Seasonal overview of beef meat quality in a small-scale slaughterhouse

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Abstract. The objective of this study was to investigate a possible relationship between blood parameters related to animal welfare and defined beef meat quality characteristics during winter and summer seasons in one small-scale slaughterhouse. At exsanguination, blood samples were collected, and serum concentrations for total proteins (TP), albumin and C-reactive protein (CRP) were evaluated. After 24 h of chilling, ultimate pH was measured and meat samples were used for drip loss and cooking loss determination. Dehydration was not observed during seasons, while elevated concentrations of TP accompanied by higher CRP values pointed to summer as a more stressful season. Analysing the meat quality parameters, it was observed that during the two seasons, ultimate pH values were in the range for normal meat acidification, but values for drip and cooking loss were significantly increased during the summer season. In conclusion, CRP could be used as potential biomarker for beef meat quality estimation, in the first instance drip loss and ultimate pH.

1. Introduction

Beef meat quality has increasingly become an important production trait worldwide, both from the aspect of customer satisfaction and of the economic profit of the industry [1-2]. Conditions and procedures with animals, starting from the farm, during transportation and in the lairage period are just some of the elements that could greatly affect the quality of meat [3]. Improper conditions at farm level lead to animals' adoption of the negative experience and inability to acclimatize to the new environment [4-5]. Inadequate handling during transportation, dehydration, limited space in trucks, climatic conditions, mixing of animals in the lairage, and social dominance are some of the disturbed procedures that impair animal well-being and affect the level of the individual's stress response [6-7]. Challenges, especially before slaughter, activate an autonomic response, and as a product, glucocorticoids are released, which perturb metabolism homeostasis, particularly at muscle level [8]. It has been reported that in term of returning the homeostasis balance, synthesis of acute phase proteins, depending on the type, is increased or decreased in order to gain protective effects against acute stressors [9-10]. Unlike pigs, humans and dogs, in cattle, C-reactive protein (CRP) is not considered as prototypical acute phase protein which could be used for diagnostic herd health assessment [11]. Despite its synthesis during acute infection, it has been observed that during severe stressful reactions, a large amount of CRP is

released in the blood with the purpose of achieving immediate protection [12]. All the above mentioned adverse conditions of the animal production cycle can alter meat quality parameters, particularly due to impaired pH, affecting water holding capacity, meat tenderness and colour [13-14].

The objective of this study was to investigate a possible relationship between blood parameters related to animal welfare and defined beef meat quality characteristics during winter and summer seasons in one small-scale slaughterhouse.

2. Materials and methods

The study was conducted on 44 Simmental crossbreed bulls, 22 per season with an average live weight of 550±20 kg. The transport distance was short, about 70 km, and animals were rested for 1 h at lairage. The sampling was performed during February and July, referred as winter and summer season, respectively. During exsanguination, a plastic cup was used to collect the blood samples which were immediately transferred to the tube with potassium oxalate. Within 4 h, the samples were centrifuged at 2500 rpm, and the serum was separated and immediately frozen for further analysis. The serum samples were analysed for total protein (TP), albumin and CRP concentrations using an automated analyser (Architect c8000, Abbott, Wiesbaden, Germany).

Ultimate pH of *Musculus Longissimus dorsi* was measured after 24 h of chilling between the 10th and 12th ribs using a portable pH meter (Testo 205, Testo AG, Lenzkirch, Germany). From the same anatomical position, 2.54 cm thickness meat samples were taken for water holding capacity determination. Evaluation of water holding capacity was done using two methods: drip loss and cooking loss. Drip loss was tested using a bag method [15] by measuring the initial weight of each individual meat sample and weighing it again after 48 h of storage period at 4 °C. Differences of two weights gave drip loss percentage. Thereafter, the samples were put in plastic zip bags, boiled until reaching 75 ºC of internal temperature, cooled under chilled conditions (1-4 ºC) and then re-weighed [15]. Cooking loss was expressed as a percentage of initial weight.

Before any statistical analysis, the obtained data were checked for normality using Shapiro-Wilk test ($P>0.05$) and outliers were rejected. Differences between winter and summer seasons in terms of meat quality parameters (pH, drip loss, cooking loss) and animal-related factors (TP, albumin, CRP) were evaluated using Student's t test. Pearson's test was also used for estimation if there was any correlation between and within meat quality and animal-related characteristics. Statistical analysis of the results was performed using SPSS 21 software package.

3. Results and discussion

Concentrations of TP and CRP taken from the bulls during summer season were significantly increased while albumin concentration as an indicator of dehydration was slightly increased, but not significant (Table 1). Dehydration, as a negative state of transportation and lairage conditions, particularly with long journeys was not manifested in this case, because it was a short transport with relatively short animal retention at abattoir level [16].

Table 1. Evaluation of animal-related parameters in bulls during two seasons

	Winter	Summer
TP g/L	66.09±1.08[a]	70.86±0.95[b]
Albumin g/L	30.32±0.49[a]	31.05±0.48[a]
CRP g/L	2.49±0.13[a]	3.41±0.27[b]

[1]Values are shown as arithmetic mean ± standard error of the mean.
Values with different lowercase letters (a-b) in the same line differ significantly ($P<0.05$)

However, concentration of total serum proteins in the summer season may be an indicator of increased globulin fraction in the blood, including acute phase proteins, which was accompanied by elevated CRP concentration. Evaluating the concentration of CRP, it could be stated that summer as a season was more stressful for bulls, which is not in agreement with a study conducted in Spain where the winter season was significantly more stressful [17].

Analysing the meat quality parameters, it was observed that during the two seasons, ultimate pH values were in the range for normal meat acidification, but water holding capacity was significantly decreased during the summer season (Table 2). When the ultimate pH approaches the isoelectric point, the ability of muscle proteins to bind water is diminished, resulting in greater water release [18]. Within the complexity of water retention at protein level, the elevated stressful reaction, with possible heat stress and decreased ultimate pH, additional analyses are required for better understanding the glycolytic potential of the meat and the development of rigor after slaughter [19].

Table 2. Examination of meat quality parameters during two seasons

	Winter	Summer
pH ^{24h}	5.77±0.04^{a}	5.61±0.03^{b}
Drip loss %	1.68±0.21^{a}	2.99±0.27^{b}
Cooking loss %	26.73±1.36^{a}	32.71±0.60^{b}

[1]Values are shown as arithmetic mean ± standard error of the mean.
Values with different lowercase letters (a-b) in the same line differ significantly (P<0.05)

Correlation coefficients among investigated variables are shown in Table 3. Ultimate pH had an intermediate negative correlation coefficient with drip loss and cooking loss, which was also confirmed in a Hungarian Simmental bull study [20]. It indicates that as pH increased, drip and cooking loss decreased, and vice versa. On the other hand, CRP was negatively correlated with ultimate pH and positively with drip loss, at intermediate level. Practically, this means as CRP concentration increased, ultimate pH decreased and drip loss increased. Based on above, ultimate pH could be used as prediction indicator for water holding capacity *post mortem*, and CRP for ultimate pH and drip loss *pre mortem*. More studies are needed to confirm these facts, especially within the occurrence of dark, firm and dry meat.

Table 3. Correlation coefficients among investigated variables

	pH ^{24h}	Drip loss %	Cooking loss %	TP g/L	Albumin g/L
CRP g/L	-0.40**	0.48**	0.25	0.24	0.49**
Albumin g/L	-0.26	0.22	0.13	0.42**	
TP g/L	-0.32*	-0.13	0.29		
Cooking loss %	-0.55**	0.43*			
Drip loss %	-0.57**				

* P<0.05
** P<0.01

4. Conclusion

Based on the results of this study, CRP could be used as potential biomarker for beef meat quality estimation, in the first instance for drip loss and ultimate pH. Recognition and identification of indicators, important in terms of animal well-being, stress and meat quality and their incorporation in animal production cycle is necessary, with the purpose of achieving higher customer satisfaction and profitability of producers.

Acknowledgment

This paper was supported by the Ministry of Education, Science and Technological Development, Republic of Serbia (No 451-03-68/2020-14/200143)

References

[1] Ilie L and Georgescu M 2019 The relationship between food safety, food quality and customer satisfaction *Sci. Pap. Ser. D Anim. Sci*. **62** (1) 364−9
[2] Huertas S M, van Eerdenburg F, Gil A and Piaggio J 2015 Prevalence of carcass bruises as an indicator of welfare in beef cattle and the relation to the economic impact *Vet. Med. Sci.* **1 (1)** 9−15
[3] Grandin T and Shivley C 2015 How farm animals react and perceive stressful situations such as handling, restraint, and transport *Animals* **5** (4) 1233−51
[4] da Costa M J P, Huertas S M, Gallo C and Dalla Costa O A 2012 Strategies to promote farm animal welfare in Latin America and their effects on carcass and meat quality traits *Meat Sci*. **92** (3) 221−6
[5] Čobanović N, Jamnikar-Ciglenečki U, Kirbiš A, Križman M, Štukelj M and Karabasil N 2019 Impact of various housing conditions on the occurrence of pathological lesions in slaughtered pigs *Vet. Glas.* **73** (1) 17−29
[6] Ferguson, D M and Warner R D 2008 Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? *Meat Sci*. **80** (1) 12−9
[7] Karabasil N, Boskovic T, Vicic I, Cobanović N, Dimitrijevic M and Teodorovic V 2019 Meat quality: Impact of various pre-slaughter conditions *IOP Conf. Ser. Earth Environ. Sci.* **333** 012033
[8] Carrasco-García A A, Pardío-Sedas V T, León-Banda G G, Ahuja-Aguirre C, Paredes-Ramos P, Hernández-Cruz B C and Murillo V V 2020 Effect of stress during slaughter on carcass characteristics and meat quality in tropical beef cattle *Asian-australas. J. Anim. Sci*. **33** (10) 1656
[9] González F H, Tecles F, Martínez-Subiela S, Tvarijonaviciute A, Soler L and Cerón J J 2008 Acute phase protein response in goats *J. Vet. Diagn. Invest*. **20** (5) 580−4
[10] Fazio F, Ferrantelli V, Cicero A, Casella S and Piccione G 2015 Utility of acute phase proteins as biomarkers of transport stress in ewes and beef cattle *Ital. J. Food Saf.* **4** (2) 4210
[11] Eckersall P D and Bell R 2010 Acute phase proteins: Biomarkers of infection and inflammation in veterinary medicine *Vet. J.* **185** (1) 23−7
[12] Lee W C, Hsiao H C, Wu Y L, Lin J H, Lee Y P, Fung H P, Chen H H, Chen Y H and Chu R M 2003 Serum C-reactive protein in dairy herds *Can. J. Vet. Res.* **67** (2) 102–7
[13] Lomiwes D, Farouk M M, Wu G and Young O A 2014 The development of meat tenderness is likely to be compartmentalised by ultimate pH *Meat Sci.* **96** (1) 646−51
[14] Ijaz M, Li X, Zhang D, Hussain Z, Ren C, Bai Y and Zheng X 2020 Association between meat color of DFD beef and other quality attributes *Meat Sci.* **161** 107954
[15] Honikel K O 1998 Reference methods for the assessment of physical characteristics of meat *Meat Sci.* **49** (4) 447−57
[16] Werner M, Hepp C, Soto C, Gallardo P, Bustamante H and Gallo C 2013 Effects of a long distance

transport and subsequent recovery in recently weaned crossbred beef calves in Southern Chile *Livest. Sci.* **152** (1) 42−6
[17] Villarroel M, Maria G, Sañudo C, García-Belenguer S, Chacon G and Gebre-Senbet G 2003 Effect of commercial transport in Spain on cattle welfare and meat quality *Dtsch. Tierarztl. Wochenschr.* **110** (3) 105−7
[18] Lonergan E H, Zhang W and Lonergan S M 2010 Biochemistry of postmortem muscle—Lessons on mechanisms of meat tenderization *Meat Sci.* 86 (1) 184−95
[19] Hamoen J R, Vollebregt H M and Van Der Sman R G M 2013 Prediction of the time evolution of pH in meat *Food Chem.* **141** (3) 2363−72
[20] Teke B, Akdag F, Ekiz B and Ugurlu M 2014 Effects of different lairage times after long distance transportation on carcass and meat quality characteristics of Hungarian Simmental bulls *Meat Sci.* **96** (1) 224−9