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EFFECT OF SEX AND AGE OF CATTLE ON BEEF MEAT pH

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Aim. The aim of the study was to explain the difference of pH values in heifer and bull meat and to carry out an analysis of the effect of age in groups of both sexes. **Methods.** The study contains data on 2,469 beef breed and their crossbreed cattle fattened on farms in Latvia and Lithuania, slaughtered in a certified Lithuanian slaughterhouse 'Agaras' in 2018. For the assessment of the effect of sex, the beef cattle were divided into 2 study groups: 1,266 bulls and 1,203 heifers. 3 study groups were created for analysis of the effect of age: 12–17 months; 18–23 months; 24 and more months. Analysis of the data acquired was based on the indicators of descriptive statistics. *T–test* and *Pearson* correlation analysis were used. **Results.** The average pH in the meat of bulls was 5.87 ± 0.011, but in the meat obtained from heifers – 5.66 ± 0.005 ($p \leqslant 0.05$). Within the desired pH value from 5.4 to 5.8, the group of bulls comprised 65 % of carcasses and the group of heifers − 86 % of carcasses. In the group of bulls, 35 % of carcasses had an increased pH in the meat (pH −⩾ 5.9), while in the heifers' group − 13%. For a small part of the carcasses in both study groups, too low pH was found in meat (pH ⩽ 5.3), with 1% in the group of bulls and 0.4% in the group of heifers. An analysis of the effect of age found no significant differences in pH values between bulls of different ages. In the heifers'study group, the highest pH in meat was found in the group above 24 months of age, pH–5.69. Correlation analysis between the meat pH and the slaughter results showed a weak or non–existent relationship. In the overall study group, stronger correlation was observed between pH and fat score ($r = -0.21$, $p < 0.05$). **Conclusions.** The results indicate that meat from heifers is better quality in terms of desired pH. Meat with the desired pH can be used in the production of high-quality products that provide higher profits.

Key words: beef cattle, meat, pH, age, sex.

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INTRODUCTION

One of the main characteristics of beef meat quality is the pH value, which is closely related to the obtainment of quality meat. pH in beef carcasses is measured 12 to 48 h after slaughter, and the desired pH in meat should be between 5.4 and 5.8. Such meat can be maturated in a quality manner, which ensures high demands and exceptional eating experience as well as maturing provides the palatability and increases the tenderness. Meat with the desirable pH could be sold fresh or packaged in a vacuum, and stored, it is visually appealing to the consumer, with good flavor characteristics (Adzitey F, Huda N 2011; Velotto S et al. 2015).

When the animal is alive, energy in muscles is stored in the form of glycogen, and pH in muscles is >7.1. After death has occurred, glycolysis in muscles takes place, in the result of which glycogen is split to lactic acid and other metabolites, which contributes to falling of pH. The larger energy reserves in muscles, the greater amounts of lactic acid will be produced. As a result of various stress factors, glycogen reserves are already spent before slaughter and thus a normal process of glycolysis cannot occur after slaughter.

The extent of loss of glycogen will depend on the intensity and duration of the various stress factors and on the sensitivity of animals to stress. If the animal is subjected to long–term stress prior to slaughter, e.g. long–term transportation, starvation, too high density in stocking conditions (Arik E, Karaca S 2017; Ferguson DM et al. 2001; Ferguson DM, Gerrard DE 2014), the reserves of muscle glycogen are dwindling and, following the slaughter of the animal, the acidification of

the meat, or a decrease in pH value to the desired limit, does not occur or does not occur sufficiently. This results in DFD (Dark, Firm, and Dry) meat having an increased pH of a value of ≥ 5.9. It is characterized by a dark color, increased water binding and toughness (especially if pH is between 5.9 and 6.2). A DFD meat is subjected to the risk of faster deterioration as a result of the effects of microorganisms on its surface (Page JK et al. 2001; Pipek P et al. 2003; Villarroel M et al. 2003). A study by Villarroel M et al. (2003) found that meat with a pH of > 5.55 is already getting tougher, has a less pronounced taste and is visually appealing to a lesser extent.

Meat with a too low pH (≤5.3) is referred to as PSE (Pale, Soft and Exudative) meat and is pale, watery and too soft. In the case of PSE meat, a decrease in pH is taking place while the carcass is still warm, with a decrease below 6.0 occurring already 45 minutes after the slaughter (Adzitey F, Huda N 2011).

Meat obtains the characteristics of PSE if the animal is subjected to severe, temporary stress shortly before slaughter, and therefore depends on the quality of the work at the slaughterhouse. A PSE meat will be obtained by the use of electric whips for the moving the animals to the slaughter spot, beating of animals, an incorrect grouping of animals, and excessive density in the pre–slaughter waiting room, as well as poor–quality slaughter.

Cattle breed has influence on several slaughter result parameters, such as live weight before slaughter, live weight gain, slaughter weight, dressing percentage and conformation score (Muizniece I, Kairisa D 2016), but as shown in other studies, breed has not significant influence on pH value of beef meat (Arik E, Karaca S 2017; Bures D et al. 2006; Cafferkey J et al. 2019).

An important factor influencing the quality of the meat obtained is the sex of the animal, which affects not only the chemical composition of the meat but also physicochemical and sensory properties (Page JK et al. 2001; Weglarz A 2010b; Weglarz A 2011). Heifers and steers produce more marbled, gentler meat with better sensing properties compared to the meat obtained from bulls. The bull meat is darker, with more coarse muscle fibres and a higher pH, which makes it less suitable for fresh sale (Marencic D et al. 2018; Weglarz A 2010b).

The aim of the study was to explain the difference of pH values of heifers and bull's meat and to carry out an analysis of the effect of age in groups of both sexes of beef cattle.

MATERIALS AND METHODS

The study used pH measurements of meat of 2,469 beef purebred (Charolais, Limousin, Angus, Hereford, Aubrac, Simmental) and their crossbreed cattle fattened on farms in Latvia and Lithuania, slaughtered in a certified Lithuanian slaughterhouse 'Agaras' in 2018. pH measurements in the meat were carried out 24 hours after the slaughter of beef cattle in the loin section, using a pH meter ProfiLine pH 3310. In our study, it was assumed that an increased pH starts at a value of 5.90 but pH 5.30 and lower is considered to be too low. It was adopted on the basis of guidelines developed by the slaughterhouse 'Agaras'.

Cattle used in the study were between 12 and 45 months old.

For the assessment of the effect of sex, the beef cattle were divided into 2 study groups:

1. bulls (n = 1,266)
2. heifers (n = 1,203).

According to the following scheme, 3 study groups were set up for analysis of the effect of age (Table 1). Most of heifers were slaughtered between the age of 18 and 24 months, 51.7 %, while in the bull group most of the bulls were slaughtered between 12 and 17 months, 56.2 %.

In the age group over 24 months, 40 bulls (3.1%) and 263 heifers (21.9%) were slaughtered.

The indicators used in the study: sex, age, live weight, slaughter weight, conformation score, fat score and meat pH, were obtained from the slaughterhouse 'Agaras' protocols.

For the calculation of dressing percentage, used was the following formula (1):

$$K = \frac{Wk}{Wt} \times 100, \quad (1)$$

where K – dressing percentage, %; Wk – cold carcass weight, kg; Wt – live weight before slaughter, kg.

For the conformation score grading, EUROP (carcass classification system) letters are used, marked with the following meaning: E – excellent (numerical mark – 5), U – very good (4), R – good (3), O – moderate (2), P – weak (1). The evaluation of fat score is indicated by figures 1 to 5, where 1 – very low, 2 – low, 3 – moderate, 4 – high, 5 – very high. Carcasses classification was done by slaughterhouse 'Agaras' expert according with Regulation (EU) No 1308/2013.

Analysis of the data acquired was based on the indicators of descriptive statistics: arithmetical mean,

standard error and coefficient of variation. *T*–test for average values was used for significance determination for trait relationship. *Pearson* correlation analysis was performed, which was established between the pH and and the features of slaughter. Different letters (a, b, c) on tables mark significant differences at $p \leq 0.05$.

RESULTS AND DISCUSSION

The results of the study are summarized in Table 2. The average age of bulls prior to slaughter was 17.3 months, and 20.4 months in the heifers' group ($p \leq 0.05$). Before slaughter, the bulls showed a higher live weight and slaughter weight of 529.6 ± 1.68 kg and 294.0 ± 1.13 kg, respectively; in the heifers' group, the respective indicators were 498.7 ± 1.53 kg and 269.8 ± 0.97 kg ($p \leq 0.05$). Calculated dressing percentage was also higher in the bulls' group, in average - 55.5 ± 0.10%, while in the heifers' group – 54.1 ± 0.12% ($p \leq 0.05$). Similar results have been found in studies by other authors (Blanco M et al. 2020; Bures D, Barton L 2012; Pesonen M, Huuskonen A 2015; Weglarz A 2010a;) showing that bulls before slaughter reached higher weight and dressing percentage.

The highest conformation score was obtained from bulls' group – 3.01 ± 0.02 points and it was significantly higher than heifers' group carcass conformation score ($p \leqslant 0.05$). Heifers' group received significantly higher fat score – 2.98 ± 0.01. As shown by the work of several other researchers, bulls are characterized by better muscularity, while heifers show a higher fat content on carcass (Blanco M et al. 2020; Pogorzelska-Przybyłek et al. 2018).

After the carcasses were refrigerated, the average pH in the meat of bulls was 5.87 ± 0.011, while in the meat of heifers, the pH was 5.66 ± 0.005, a difference of 0.22, which is significant ($p \leq 0.05$). Also, several studies conducted by foreign scientists, like our study, found that pH was higher in bull meat rather than in that of heifers and that the difference was significant (Page JK et al. 2001; Weglarz A 2010a; Weglarz A 2010b; Weglarz A 2011; Zhang YY et al. 2010). The results obtained show that heifers are more stress-resistant and suffer from stressors that occur during transportation and during the pre-slaughter stocking to a lesser extent. Bulls are more sensitive to various changes and more under the influence of hormonal functioning aimed at fighting and proof of dominance, thus being in a continuous state of anxiety which, in its turn, has a negative effect on the quality of their meat.

Both study groups contained carcasses in the meat of which pH exceeded the desired limit – 5.90. In the group of bulls, 35 % of carcasses were with an increased pH in the meat, while in the heifers' group – 13 %. Within the desired span of the pH of a value of 5.40 to 5.80, the percentage of carcasses reached 65% in the group of bulls, and 86 % – in the group of heifers (Figure). For a small part of the carcasses in both study groups, too low pH was found in meat (pH ≤ 5.3), with 1% in the group of bulls and 0.4 % in the group of heifers.

Several studies have shown that it is also possible to obtain meat from bulls with a pH value not exceeding 5.8 (Cafferkey J et al. 2019; Moran L et al. 2019;

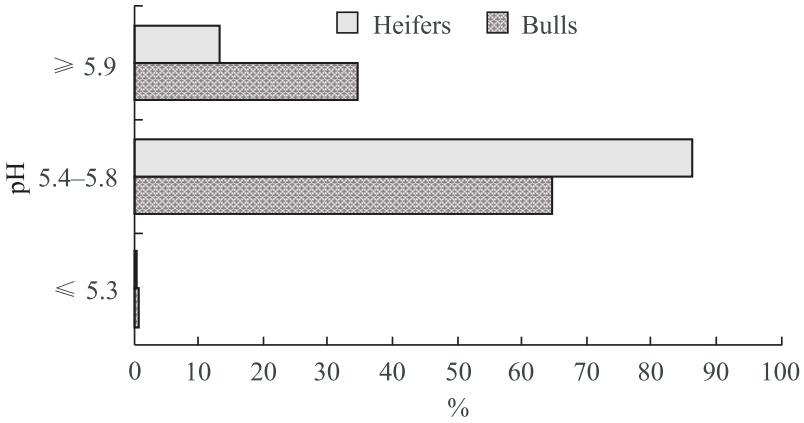
Table 1. Number of animals used in the study groups of sex and age

Sex	Age (months)		
	12–17	18–23	24 and more
Heifers	318	622	263
Bulls	711	515	40

Table 2. Results of slaughter and carcass quality in study groups

Indicators	Bulls (n = 1266)		Heifers (n = 1203)	
	$x \pm Sx$	v, %	$x \pm Sx$	v, %
Age before slaughter (months)	17.3 ± 0.09[a]	19.39	20.4 ± 0.12[b]	19.72
Live weight before slaughter (kg)	529.6 ± 1.68	11.31	498.7 ± 1.53	10.65
	294.0 ± 1.13[a]	13.65	269.8 ± 0.97[b]	12.49
Cold carcass weight (kg)	55.5 ± 0.10[a]	6.37	54.1 ± 0.12[b]	7.40
Dressing percentage (%)	3.01 ± 0.02[a]	20.55	2.86 ± 0.02[b]	16.77
Conformation score (points)	2.24 ± 0.01[a]	20.11	2.98 ± 0.01[b]	18.26
Fat score (points)	5.87 ± 0.011[a]	6.77	5.66 ± 0.005[b]	3.03
pH				

Note. a b – significant differences between the study groups, p ≤ 0.05.



The percentage of pH in bull and heifer meat

Soidla R et al. 2019). These studies were conducted on a relatively small number of animals, mainly on study farms, where stress factors could be minimized both on the farm, during transportation and before slaughter.

Upon the conduct of the analysis of the effect of age on changes in pH according to the group of sex, it was found that in the bulls' group pH in meat did not differ significantly in different ages (Table 3). The average pH of the meat was between 5.85 and 5.88.

The pH of the meat obtained from heifers ranged from 5.63 to 5.69. The highest pH in meat was found in the group above 24 months of age – 5.69, which was by 0.03 higher than in the age group of 18 to 23 months and by 0.06 higher than in the age group 12–17 months ($p \leq 0.05$). A study conducted by Weglarz A (2010) showed that beef from cows slaughtered during the winter and summer season was higher than that of heifers (> 5.8). In heifer meat, pH < 5.8 was present in 72.5% of cases in the winter season and over 86% in the summer season. The percentage of cow meat at the desired pH value was only 46.75% during the winter season, but only slightly above 30% of carcasses met the desired value of pH during the summer season. The results have shown that, as the age of female beef cattle increases, they respond to

Table 3. pH value indicators in beef cattle meat in study groups of different age and sex

Age group	Bulls		Heifers	
	$x \pm Sx$	v, %	$x \pm Sx$	v, %
12–17 months	5.88 ± 0.02	6.87	5.63 ± 0.01[a]	2.93
18–23 months	5.85 ± 0.02	6.68	5.66 ± 0.01[b]	2.83
>24 months	5.87 ± 0.06	6.13	5.69 ± 0.01[c]	3.47

Note. a b c – significant differences between the study groups, $p \leq 0.05$.

Table 4. Pearson correlation coefficients between the features of pH and of slaughter results

Group	Age	Live weight	Slaughter weight	Dressing percentage	Conformation score	Fat
			pH			
Total (n = 2469)	–0.10	0.06	0.06	0.02	–0.05	–0.21 *
bulls	–0.02	–0.02	–0.04	–0.05	–0.09 *	–0.0004
heifers	0.13 *	–0.05	–0.06	–0.04	–0.10 *	–0.08 *

Note. $p \leq 0.05$.

different changes more sensitively and suffer more from the effects of stress.

An analysis of the correlation between the features of pH and of slaughter results showed weak or non–existent relationships (Table 4). In the overall study group, a closer correlation was observed between the features of pH and of fat score, nevertheless, it was weak (-0.21), but significant ($p < 0.05$).

A study by Weglarz A (2010a) shows similar Pearson correlation results between the features of pH and of slaughter results – the correlations obtained were weak or did not exist. A study conducted by Mach N et al (2008) results showed that fat score had a significant relationship with pH – the higher the fat score value, the smaller the number of cases with increased pH was identified. Conformation score was also in correlation with pH – the lower the conformation score, the higher the growth of the number of cases with increased pH.

CONCLUSIONS

The biggest weight before slaughter, slaughter weight and dressing percentage showed bulls' group, but heifers' group obtained highest fat score.

In the group of bulls, the average pH value was 5.87, while in the group of heifers it was 5.66 ($p \leq 0.05$). 35 % of the carcasses of bulls had an increased pH of ≥5.90, but in the heifers' group, an increased pH has been identified in only 13 % of the carcasses. An increased pH means that these carcasses will only be used for the production of processed products, thus the creation of lower–value products.

Based on the analysis of the effect of age, we can conclude that the age of the bulls did not have a significant effect on the pH value, but the findings in the group of heifers show that pH increased with the age, while remained within the required limits for the obtainment of quality meat.

Adherence to ethical principles. All the European Union and national principles of caring for animals and using them have been complied with.

Conflict of interests. The authors declare that they have no conflict of interests.

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Вплив статі та віку великої рогатої худоби на pH яловичини

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Мета. Метою дослідження було пояснити різницю між значеннями pH яловичини від телиць та бичків і провести аналіз впливу віку у групах тварин обох статей. **Методи.** Дослідження містить дані щодо 2 469 представників порід великої рогатої худоби та їхніх гібридів, яких відгодовували у господарствах Латвії та Литви і забивали на сертифікованій бійні «Agaras», Литва, у 2018 р. З метою оцінки впливу статі велику рогату худобу поділили на дві групи дослідження: 1 266 бичків та 1 203 телиць. Для аналізу впливу віку було створено три групи дослідження: 12–17 місяців; 18–23 місяців; 24 і більше місяців. Аналіз отриманих даних ґрунтувався на показниках описової статистики. Були використані t-критерій Стьюдента та коефіцієнт кореляції Пірсона. **Результати.** Середнє значення pH м'яса бичків становило 5,87 ± 0,011, а м'яса, отриманого від телиць, – 5,66 ± 0,005 ($p \leqslant 0,05$). У межах бажаних значень pH від 5,4 до 5,8, група бичків складала 65 % туш, а група телиць – 86 % туш. У групі бичків, 35 % туш мали підвищене значення pH м'яса (pH – ≥ 5,9), у той час як у групі телиць – 13 %. У невеликій частині туш з обох груп дослідження було виявлено занадто низьке значення pH м'яса (pH ≤ 5,3) – 1 % у групі бичків і 0,4 % у групі телиць. Аналіз впливу віку не виявив значних відмінностей між значеннями pH щодо бичків різного віку. Що стосується групи телиць, найвище значення pH м'яса було виявлено у групі віком понад 24 місяці, pH – 5,69. Аналіз кореляції між значеннями pH м'яса та результатами забою продемонстрував слабкий або відсутній зв'язок. Загалом у групі дослідження було помічено сильніший зв'язок між показниками pH та жирності ($r = –0,21$, $p < 0,05$). **Висновки.** Результати вказують на те, що м'ясо телиць має кращу якість у плані бажаних значень pH. М'ясо з бажаними показниками pH можна використовувати у виробництві високоякісної продукції, що забезпечить більший прибуток.

Ключові слова: велика рогата худоба, м'ясо, pH, вік, стать.

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