17 - 14 month		12 - 14 month	14 - 14 month	16 - 17 month	
Carcass slaughter characteristics								
Slaughter weight (kg)	358.51	364.06	366.05	2.91	268.52^{a}	273.04^{b}	276.26^{b}	1.20
Net daily gain (g/kg)	863.16^{a}	765.38^{b}	683.44^{c}	0.01	706.52^{a}	623.83^{b}	551.95^{c}	0.01
Degree of fatty tissue coverage	3.14^{a}	2.94^{b}	2.97^{b}	0.04	3.26^{a}	3.20^{ab}	3.15^{b}	0.02
Quality of baby-beef meat								
pH	5.60	5.60	5.63	0.01	5.57	5.57	5.58	0.01
EC	7.38	7.33	7.11	0.10	4.77	4.84	4.76	0.07
L*	42.59^{a}	42.06^{ab}	41.55^{b}	0.19	43.76	43.71	43.58	0.12
a*	29.22	29.43	29.35	0.13	28.61	28.81	28.91	0.09
b*	11.38	11.48	11.48	0.09	11.65	11.72	1.77	0.05
C*	31.37	31.56	31.53	0.15	30.90	31.11	31.21	0.10
h*	21.30	21.26	21.23	0.11	22.10	22.03	22.14	0.07

EC - electrical conductivity; Values presented in the same row of the table that are labelled with different letters are significantly different (P<0.05).

Table 4. Effect of slaughter age on distribution of baby-beef quality grades originating from both male and female cattle (number of livestock,%)

Sex	Group	Desirable (pH_{24}< 5,8)	DFD (pH_{24}> 5.8)	Chi-squared test
Male	13 - 14 month	187 (93.50%)	13 (6.50%)	NS
	15 - 16 month	188 (94.00%)	12 (6.00%)	
	17 - 18 month	184 (92.00%)	16 (8.00%)	
Female	12 - 13 month	194 (97.00%)	6 (3.00%)	NS
	14 - 15 month	196 (98.00%)	4 (2.00%)	
	16 - 17 month	194 (97.00%)	6 (3.00%)	

DFD - dark, firm and dry meat; NS - no significant difference P>0.05

Discussion

On the basis of the results of this research, we established the significant effect of sex on both the slaughter characteristics of carcasses and the quality of baby-beef (P<0.001). When we considered the slaughter characteristics of the carcasses, we observed that young male cattle had a significantly greater slaughter weight and larger net daily gain, while young female cattle had a significantly higher degree of fatty tissue coverage (P<0.001).

Regarding the quality of baby-beef, our results show that sex had a significant effect on both the quality and the colour of baby-beef (P<0.001). Several authors have stated that young female cattle typically produce halves with a higher degree of intramuscular fat (marbling), which in turn causes a higher L* and a higher b* value (WULF et al., 1997; PAGE et al., 2001; TATUM et al., 2007). Young female cattle in our research recorded significantly lower electrical conductivity (EC) values than young male cattle (P<0.001). ALDAI et al. (2006) found that young cattle with a higher degree of intramuscular fat (marbling) showed a lower loss of water and had a lower EC value.

The results obtained in this study regarding the effect of sex on the baby-beef quality grades were consistent with the majority of other research (MOJTO et al., 2009; WULF et al., 1997; PAGE et al., 2001). Despite the more favourable incidence of DFD meat in both young male and female cattle, the results of this study also showed a significantly higher incidence of DFD meat in young males than in young female cattle (P<0.001). By comparing young male and female cattle, MOJTO et al. (2009) reported that young male cattle were physically more active during the night and therefore depleted their glycogen reserves, causing a higher final pH value and a higher incidence of DFD meat. In our opinion, the differences between the sexes in this research were primarily caused by differences in temperament, as well as the different response to stress that usually

occurs immediately before the slaughter of animals. This conclusion was substantiated by previous studies that suggested that young male cattle are more prone to glycogen exhaustion before slaughter than females and castrated cattle, due to their irritable temperament and aggressive behaviour (MONIN, 2004; TATUM, 2006; MARENČIĆ et al., 2012). In comparison to cattle that were less excitable, TATUM et al. (2007) recorded higher final pH values in muscles, darker colour of muscles, greater calpastatin (CAST) activity, greater firmness, poor sensory properties and unpleasant taste in cattle that were more excitable. IMMONEN et al. (2000) associated temperament with the concentration of glycogen in the muscles and a higher incidence of DFD meat.

Regarding the quality of baby-beef, the results of our research confirmed that different ages at slaughter, in both young male and female cattle, only produce a negligible effect on pH and EC values, as well as meat colour parameters ($P>0.05$). The results reported in this study are in line with research conducted by PREZIUSO and RUSSO (2004), who also reported only a modest effect on the pH value and colorimetric parameters associated with meat of different slaughter age. PLESSIS and HOFFMAN (2007) observed that an increase in slaughter age significantly increased pH and a* values, and at the same time significantly reduced the L* value ($P<0.05$), while negligibly increasing the b* value ($P>0.05$). In this study, the increase of slaughter age in young female cattle had only a negligible effect on the quality of the baby-beef meat ($P>0.05$). In young male cattle of different slaughter ages, significant differences were only found for the L* parameter, namely a significant difference was found only between young male cattle slaughtered at the age of 13 to 14 months and the age of 17 to 18 months ($P<0.05$). We established only a negligible difference between all the other parameters relating to young male cattle ($P>0.05$). SARGENTINI et al. (2010) reported that young male cattle of Maremmana breed slaughtered at the age of 24 months showed significantly higher L*, b* and h* values ($P<0.05$), as well as negligibly higher a* and C* values ($P>0.05$) than young male cattle slaughtered at the age of 18 months. MPAKAMA et al. (2014) found that young male cattle at the age of 16 months had higher a* and b* values than young cattle at 24 months of age. LAWRIE (1974) associated the observed differences in the colour of meat with variations of intramuscular fat, and concluded that age had no effect on the amount of myoglobin. WULF and WISE (1999) found subcutaneous fat and intramuscular fat (marbling) to be in high positive correlation and reported that, since intramuscular fat is generally white, it can increase the range of L* values on a scale from 0 (black) to 100 (white). CVRTILA FLECK et al. (2016) considered the quality of meat pertaining to animals that were slaughtered at a later age to be different from the quality of meat pertaining to younger animals and concluded that an increase in age and slaughter weight of animals (most often with *ad libitum* feeding) results in slower overall growth and an increase in both inter-and intra-muscular fat tissue content that can, in turn, cause a decrease in muscle fibre tenderness and impair the flavour properties of meat. It has

been reported that all carcasses containing less than 0.76 cm of subcutaneous fat had both darker meat and a higher pH value than carcasses containing more than 0.76 cm of subcutaneous fat (PAGE et al., 2001). The process of ageing meat reduces the ability of myoglobin to bind oxygen in animals and this is the precise reason why, in most cases, older cattle usually have darker meat. The amount of myoglobin in the muscles of younger cattle primarily depends on the breed, sex and type of muscle tissue, and may slightly vary at the level of individual organisms (FAUSTMAN and CASSENS, 1990; STEINHAUSER, 1995). However, on the basis of the results obtained in this study, it could be argued that the age at slaughter of young male and female cattle has only a marginal effect on the colour of meat.

In this study, the highest incidence of DFD meat among young female cattle amounting to 3%, that was found at the age of 12 to 13 months and the age of 16 to 17 months, did not significantly differ from the incidence of DFD at the age of 14 to 15 months ($P>0.05$). The highest incidence of DFD meat, amounting to 8%, that was found among young male cattle at the age of 17 to 18 months, did not significantly differ from the incidence of DFD meat recorded for young male cattle slaughtered at the age of 13 to 14 months and young male cattle slaughtered at the age of 14 to 15 months ($P>0.05$). MPAKAMA et al. (2014) concede that animals younger than 36 months produce baby-beef of the highest quality and that older animals almost always produce darker meat with a higher pH value, and show more frequent incidence of DFD meat.

Conclusion

The results of this study demonstrated that sex had a significant effect on the physicochemical properties of meat ($P<0.001$), while the age at slaughter in young male and female cattle had little effect on the physicochemical properties and quality of meat ($P>0.05$). The results obtained from this research therefore confirm that the age at slaughter may be increased to up to 18 months in male Simmental cattle, and to up to 17 months in female Simmental cattle, without any significant negative effects on the physicochemical properties and quality of the meat.

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MARENČIĆ, D., A. IVANKOVIĆ, L. KOZAČINSKI, M. POPOVIĆ, Ž. CVRTILA: Utjecaj spola i klaoničke dobi na fizikalno-kemijska svojstva junećega mesa. Vet. arhiv 88, 101-110, 2018.

SAŽETAK

Cilj rada bio je utvrditi utjecaj spola i klaoničke dobi na fizikalno-kemijska svojstva kakvoće mesa simentalske junadi. Istraživanje je provedeno na 1200 jedinki od kojih je 600 bilo muškoga i 600 ženskog spola. Muška junad klana je u starosti od 13 do 14 mj., 15 do 16 mj. i 17 do 18 mj., dok je ženska junad klana u starosti od 12 do 13 mj., 14 do 15 mj., i 16 do 17 mj. Fizikalno-kemijska svojstva kakvoće mesa (pH, EC i pokazatelji boje mesa) izmjerena su 24 sata *post mortem* na m. longissimus dorsi. Spol je imao značajan utjecaj na fizikalno-kemijska svojstva kakvoće junećega mesa ($P<0,001$), dok je različita klaonička dob imala mali utjecaj na fizikalno-kemijska svojstva kakvoće mesa ($P>0,05$), upućujući na mogućnost povećanja klaoničke dobi kod muške simentalske junadi do 18 mj. i kod ženske simentalske junadi do 17 mj., bez značajno negativnog utjecaja na fizikalno-kemijska svojstva kakvoće junećega mesa.

Ključne riječi: spol; dob pri klanju; fizikalno-kemijska svojstva; baby-beef

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