

## **Physico-chemical and sensory properties of meat from Black-and-White and Black-and-White × Limousine heifers differing in intramuscular fat content**

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The study was performed on samples of the *longissimus dorsi* muscle (LD) of 71 Black-and-White (BW) and 50 crossbred BW x Limousine (BWL) heifers. The samples were divided into five groups, depending on the intramuscular fat (IMF) content – ≤1.00, 1.01-2.00, 2.01-3.00, 3.01-4.00 and >4.00%. An increase in the IMF content of LD was accompanied by a decrease in the number of samples with pH<sub>u</sub> higher than 6.0. In the meat from BW heifers (characterized by lower pH<sub>u</sub> variation) an increase in the IMF level positively affected palatability, juiciness and tenderness. In meat from BWL crossbreds (characterized by wider pH<sub>u</sub> variation) the sensory properties depended to a higher degree on pH<sub>u</sub> than on IMF content.

**KEY WORDS:** heifers / intramuscular fat / *longissimus dorsi* / meat quality

The level of intramuscular fat (IMF) affects the quality of meat, especially its sensory properties [Eikelenboom *et al.* 1996, Park *et al.* 2001, Wichłacz *et al.* 1998]. However, according to Bejerholm and Barton-Gade [1986] the relation is not linear. A higher fat content of meat is believed to limit, in a mechanical way, water “release” outside muscle fibres while heating and chewing, as well as to stimulate saliva secretion which leads to the impression of juiciness during chewing [Davis 1975, Grabowski 1993]. The content (%) and composition (the level of estrified and free fatty acids, saturated and unsaturated) of IMF as well as quality and quantity of compounds formed as a result of its chemical and biochemical changes taking place both during storage and heat treatment also determine the palatability traits of meat [Mottram and Edwards 1983, Campo *et al.* 2001].

Despite the prevailing opinion that IMF positively affects meat quality, some authors question the relation between a high IMF content and sensory characteristics of meat, or emphasize the significant effect of other factors on the trait [Göransson *et al.* 1992, Eikelenboom *et al.* 1996, Homer *et al.* 1997]. In light of this, the relationship between the meat IMF level or composition and meat quality requires further investigation.

The aim of the present study was to evaluate the physico-chemical and sensory properties of young beef as related to its IMF content.

### Material and methods

Samples of the *longissimus dorsi* muscle (LD) were randomly collected from carcass-sides of 71 Black-and-White (BW) and 50 BW × Limousine (BW cows × Limousine bulls – BWL) crossbred heifers purchased by the Meat Plant MORLINY for further processing. The carcass weight varied from 210 to 300 kg.

LD samples, about 400 g each, were taken from chilled (48 h at 0–4°C) right carcass-sides, from the region of the last three thoracic vertebra and stored under vacuum in polyethylene (PA/PE) bags at 0–2°C. Laboratory analyses were made after three days of cold storage. Fresh (after about 15 min.) cross-section areas of the samples were used for scoring meat colour (1 point – light, 8 points – dark). Another part of sample was minced and used for determination of the per cent of intramuscular fat (IMF) with Soxhlet method, ultimate pH ( $\text{pH}_v$ ) in water homogenates using the 1:1 meat to distilled water ratio (RADIOMETER, GK 2311C electrode), color lightness (spectrophotometer SPECOL with a remission attachment R 45/O, 560 nm wavelength) and the water holding capacity (WHC) with the Grau and Hamm method [Van Oeckel *et al.* 1999]. The remaining part of a sample was used for a panel evaluation of taste. The sensory properties (aroma, palatability, juiciness and tenderness) of cooked meat [Znaniecki 1983] were evaluated on a 5-point scale (1 point – the worst, 5 points – the best) following the Polish Standard [PN-ISO 4121, 1998] procedure.

The samples were divided into five groups, depending on their IMF content, to determine the effect of IMF on meat quality traits examined (Tab. 1).

Table 1. Number (n) and per cent of heifers arranged according to intramuscular fat content (IMF) of *longissimus dorsi* muscle

Heifers		IMF (%)				
		≤1.00	1.01-2.00	2.01-3.00	3.01-4.00	≥4.00
BW	n	4	9	13	15	30
	%	5.63	12.68	18.31	21.13	42.25
BWL	n	5	9	12	7	17
	%	10.00	18.00	24.00	14.00	34.00

BW – Black-and-White.

BWL – BW × Limousine.

The statistical evaluation of results was performed separately for BW and BWL heifers, applying a one-factor analysis of variance in a non-orthogonal design. The significance of differences between means for groups was identified with the Duncan test. The calculations were done using the computer programme STATISTICA 6.0.

**Results and discussion**

The IMF content of meat from randomly selected heifers coming from mass purchase appeared relatively high – 63.38% of samples from BW and 48.00% from BWL heifers contained more than 3% IMF (Tab. 1). According to the assumption made, the mean IMF content of meat was increasing by about 1 per cent point (pp) in successive groups (Tab. 2). Only in the group of samples containing more than 4.0% IMF the increase was much higher, due to the wide variation in this group, caused by lack of its upper border.

The pH<sub>u</sub> means of LD from BW heifers varied from 5.71 to 5.85 (Tab. 2). Much wider variation (significant differences between means for groups) was noted in pH<sub>u</sub> of meat from BWL crossbreds – from 5.54 to 6.10. An increase in the IMF content of

Tab. 2. Mean intramuscular fat (IMF) content and physico-chemical properties of longissimus dorsi muscle

Item	Heifer		IMF (%)				
			≤1.00	1.01-2.00	2.01-3.00	3.01-4.00	>4.00
IMF (%)	BW	mean	0.74 <sup>ab</sup>	1.56 <sup>a</sup>	2.44 <sup>c</sup>	3.53 <sup>ab</sup>	6.19 <sup>abcd</sup>
		SD	0.02	0.19	0.28	0.33	1.51
	BWL	mean	0.73 <sup>abc</sup>	1.58 <sup>a</sup>	2.35 <sup>c</sup>	3.42 <sup>abcd</sup>	6.20 <sup>abcd</sup>
		SD	0.41	0.34	0.27	0.24	1.33
pH <sub>u</sub>	BW	mean	5.85	5.71	5.78	5.73	5.72
		SD	0.07	0.38	0.30	0.33	0.25
	BWL	mean	6.10 <sup>abcd</sup>	5.71 <sup>a</sup>	5.60 <sup>b</sup>	5.57 <sup>c</sup>	5.54 <sup>d</sup>
		SD	0.44	0.42	0.42	0.23	0.14
Color lightness (%)	BW	mean	12.50	11.78	11.62	12.27	12.20
		SD	0.71	2.22	1.89	1.68	1.95
	BWL	mean	10.67	12.11	11.67	12.86	12.35
		SD	1.53	1.90	1.47	1.68	1.84
Color (points)	BW	mean	4.75	5.17	5.50	5.23	5.00
		SD	1.77	0.75	0.65	0.73	0.97
	BWL	mean	5.50	5.11	5.25	4.34	5.00
		SD	0.50	0.99	0.78	0.80	0.85
Water holding capacity (cm <sup>3</sup> )	BW	mean	7.44	7.67	7.95	7.20	7.00
		SD	0.24	1.72	1.17	1.61	1.20
	BWL	mean	5.45 <sup>ab</sup>	6.39	7.86 <sup>a</sup>	7.44 <sup>a</sup>	6.59
		SD	1.19	1.84	1.27	1.05	1.34

BW - Black-and-White.

BWL - BW × Limousine.

<sup>ab</sup> Within rows means bearing the same superscript differ significantly at: capital - P ≤ 0.01;

<sup>a</sup> small letter - P ≤ 0.05.

Tab le 3. Share of longissimus dorsi samples with pH<sub>u</sub> lower or higher than 6.0 across intramuscular fat (IMF) content

Heifer	pH <sub>u</sub>	IMF (%)										Total	
		≤1		1.00-2.00		2.01-3.00		3.01-4.00		≥4.00		n	%
		n	%	n	%	n	%	n	%	n	%		
BW	<6	3	75.00	8	88.89	9	49.23	14	93.33	27	90.00	41	85.92
	≥6	1	25.00	1	11.11	4	30.77	1	6.67	3	10.00	10	14.08
BWL	<6	2	40.00	7	77.78	10	83.33	7	100.00	17	100.00	43	84.00
	≥6	3	60.00	2	22.22	2	14.67	0	0.00	0	0.00	7	14.00

BW - Black-and-White.

BWL - BW × Limousine.

n - number of animals.

meat was accompanied by a decrease in the number of samples with pH<sub>u</sub> exceeding 6.0 in both groups of heifers (Tab. 3). These results suggest that an increase in IMF in heifer meat had a beneficial effect on its pH<sub>u</sub> and could be connected with a higher level of energy components in muscular tissue of animals characterized by higher fatness, protecting it from an excessive decrease in the glycogen content during pre-slaughter treatment and insufficient post-slaughter acidification of meat. A positive effect of a high IMF content on pH of meat from young bulls and fatteners (a lower occurrence of DFD and PSE meat) was also suggested by Jones *et al.* [1994] and Tyszkiewicz [1990].

No significant differences were found between the IMF groups in colour lightness of meat from BW as well BWL heifers (Tab. 2). However, meat containing more than 3% of IMF appeared slightly lighter (not significantly) than that containing less IMF. This could result from a relatively high IMF content of meat (a whiteness carrier) in these samples, or their lower pH<sub>u</sub> compared to the other groups. It is well-known that pH of meat is closely correlated with the meat colour lightness [Wichłacz and Krzywicki 1986]. Meat from BW heifers with the lowest IMF content (below 1%) was also light, probably because the animals from this group were younger and characterized by low concentration of muscular pigments.

WHC is an important indicator of meat quality. Too low WHC causes loss of water and the water-soluble components during heat treatment of meat, which affects not only the weight of finished dishes, but also their sensory properties [Zalewski 1988]. In the present study the WHC of meat from BW heifers was not found affected by IMF content (Tab. 2). In the group of crossbreds, the best WHC appeared in meat with the lowest IMF content (below 1%), and the worst in samples containing 2.01-3.00% ( $P \leq 0.01$ ) and 3.01-4.00% ( $P \leq 0.05$ ) IMF.

According to many authors IMF positively affects meat quality, whereas others doubt whether there is a significant relation between a high IMF content of meat and meat eating quality. In the present study, higher IMF content of meat in BW heifers was accompanied by better meat palatability and tenderness (Tab. 4). An improve-

Selected properties and intramuscular fat content of beef in crossbred heifers

Table 4. Mean intramuscular fat (IMF) content and sensory properties (points) of longissimus dorsi muscle

Item	Heifers		IMF (%)				
			≤1.00	1.01-2.00	2.01-3.00	3.01-4.00	≥4.00
Aroma-intensity	BW	mean	5.00	5.00	4.92	5.00	4.98
		SD	0.00	0.00	0.28	0.00	0.09
	BWL	mean	5.00	4.94	4.92	5.00	4.97
		SD	0.00	0.17	0.29	0.00	0.12
Aroma-desirability	BW	mean	5.00	4.89	4.92	4.97	4.98
		SD	0.00	0.33	0.28	0.13	0.09
	BWL	mean	5.00	4.94	4.83	5.00	4.97
		SD	0.00	0.17	0.33	0.00	0.12
Palatability-intensity	BW	mean	3.50*	3.89	3.94	4.17	4.30*
		SD	0.71	0.42	0.44	0.52	0.70
	BWL	mean	4.50	4.39	4.00	4.07	4.35
		SD	0.50	0.45	0.77	0.47	0.42
Palatability-desirability	BW	mean	3.75	3.94	4.00	4.17	4.32
		SD	1.04	0.44	0.45	0.52	0.49
	BWL	mean	4.33	4.28	4.08	4.07	4.38
		SD	0.58	0.71	0.74	0.47	0.45
Juiciness	BW	mean	3.75	3.72	3.88	3.75	4.15
		SD	1.04	0.51	0.45	0.59	0.45
	BWL	mean	4.33	4.04	3.92	3.79	3.94
		SD	0.58	0.48	0.73	0.43	0.58
Tenderness	BW	mean	3.50	3.83	3.88	3.93	4.22
		SD	0.71	0.41	0.48	0.48	0.75
	BWL	mean	4.50	4.28	3.83	4.07	4.24
		SD	0.50	0.71	0.75	0.88	0.54

BW - Black-and-White.

BWL - BW × Limousine.

\*Within row means bearing the same superscript differ significantly at P ≤ 0.05.

ment in meat juiciness was also observed, but only in meat containing more than 4% IMF. Although no significant inter-group differences were identified concerning the palatability, juiciness and tenderness of meat from BWL heifers, means for these traits appeared slightly lower in samples containing 2.01-3.00% and 3.01-4.00% of IMF. This could be connected with lower WHC of these samples (Tab. 2), resulting in higher water losses during heat treatment, which was confirmed by an evaluation of juiciness. This is a well-known fact that cooking losses are negatively correlated with meat tenderness and juiciness [Guignot *et al.* 1994].

It is concluded that in meat from BW heifers, characterized by lower pH<sub>u</sub> variation, an increase in the IMF content had a positive effect on meat palatability, juiciness and tenderness. In meat from BWL crossbreds, characterized by wider variation in pH<sub>u</sub>, the sensory properties depended to a higher degree upon meat pH<sub>u</sub> than on its

IMF content. The influence of IMF on these traits was noted when IMF content was higher than 4.00%. Eikelenboom *et al.* [1996] also found the eating quality of pork to be determined by ultimate pH rather, than by IMF content of meat.

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### Właściwości fizykochemiczne i sensoryczne mięsa jałówek rasy cb i mieszańców cb × limousine o różnej zawartości tłuszczu śródmięśniowego

#### Streszczenie

Badania przeprowadzono na próbkach mięsa (*m. longissimus dorsi*) 71 jałówek rasy cb (BW) i 50 jałówek mieszańców uzyskanych z krzyżowania krów rasy cb z buhajami rasy limousine (BWL). Próbki podzielono na 5 grup zależnie od zawartości tłuszczu śródmięśniowego (IMF): ≤1,00, 1,01-2,00, 2,01-3,00, 3,01-4,00 i >4,00%. Wzrostowi zawartości IMF w mięsie towarzyszyła tendencja do zmniejszania się liczby próbek z wartością pH końcowego (pH<sub>u</sub>) powyżej 6,0. Wyniki oceny sensorycznej wykazały, że w mięsie jałówek rasy cb (które odznaczało się mniejszą zmiennością wartości pH<sub>u</sub>) wzrost zawartości IMF korzystnie wpływał na smakowitość, soczystość i kruchość mięsa. Z kolei na cechy organoleptyczne mięsa jałówek BWL (które odznaczało się większą zmiennością wartości pH<sub>u</sub>) większy wpływ miał odczyn niż udział (%) IMF.

