*Animal Science Papers and Reports* vol. 27 (2009) no. 4, 293-302
Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

# Quality of meat from young bulls in relation to its ultimate pH value

**Tomasz Daszkiewicz*, Stanisław Wajda, Dorota Kubiak, Joanna Krasowska**

Department of Commodity Science of Animal Raw Materials,
University of Warmia and Mazury in Olsztyn,
Oczapowskiego 5, 10-719 Olsztyn, Poland

*(Received September 22, 2008; accepted September 10, 2009)*

**Samples of *longissimus dorsi* muscle were analysed from two groups of young cattle: 71 Polish Holstein-Friesian Black-and-White bulls (PHF) and 79 bulls, crossbreds of PHF dams with Limousine sires (PHF×L). Within each of two groups the samples were divided into four subgroups based upon the value of meat ultimate pH ($pH_u$) measured 48 h post-slaughter: ≤5.4, 5.5-5.7, 5.8-6.0 and >6.0. It was found that an increase in meat $pH_u$ was accompanied by a decrease in dry matter content of meat of both groups, and in the content of total protein in crossbreds. Lower meat $pH_u$ was accompanied by a higher concentration of soluble protein. Determination of the non-protein nitrogen content of meat revealed its lowest concentration in samples with $pH_u$ ≤5.4 and 5.8-6.0 in PHF bulls, and in samples with $pH_u$ ≤5.4 and >6.0 in crossbreds. Meat with highest $pH_u$ was darkest in colour and showed lower water-holding capacity. Meat with the highest ultimate pH received the highest scores for sensory properties.**

**KEY WORDS: bulls / meat quality /ultimate pH**

Meat pH, as affected by post-mortem glycolysis in muscle tissue, has a profound influence on meat quality since it determines traits responsible for the processing suitability and eating attributes of meat [van Laack *et al*. 2001]. This is also the simplest parameter characterizing the course of post-mortem changes in muscles. Thus, the determination of pH is applied in practice to detect meat quality deviations [Byrne *et al*. 2000].

*Corresponding author: tomasz.daszkiewicz@uwm.edu.pl

In the light of reference data [Kortz 2001], quality differences between the meat classified as "defective" and "normal" are obvious. However, some meat samples may show intermediate quality values. The results of earlier experiments indicate that beef with $pH_u$ within the range of 5.8 to 6.2 is characterized by intermediate values between normal-quality ($pH_u$ 5.4-5.8) and DFD meat ($pH_u \geq 6.2$) with respect to colour, palatability and water-holding capacity, as well as by lower tenderness [Purchas 1990, Silva *et al*. 1999, Obanor *et al*. 2001, Jeleníková *et al*. 2008]. Therefore, a question arises whether the above relationship can be considered a general rule, and to what degree it may determine the eating quality of beef.

The objective of this study was to analyse the effect of different ultimate pH ($pH_u$) values on the quality of meat from young Polish Holstein-Friesian Black-and-White (PHF) and crossbred (PHF × Limousine) bulls.

## Material and methods

Samples of the *longissimus dorsi* muscle were collected at random from 71 carcass-sides of Polish Holstein-Friesian Black-and-White (PHF) bulls and 79 carcass-sides of crossbred bulls from mating PHF dams to Limousine sires (PHF×L.).

The animals were purchased by the "Morliny" Meat Plant during three weeks of September. Crossbreds were identified based on their characteristic coat colour and mating records of dams. Prior to slaughter the animals were kept at the lairage for 20-24 hours. Slaughter and post-slaughter processing was carried out in accordance with the regulations binding in the meat industry.

The following determinations were made on carcasses chilled to 3°C over 48 h.

- cold carcass weight, accurate to 0.1 kg (the analysis covered carcasses weighing 210-240 kg in the PHF group, and 270-300 kg in the crossbred group);
- ultimate pH of *longissimus dorsi* muscle ($pH_u$) measured 48 h post-slaughter between the last and before the last thoracic vertebra, with the use of a Double Pore combination electrode (Hamilton) and a pH 340i pH-meter with a TFK 150/E temperature sensor (WTW). In order to determine the effect of different values of $pH_u$ on meat quality, samples were divided into four subgroups subject to $pH_u$ value, as follows: ≤5.4, 5.5-5.7, 5.8 -6.0, and 6.0. The numbers of meat samples in particular groups are given in Table 1.

Samples of *longissimus dorsi* muscle of approximately 300 g were collected from chilled right carcass-sides, in the area of the last three thoracic vertebrae. The samples were vacuum-packed in polyamide/polyethylene (PA/PE) bags and transported to the laboratory in an isothermal container.

A laboratory analysis was performed on vacuum-packed samples stored at 0 to 2°C for three days. Meat colour (1 point – light, 8 points – dark) and marbling (1 point – invisible, 5 points – very strong) were determined on fresh (15 minutes) cross-section areas of the samples. Next, part of each sample was used for the sensory evaluation, and the remaining was thoroughly minced in order to determine the basic

**Table 1.** Number of LD samples within each of four ultimate pH ($pH_u$) subgroups

| Animals | | $pH_u$ subgroup of LD muscle (48 h *post-mortem*) | | | |
|---|---|---|---|---|---|
| | | ≤5.4 | 5.5-5.7 | 5.8-6.0 | >6.0 |
| PHF bulls[1] | number | 3 | 12 | 4 | 52 |
| | % | 4.23 | 16.90 | 5.63 | 73.24 |
| Crossbred bulls[2] | number | 14 | 10 | 13 | 42 |
| | % | 17.72 | 12.66 | 16.46 | 53.16 |

LD – *longissimus dorsi* muscle.
[1]Polish Holstein-Friesian Black-and-White.
[2]Polish Holstein-Friesian Black-and-White × Limousine.

chemical composition and physico-chemical properties of meat. The sensory properties of cooked meat [Znaniecki *et al*. 1983], namely aroma, palatability, juiciness and tenderness, were estimated by five panelists according to Polish Standard [1998] on a five-point scale (1 point – the worst, 5 points – the best). Moreover, the following determinations were made: chemical composition of meat (dry matter, total protein, soluble protein, non-protein nitrogen, fat, ash) – with conventional methods [AOAC 1990]; physico-chemical properties of meat (pH – in water homogenates of meat, at the meat to distilled water ratio of 1:1; colour brightness – based on light reflection (%) from the surface of minced meat, measured with a SPEKOL spectrophotometer with a R45/0 remission attachment, at a wavelength of 560 nm; water-holding capacity – with the Grau and Hamm method [Van Oeckel *et al*. 1999].

In order to determine the effect of $pH_u$ on meat quality, the results were verified statistically by one-factor analysis of variance, using STATISTICA [2005] data analysis software system, version 7.1. A one-factor analysis of variance in a non-orthogonal design was performed separately for PHF and crossbred bulls, to eliminate the impact of their different carcass weight on meat quality. The significance of differences between group means was identified with the Duncan's test.

### Results and discussion

Higher $pH_u$ was accompanied by a decrease in the dry matter content of meat (Tab. 2). However, significant differences between group means were identified only in crossbreds. No significant (P>0.05) differences were found between meat samples with various pH levels with respect to the content of ash and fat, and rate of marbling. However, meat with $pH_u$ >6.0 had a lower intramuscular fat content. The total protein content of meat in crossbred bulls characterized by various pH values, remained at a similar level (P>0.05). Relatively small inter-subgroup differences regarding total protein content of meat were also noted in PHF group. In this group, the difference between the highest and the lowest protein content of meat with pH 5.8-6.0 and pH ≤5.4 reached 1.10 per cent points (pp), and only this difference was found to be significant (P≤0.05).

**Table 2.** Proximate chemical composition (%) and marbling (points) of LD samples as related to ultimate pH ($pH_u$) values

| Compound | Animals | | $pH_u$ subgroup of LD (48 h *post-mortem*) ≤5.4 | 5.5-5.7 | 5.8-6.0 | >6.0 |
|---|---|---|---|---|---|---|
| Dry matter | PHF bulls[1] | mean | 25.69 | 25.19 | 24.58 | 24.08 |
| | | SD | 2.15 | 2.71 | 0.55 | 1.65 |
| | crossbred bulls[2] | mean | 25.72$^{Aa}$ | 25.36$^{B}$ | 24.71$^{a}$ | 23.84$^{AB}$ |
| | | SD | 0.77 | 0.92 | 1.53 | 1.36 |
| Fat | PHF bulls[1] | mean | 2.30 | 2.35 | 1.58 | 1.52 |
| | | SD | 1.59 | 1.90 | 0.61 | 1.21 |
| | crossbred bulls[2] | mean | 1.71 | 1.82 | 1.92 | 1.44 |
| | | SD | 1.12 | 1.00 | 1.56 | 0.87 |
| Marbling | PHF bulls[1] | mean | 1.83 | 2.17 | 2.13 | 1.77 |
| | | SD | 1.04 | 1.17 | 0.85 | 0.91 |
| | crossbred bulls[2] | mean | 2.18 | 1.95 | 2.35 | 2.00 |
| | | SD | 0.70 | 0.60 | 1.13 | 0.95 |
| Crude protein | PHF bulls[1] | mean | 20.80$^{a}$ | 21.32 | 21.90$^{a}$ | 21.51 |
| | | SD | 0.18 | 0.62 | 0.62 | 0.80 |
| | crossbred bulls[2] | mean | 21.84 | 21.69 | 21.47 | 21.45 |
| | | SD | 0.66 | 0.76 | 0.42 | 0.93 |
| Soluble protein | PHF bulls[1] | mean | 4.73$^{A}$ | 5.73$^{a}$ | 5.27$^{B}$ | 7.00$^{ABa}$ |
| | | SD | 1.07 | 0.76 | 0.45 | 0.90 |
| | crossbred bulls[2] | mean | 5.49$^{Aa}$ | 6.09$^{Ba}$ | 5.94$^{C}$ | 6.90$^{ABC}$ |
| | | SD | 0.42 | 0.81 | 0.77 | 0.76 |
| Non-protein nitrogen | PHF bulls[1] | mean | 0.400 | 0.427$^{a}$ | 0.385$^{ab}$ | 0.428$^{b}$ |
| | | SD | 0.046 | 0.038 | 0.017 | 0.033 |
| | crossbred bulls[2] | mean | 0.410$^{a}$ | 0.459$^{ab}$ | 0.427 | 0.413$^{b}$ |
| | | SD | 0.069 | 0.037 | 0.039 | 0.043 |
| Ash | PHF bulls[1] | mean | 1.19 | 1.10 | 1.18 | 1.12 |
| | | SD | 0.12 | 0.09 | 0.18 | 0.10 |
| | crossbred bulls[2] | mean | 1.18 | 1.18 | 1.14 | 1.14 |
| | | SD | 0.15 | 0.10 | 0.10 | 0.13 |

LD – *longissimus dorsi* muscle.
[1]Polish Holstein-Friesian Black-and-White.
[2]Polish Holstein-Friesian Black-and-White × Limousine.
$^{aA...}$Within rows means bearing the same superscripts differ significantly at: small letters – $P \leq 0.05$; capitals – $P \leq 0.01$.

Available literature vary widely with regard to the proximate composition of meat differing in pH. McLounghlin and Goldspink [1963] reported no significant differences in the dry matter content between the normal-quality pork and pork with low pH. Aaslyng *et al*. [2003] in beef, and Sobina [1998] in pork noted a higher dry matter content of meat with low pH. A lower fat content of meat of high pH, observed in the present study, corroborates the results obtained by Meller *et al*. [1998], but contradicts the findings of Aaslyng *et al*. [2003] who reported the opposite relation. Aaslyng *et al*. [2003] and Meller *et al*. 1998] also demonstrated that meat with low acidity is characterized by a lower total protein content, which corresponds to the present results, but only with reference to crossbreds.

The highest significant (P≤0.05 and P≤0.01) intergroup difference in soluble protein concentration was observed in meat with $pH_u$ >6.0, while the lowest – in meat with $pH_u$ ≤5.4. The relation between the $pH_u$ and the soluble protein content of beef could be a consequence of a decrease in the ionic activity of protein and its lower solubility at high acidity. Moreover, rapid and profound acidification of muscle tissue may lead to partial protein denaturation, thus decreasing protein solubility in water [Honikel and Kim 1985].

In PHF bulls the non-protein nitrogen content was lowest in meat of the highest acidity ($pH_u$ ≤5.4) as well as in meat with $pH_u$ 5.8-6.0. In crossbreds, the lowest non-protein nitrogen concentration was found in meat with the lowest and highest acidity. A lower non-protein nitrogen content of PSE and DFD porcine meat, compared to that with normal pH, was also observed by Sobina [1998]. Lower content of non-protein nitrogen may be indicative of a slower rate of protein degradation, resulting from reduced activity of proteolytic non-lysosomal (calpains) and lysosomal (cathepsins) enzymes of meat with low and high pH, respectively [Schwagele 1999].

**Table 3.** Physico-chemical properties of LD samples as related to ultimate pH ($pH_u$) values

| Trait | Animals | | $pH_u$ subgroup of LD (48 h *post-mortem*) | | | |
|---|---|---|---|---|---|---|
| | | | ≤5.4 | 5.5-5.7 | 5.8-6.0 | >6.0 |
| $pH_{48}$ | PHF bulls[1] | mean | $5.32^{Aa}$ | $5.60^{Ba}$ | $5.85^{A}$ | $6.50^{AB}$ |
| | | SD | 0.05 | 0.06 | 0.06 | 0.21 |
| | crossbred bulls[2] | mean | $5.34^{A}$ | $5.58^{A}$ | $5.90^{A}$ | $6.52^{A}$ |
| | | SD | 0.04 | 0.07 | 0.09 | 0.19 |
| $pH_{120}$ | PHF bulls[1] | mean | $5.33^{Aa}$ | $5.63^{Ba}$ | $5.83^{A}$ | $6.54^{AB}$ |
| | | SD | 0.06 | 0.08 | 0.05 | 0.24 |
| | crossbred bulls[2] | mean | $5.36^{A}$ | $5.60^{A}$ | $5.91^{A}$ | $6.54^{A}$ |
| | | SD | 0.06 | 0.08 | 0.10 | 0.22 |
| Colour brightness | PHF bulls[1] | mean | $14.67^{Aa}$ | $12.17^{ab}$ | $12.75^{c}$ | $9.90^{Abc}$ |
| | | SD | 1.53 | 1.80 | 1.89 | 1.75 |
| | crossbred bulls[2] | mean | $13.07^{A}$ | $12.00^{a}$ | $12.08^{b}$ | $10.33^{Aab}$ |
| | | SD | 2.20 | 1.94 | 2.40 | 1.32 |
| Colour (points) | PHF bulls[1] | mean | $4.67^{AC}$ | $5.25^{B}$ | $6.00^{C}$ | $6.65^{AB}$ |
| | | SD | 0.76 | 1.08 | 0.41 | 0.76 |
| | crossbred bulls[2] | mean | $4.29^{ABa}$ | $5.60^{Ab}$ | $5.12^{Ca}$ | $6.50^{BCb}$ |
| | | SD | 0.97 | 1.15 | 1.21 | 0.74 |
| Water holding capacity ($cm^2$) | PHF bulls[1] | mean | $8.47^{A}$ | $7.05^{a}$ | $6.96^{b}$ | $5.38^{Aab}$ |
| | | SD | 1.34 | 1.20 | 1.34 | 1.25 |
| | crossbred bulls[2] | mean | $8.54^{Aab}$ | $7.30^{Ba}$ | $7.37^{Cb}$ | $5.56^{ABC}$ |
| | | SD | 2.06 | 0.82 | 1.38 | 1.54 |

LD – *longissimus dorsi* muscle.
[1]Polish Holstein-Friesian Black-and-White.
[2]Polish Holstein-Friesian Black-and-White × Limousine.
[aA...]Within rows means bearing the same superscripts differ significantly at: small letters – P≤0.05; capitals – P≤0.01.

Table 3 presents the physico-chemical properties of meat. The differences between the mean pH values of meat determined in particular $pH_u$ subgroups were statistically confirmed. Meat with the highest $pH_u$ (> 6.0) was characterized by the darkest colour and the highest water-holding capacity, while that with the lowest acidity (pH≤5.4) - by the lightest colour and the lowest water-holding capacity. The results of an assessment of the colour and water-holding capacity of meat with various pH are in accordance with Seideman *et al*. [1984], Meller *et al*. [1998], and Sobina [1998]. Seideman *et al*. [1984] reported that if the ultimate pH of meat is high, the physical state of proteins will be above their iso-electric point. Proteins will associate with more water in the muscle and moreover fibres will be tightly packed. Therefore, such meat is dark because its surface does not scatter light to the same extent as the more open surface of meat with lower $pH_u$.

**Table 4.** Sensory properties of LD samples as related to ultimate pH ($pH_u$) values

| Trait | Animals | | $pH_u$ subgroup of LD (48 h *post-mortem*) | | | |
|---|---|---|---|---|---|---|
| | | | ≤5.4 | 5.5-5.7 | 5.8-6.0 | >6.0 |
| Aroma – density | PHF bulls[1] | mean | 5.00 | 4.83 | 5.00 | 4.99 |
| | | SD | 0.00 | 0.39 | 0.00 | 0.07 |
| | crossbred bulls[2] | mean | 4.96 | 5.00 | 4.96 | 5.00 |
| | | SD | 0.13 | 0.00 | 0.14 | 0.00 |
| Aroma – desirability | PHF bulls[1] | mean | 5.00 | 5.00 | 5.00 | 4.93 |
| | | SD | 0.00 | 0.00 | 0.00 | 0.24 |
| | crossbred bulls[2] | mean | 4.93 | 5.00 | 4.96 | 5.00 |
| | | SD | 0.18 | 0.00 | 0.14 | 0.00 |
| Taste intensity | PHF bulls[1] | mean | 4.33 | $4.13^{a}$ | $3.88^{A}$ | $4.80^{Aa}$ |
| | | SD | 0.58 | 0.68 | 0.48 | 0.47 |
| | crossbred bulls[2] | mean | $4.23^{a}$ | 4.55 | $4.42^{b}$ | $4.90^{ab}$ |
| | | SD | 0.43 | 0.76 | 0.73 | 0.34 |
| Taste desirability | PHF bulls[1] | mean | 4.33 | $4.13^{a}$ | 4.25 | $4.80^{a}$ |
| | | SD | 0.58 | 0.68 | 0.29 | 0.47 |
| | crossbred bulls[2] | mean | $4.21^{A}$ | $4.50^{a}$ | $4.46^{b}$ | $4.90^{Aab}$ |
| | | SD | 0.51 | 0.67 | 0.69 | 0.34 |
| Tenderness | PHF bulls[1] | mean | $4.50^{a}$ | $3.88^{Aa}$ | $4.00^{B}$ | $4.79^{AB}$ |
| | | SD | 0.50 | 0.57 | 0.71 | 0.44 |
| | crossbred bulls[2] | mean | $4.14^{A}$ | $4.25^{B}$ | $4.23^{C}$ | $4.93^{ABC}$ |
| | | SD | 0.82 | 0.92 | 0.70 | 0.21 |
| Juiciness | PHF bulls[1] | mean | $4.33^{a}$ | $3.67^{Aa}$ | 4.25 | $4.70^{A}$ |
| | | SD | 0.58 | 0.62 | 0.29 | 0.52 |
| | crossbred bulls[2] | mean | $4.07^{A}$ | $4.15^{B}$ | $4.15^{C}$ | $4.80^{ABC}$ |
| | | SD | 0.55 | 0.71 | 0.66 | 0.40 |

LD *longissimus dorsi* muscle.
[1]Polish Holstein-Friesian Black-and-White.
[2]Polish Holstein-Friesian Black-and-White × Limousine.
[aA...]Within rows means bearing the same superscripts differ significantly at: small letters – $P \le 0.05$; capitals – $P \le 0.01$.

Table 4 illustrates the results of an evaluation of the sensory properties of meat. The best palatability was reported for meat with $pH_u$ >6.0. PHF bulls' meat with $pH_u$ ranging from 5.5 to 5.7 and from 5.8 to 6.0, and the most acidic meat from crossbreds (pH ≤5.4) received the lowest scores for this trait. Significant differences were identified between the means for groups given the highest and lowest scores for palatability. The present results, similarly to those reported by Viljoen *et al*. [2002], do not confirm the opinion by Kortz [2001] that DFD meat is characterized by worse palatability than meat with normal pH value.

The distribution of mean scores for the meat tenderness and juiciness in relation to various $pH_u$ levels (Tab. 4) was similar to that determined for palatability. Meat with $pH_u$ >6.0 was characterized by best tenderness and juiciness. In PHF bulls, significant ($P \leq 0.01$) differences occurred with respect to tenderness between meat with $pH_u$ >6.0 and meat with $pH_u$ 5.5-5.7 and 5.8-6.0 which received the lowest scores. A significant ($P \leq 0.05$) difference was also observed between the tenderness of meat with $pH_u$ ≤5.4 and 5.5-5.7. As regards juiciness, significant differences were found between means for meat with $pH_u$ > 6.0 and 5.5-5.7 ($P \leq 0.01$) as well as for meat with $pH_u$ ≤5.4 and 5.5-5.7 ($P \leq 0.05$). In crossbreds, the differences between the mean values of tenderness and juiciness of meat with the lowest acidity and the mean scores for these traits determined for meat in the other pH ranges were found to be significant at $P \leq 0.01$.

The relation between the ultimate pH and tenderness of meat was also described by Purchas [1990] and Devine *et al*. [1993] who demonstrated that meat tenderness decreased along with an increase in $pH_u$ from 5.5 to 6.0, and increased when $pH_u$ exceeded 6.0. Purchas [1990] observed the lowest beef tenderness at $pH_u$ around 6.0. The reasons for these relationships are not clear. Geesink *et al*. [1992] suggested that $pH_u$ within the range of 5.8-6.3 is associated with lower activity of proteolytic enzymes (calpains and cathepsins) According to Obanor *et al*. [2001], the greater shear force of meat with such $pH_u$ may be related to the shorter sarcomers. Better juiciness of beef with high pH values could result from its higher water-holding capacity and lower water loss during thermal treatment [Guignot *et al*. 1994]. Higher scores for juiciness in meat with low acidity were reported also by Meller *et al*. [1998] and Sobina [1998].

The results of the present study show clear differences in the quality of meat in relation to its $pH_u$ measured 48 h post-slaughter, and classified as "defective" (PSE, DFD) *vs*. "normal". No significant differences were identified with respect to the physico-chemical and sensory properties of normal-quality meat, *i.e*. meat with $pH_u$ 5.5-5.7 and 5.8-6.0. Therefore, there is no need to divide normal-quality meat (with $pH_u$ 5.5 -6.0) into technological subgroups based on its acidity.

**REFERENCES**


1. AASLYNG M.D., BEJERHOLM C., ERTBJERG P., BERTRAM H.C., ANDERSEN H. 2003 – Cooking loss and juiciness of pork in relation to raw meat quality and cooking procedure. ***Food Quality and Preference*** 14, 277-288.
2. AOAC, 1990 – Official Methods of Analysis. 15th Edition. Association of Official Analytical Chemists, Washington, D.C.
3. BYRNE C.E., TROY D.J., BUCKLEY D.J., 2000 – Postmortem changes in muscle electrical properties of bovine *M. longissimus dorsi* and their relationship to meat quality attributes and pH fall. ***Meat Science*** 54, 23-34.
4. DEVINE C. E., GRAAFHUIS A.E., MUIR P.D., CHRYSTALL B.B., 1993 – The effect of growth rate and ultimate pH on meat quality of lambs. ***Meat Science*** 35, 63-77.
5. GEESINK G.H., OUALI A., SMULDERS F.I.M., TALMANT A., TASSY C., GUIGNOT F., VAN LAACK R.L.J.M., 1992 – The role of ultimate pH on proteolysis and calpain, and calpastatin activity in bovine muscle. ***Biochimie*** 74, 283-289.
6. GUIGNOT F., TOURAILLE C., OUALI A., RENERRE M., 1994 – Relationship between post-mortem pH changes and some traits of sensory quality in veal. ***Meat Science*** 37, 315-325.
7. HONIKEL K.O., KIM C.J., 1985 – Űber die ursachen der entstehung von PSE-schweinefleisch. ***Fleischwirtschaft*** 65, 1125-1131.
8. JELENÍKOVÁ J., PIPEK P., MIYAHARA M., 2008 – The effects of breed, sex, intramuscular fat and ultimate pH on pork tenderness. ***European Food Research and Technology*** 227, 989-994.
9. KORTZ J., 2001 – The chief defects of meat and methods of detection. ***Polish Journal of Food and Nutrition Sciences*** 10/51, 3(S), 6-10.
10. MCLOUNGHLIN I.V., GOLDSPINK C., 1963 – Post mortem changes in the colour of pig *longissimus dorsi* muscle. ***Nature*** 198, 584-587.
11. MELLER Z., DASZKIEWICZ T., BĄK T., KLUPCZYŃSKI J., 1998 – Zmiany składu podstawowego i cech fizykochemicznych podczas dojrzewania mięsa wołowego normalnego i z wadą DFD, pochodzącego od bydła zróżnicowanego genetycznie (Changes in the basic composition and physical and chemical properties during the ripening of „normal" and DFD meat coming from genetically different cattle). In Polish, summary in English. ***Acta Academiae Agriculturae ac Technicae Olstenensis,*** Zootechnica 48, 63-70.
12. OBANOR F., MORTON J. D., GESSINK G., BICKERSTAFFE R., 2001 – Effect of pre-slaughter stress on beef quality. Proceedings of the 47th International Congress of Meat Science and Technology, August 26-31, Cracow, Poland, Volume I, 272-273.
13. Polish Standard PN-ISO 4121, 1998 – Analiza sensoryczna. Metodologia. Ocena produktów żywnościowych przy użyciu metod skalowania (Sensory analysis. Methodology. Evaluation of food products by methods using scales). In Polish.
14. PURCHAS R.W., 1990 – An assessment of the role of pH differences in determining the relative tenderness of meat from bulls and steers. ***Meat Science*** 27, 129-140.
15. SEIDEMAN S.C., CROSS H.R., SMITH G.C., DURLAND P.R., 1984 – Factors affecting fresh meat colour: a review. ***Journal of Food Quality*** 6, 211-237.
16. SCHWÄGELE F., 1999 – Kühlung, Kühllagerung und Fleischreifung. Chemische und physikalische Grundlagen – 2. Biochemische Vorgänge. ***Fleischwirtschaft*** 6, 103-106.
17. SILVA J.A., PATARATA L., MARTINS C. 1999 – Influence of ultimate pH on bovine meat tenderness during ageing. ***Meat Science*** 52, 453-459.

18. SOBINA I., 1998 – Badania zmian jakości mięsa wieprzowego normalnego i wadliwego (PSE i DFD) w procesie autolizy w zależności od temperatury składowania (Changes in the quality of normal, PSE and DFD pork in the process of autolysis, depending on different temperatures of storage). Thesis. In Polish. Published by the Agricultural University in Olsztyn. ***Rozprawy Habilitacyjne i Monografie*** 1.
19. StatSoft, Inc., 2005 – STATISTICA (data analysis software system), version 7.1. www.statsoft.com.
20. VAN LAACK R.L.J.M., KAUFFMAN R.G., GREASER M.L., 2001 – Determinants of ultimate pH of meat. Proceedings of the 47th International Congress of Meat Science and Technology, August 26-31, Cracow, Poland, Volume I, 22-26.
21. VAN OECKEL, M.J., WARNANTS, N. BOUCQUEÉ, CH.V., 1999 – Comparison of different methods for measuring water holding capacity and juiciness of pork versus on-line screening methods. ***Meat Science*** 51, 313-320.
22. VILJOEN H.F., DE KOCK H.L., WEBB E.C., 2002 – Consumer acceptability of dark, firm and dry (DFD) and normal pH beef steaks. ***Meat Science*** 61, 181-185.
23. WICHŁACZ H., KRZYWICKI K., 1986 – Barwa mięsa wołowego (The beef colour). In Polish. ***Gospodarka Mięsna*** 2, 16-18.
24. ZNANIECKI P. (editor), 1983 – Zarys obrotu, oceny i przetwórstwa surowców pochodzenia zwierzęcego (Outline of Turnover, Evaluation and Processing of Animal Raw Materials). In Polish. PWRiL, Warszawa, 221-237.

Tomasz Daszkiewicz, Stanisław Wajda,
Dorota Kubiak, Joanna Krasowska

## Zależność między końcowym pH mięsa buhajków ($pH_u$) a jego jakością

Streszczenie

Badania przeprowadzono na próbkach mięśnia najdłuższego grzbietu buhajków rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej (PHF) oraz mieszańców uzyskanych z krzyżowania krów rasy PHF z buhajami rasy limousine (odpowiednio 71 i 79 zwierząt). Na podstawie wartości $pH_u$ oznaczonej po 48 godzinach od uboju wyodrębniono cztery grupy próbek: pH ≤5,4, 5,5-5,7, 5,8-6,0 i >6,0. Wraz ze wzrostem wartości $pH_u$ mięsa obu grup obserwowano w nim tendencję do obniżania się % suchej masy, a w mięsie mieszańców również białka ogólnego. Mniejszej kwasowości mięsa towarzyszył wzrost zawartości w nim białka rozpuszczalnego. Najniższy udział azotu niebiałkowego w mięsie buhajków rasy PHF stwierdzono w próbkach o $pH_u$ ≤5.4 i 5.8-6.0, natomiast w mięsie mieszńców – w próbkach o $pH_u$ ≤5.4 i >6.0. Mięso o wyższych wartościach $pH_u$ odznaczało się ciemniejszą barwą i mniejszym wyciekiem soku. Najlepszą jakością w ocenie sensorycznej charakteryzowało się mięso o najmniejszym zakwaszeniu.