

## Influence of energy level reduction in young bulls diet on meat quality

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**Abstract:** *Influence of energy level reduction in young bulls diet on meat quality.* The influence of energy level reduction in bulls' diet at the end of the fattening period was evaluated. The bulls were divided into 2 groups, a control group (K) and a study group (D) in which the energy level limit was 80% of the maintenance requirement. The diet was altered during the last 60 days of the fattening period, however, it did not affect the level of protein, mineral compounds and vitamins intake as their balancing was in line with the animals' needs. The fattening bulls were slaughtered at the age of 25 months. The aim of the study was to analyse the impact of reduced energy levels on the meat traits which proved its culinary usefulness and nutritional value. An assumption was made that reducing energy level in the bulls' diet at the end of the fattening period would not significantly deteriorate the said indicators. D group animals had a smaller weight gain, an average of 35.1 kg. This effect, with full coverage of the protein demand, triggered energy reserves from internal fat. However, the deterioration of the quality of carcasses has not been confirmed. It was found a higher percentage of carcasses in EUROP classes better. The *Longissimus lumborum* muscles had a lower content of dry matter and fat in ( $P < 0.05$ ). There were no significant changes in the colour (L) and acidity of the meat. There were, however differences in thermal loss. The meat of group K had significantly higher results ( $P < 0.05$ ). From a practical point of view, these changes should be considered minor. What is important is the fact

that there was no significant effect on the characteristics of the most frequently subject to consumer evaluation. This applies to colour (L) and marbling, which were at an acceptable level. Not without significance is the lack of deterioration in nutritional quality, for evaluation the participation of protein and fat was assumed. Meat of group D had a comparable protein content and lower fat content. It was shown that the used solution did not worsen the culinary traits of the meat; the crispness and surface of the roast beef.

*Key words:* fattening, cattle, energy level, quality, beef

### INTRODUCTION

The beginning of the 21st century witnessed an increase in the production of beef both in Poland and abroad. The data published by the GUS (2016) showed an increase in beef production from 599 to 918 thous. tons in 2005 and 2015 respectively.

The increased beef production more and more frequently calls for the search for solutions to raise the efficiency of fattening, at the same time maintaining high quality of the meat. Studies indicate that, among environmental factors, the greatest impact on meat quality is

exerted by animal nutrition, followed by the maintenance system and age.

Recent research has shown multiple opportunities to improve the culinary properties of beef by employing proper animal nutrition (Kuczaj 2010, Maciaszek and Strzetelski 2006). The energy value of the ration applied throughout the entire fattening period is deemed to constitute a highly significant factor in the nutrition of fattening cattle (Jurczak 2004, Kuczaj 2010).

Also, the growing awareness of consumers who are starting to appreciate meat of animals fed less intensively as well as from farms where balanced feeding systems are applied, is an important aspect of the search for solutions aimed at increasing the effectiveness of beef production. Decreasing the amount of energy that is indispensable to produce a kilogram of beef contributes to lowering the so-called carbon footprint (Rotz et al. 2010, IPCC 2013). Worldwide trends of evolving consumer demands and minimising the impact of production on the environment make the search for new beef production solutions still very much valid.

The purpose of the present study was to determine the impact of lowered energy levels of the feed ration in the final phase of the fattening of young bulls on the quality of meat.

## MATERIAL AND METHODS

### Material and feeding

The study group consisted of 26 bulls – crossbred hybrids produced by mating Polish Holstein-Friesian cows with Limousine bulls. The age at slaughter was 25 months.

After the rearing period the young bulls were kept in confinement, provided with fodder twice a day, and had constant access to water by means of automatic water tanks and mineral licks. The nutrition of animals in individual groups was as follows:

- control group (K – 13 bulls) – the bulls intended for slaughter were fed with a ration that was balanced in terms of protein and energy;
- study group (D – 13 bulls) – in the last 60 days before slaughter, the bulls' energy consumption level was reduced to 80% of the maintenance requirement.

The nutritional basis was maize silage and grass silage (*Lolium perenne* L., *Medicago sativa* L. ssp. *Sativa*; harvested during the flowering). The ration of roughage was supplemented with concentrated fodder (barley, triticale, post-extraction rape meal, soybean). In the case of the study group, the reduction of energy level in the final stage of fattening was obtained by decreasing the amount of cereal and maize silage in the ration, with simultaneous increase in the amount of high protein fodder (mainly soy meal) and fodder containing high levels of rumen protected proteins. The animals were fed ad libitum; twice daily (morning and afternoon). The diets were formulated according to the maintenance requirement of animals specified by French National Institute for Agricultural Research (INRA) feeding standards with the use of INRAration Software for Ruminant Diet Calculation, version 2.03 (DJ Group, Krakow, Poland), drawing on the earlier chemical analysis of feeds and calculating their nutritional value. Maintenance requirement was predicted

by the equation: protein (BTJ) =  $3,25 \text{ g} \times (\text{MC})^{0,75}$ ; energy (EN) =  $88 \text{ kcal} \times (\text{MC})^{0,75}$ .

### Study methods

The analyses were performed using samples of *M. Longissimus lumborum* (*MLL*) taken from the carcasses of both bull groups. In order to diagnose the typical post-mortem transformations, pH level was measured after 45 minutes (pH<sub>45</sub>) as well as following 24 and 48 hours (pH<sub>24</sub> and pH<sub>48</sub>) after slaughter. The acidity measurement was carried out in the raw meat by means of a glass electrode meter, using pH-meter. After 24-hour storage at 4°C, the *MLL* sample was subject to visual assessment with respect to marbling, and contours of the roast beef area were set and evaluated by planimetry. Meat marbling was assessed using a subjective 5-point scale (1 point – no visible presence of fat, 5 points – rich and even distribution of fat).

Meat sections from the *MLL* muscle were collected, packed in PE foil and stored under refrigeration conditions at a temperature of  $4.0 \pm 0.5^\circ\text{C}$ . The following parameters were assessed seven days after slaughter:

- basic chemical composition (water content by drying method according to PN-ISO 1442: 2000P, general protein content by Kjeldahl method according to PN-A-04018: 1975, fat content by Soxhlet method according to PN-ISO 1444: 2000);
- meat colour was evaluated with the Minolta CR-310 Chroma Meter, by Joo et al. method (2000). Standardisation of the apparatus was carried out using the Minolta CR 310 model plate

with the value  $Y = 92.80$ ,  $x = 0.3175$  and  $y = 0.3333$ . The colour parameters were described in the CIE Lab system (CIE, 1986), using D65 illuminant and a standard 2° observer;

- tenderness of heated meat (internal temperature + 70°C) using ISTRON 3342 apparatus with Warner-Bratzler blade ( $N/\text{cm}^2$  – measurement taken from  $1 \times 1 \text{ cm}$  samples),
- thermal loss, as a percentage loss of meat weight while heating in tightly sealed foil bags in a water bath until the internal temperature of 75°C is achieved;
- water holding capacity (WHC) using the Grau and Hamm method (1957), infiltrations were evaluated by planimetry, and the result was converted into a loss of water from the sample (%).

### Statistical analysis

The obtained results were subject to mathematical analysis using one-way analysis of variance ( $P < 0.05$ ) with the Statistica 12.5 programme. The results were shown in the form of the mean ( $x$ ) and standard deviation ( $SD$ ).

## RESULTS AND DISCUSSION

Carcasses of animals from group D were more often classified as better EUROP classes. This is evidenced by the proportions of carcasses belonging to the extreme EUROP grades found after slaughter. Group of animals with reduced a (60 days before slaughter) supply of energy to 80% of living needs, had less fatness of carcasses and 38.3% less amount of internal fat and 38.3% lower amount of internal fat. This may

explain an average of about 35.1 kg less mass of slaughter (Table 1). In the *M. longissimus lumborum* (MLL) sampled in the study group (D), pH45 amounted to an average of 6.71, compared to the level of 6.69 in the control group (K) (Table 2). Twenty four hours after slaughter the obtained pH value was 5.74 and 5.70 in the study and control group respectively. The reduction of energy level in the final phase of the fattening period did not have any influence on the pH level

evaluated 48 hours post mortem. The obtained pH48 values in the MLL were similar in both groups (5.62 and 5.67).

As far as acidity was concerned, the results of the own research were consistent with the outcomes of the research conducted by Domaradzki et al. (2011), which did not show the effect of refrigeration storage on pH values. In view thereof, the studied decrease in energy supply in the final phase of fattening did not affect the glycogen levels, whose

TABLE 1. Characteristics body mass of the bulls in the subsequent stages of the experiment and selected carcass quality indicators

Specification	Feeding group				P-value
	D		K		
	X	SD	X	SD	
	(N = 13)		(N = 13)		
The weight:					
– start of fattening (kg)	323.48	32.83	329.41	29.72	0.829
– before changing the ration (kg)	492.21	48.25	487.29	45.59	0.621
– mass of slaughter (kg)	511.65	42.25	541.79	51.92	0.358
Internal fat* (kg)	9.78	2.22	13.53	2.98	0.042
Carcass conformation score** : U (%)	40.0		20.0		0.045
O (%)	13.3		33.3		
Carcass fatness score** : 1 (%)	38.5		15.4		0.038
4 (%)	23.1		53.8		

\*types of internal fat: kidney fat, caul fat, gut fat; \*\*extreme EUROP class obtained during the evaluation

TABLE 2. The effect of nutrition on the formation of pH in *M. longissimus lumborum*

pH after slaughter	Feeding group				P-value
	D		K		
	X	SD	X	SD	
	(N = 13)		(N = 13)		
45'	6.71	0.11	6.69	0.07	0.592
24h	5.74	0.12	5.70	0.13	0.632
48h	5.62	0.08	5.67	0.09	0.572

breakdown is usually responsible for meat acidity after slaughter (Immonen et al. 2000, Mlynek et al. 2012). The results of  $\text{pH}_{48}$  found in our own research corresponded to the values of this indicator observed by Florek et al. (2007) as well as Daszkiewicz et al. (2009). These studies showed that in the case of culinary use of beef, the pH value after 48 hours from slaughter should amount to 5.8. The final pH values obtained in our study did not indicate any changes suggestive of deviations in meat quality.

The results pertaining to the content of basic chemical components discussed in Table 3 showed that the *MLL* of the young bulls from group D exhibited a lower content of dry matter, compared to the meat of bulls from group K, by an average level of 0.8% ( $P \leq 0.05$ ). This is undoubtedly due to the lower fat content, by 0.73% ( $P < 0.05$ ), which was seen in the meat of the young bulls from group D (0.98% compared to 1.71% in group K). The use of energy from fat reserves in animals from group D, not

only decreased the amount of internal fat (Table 1). It reduced the intramuscular fat content, but also to a small extent on the loss of muscle protein (Table 3). However, if the difference in protein content of the *MLL* not confirmed the statistically significant ( $P < 0.325$ ). In view of the pro-health and dietary value of meat, the fat content obtained in group D should be deemed to be beneficial. Grębowiec (2015) showed the significance of fat content as a factor that consumers bear in mind when choosing meat to buy. The researcher proved that the meat with more than 2.5% fat content is considered unattractive. However, too small proportion of fat may turn out to be insufficient to ensure satisfactory meat juiciness or aroma (Keane and Allen 1998).

In comparison with the outcomes of the present study, the results obtained by Chmielnik et al. (2005) showed a slightly lower share of dry matter and protein and at the same time a higher fat content in *M. longissimus dorsi*. A similar tendency was observed by Wajda et al. (2014),

TABLE 3. The formation of selected traits and colour of *M. longissimus lumborum*

Specification	Feeding group				P-value
	D		K		
	X	SD	X	SD	
	(N = 13)		(N = 13)		
Traits:					
– dry matter (%)	24.21	1.08	25.01	1.11	0.048
– protein (%)	22.95	0.91	23.02	0.97	0.325
– fat (%)	0.98	0.22	1.71	0.48	0.015
Colour:					
L	38.54	1.91	38.48	1.99	0.859
a	18.39	1.09	19.91	1.23	0.012
b	4.16	2.65	4.26	2.79	0.722

however, it should be added that the study animals were fed with a balanced ration. The influence of feeding intensity on beef quality traits was demonstrated, among others, by Vestergaard et al. (2000) and Młynek et al. (2014). Domaradzki et al. (2016) proved that intensive fattening caused fatter carcass, whereas elevating the energy value of the ration at the end of the fattening period contributed to increased meat marbling.

The obtained 4 points results (Table 4) showed that the energy limit in the final phase of fattening (group D) favoured lower accumulation of fat in *MLL* and decreased marbling. The difference in marbling found in the study and control groups amounted to an average of 0.34 points ( $P < 0.05$ ). Similar findings related to the correlation between fat content and meat marbling were also obtained in studies of Dasiewicz et al. (2002). In this respect, the results of our research were consistent with the tendency observed by Młynek (2011), with the average marbling value of 2. The studies conducted by Póltorak et al. (2013) showed that obtaining the content of fat in *m. longissimus dorsi* at the level

of 1.1–1.3%, with fat content in the carcass of 2 to 3%, allowed obtaining the optimal degree of meat marbling. These findings are extremely significant since intramuscular fat constitutes an important factor affecting the taste and juiciness of culinary meat (Domaradzki et al. 2016), and its excessive amount may hinder the nutritional value of meat. In spite of the effect of limited energy level on meat marbling shown in Table 4, the obtained small values of the said assessment seemed to have little influence on consumer evaluation. Although, the difference (0.34 points) found was confirmed statistically ( $P < 0.05$ ), in practice its significance may be of minor importance on the consumer assessment. The performed analysis of the indicators for meat colour assessment (Table 3) did not show any influence of the group on colour clarity (L), which was however observed in the case of yellow colour intensity (a) ( $P < 0.05$ ). Our own findings were partly consistent with the results of the study conducted by Młynek (2011) which showed the effect of feeding intensity on the clarity of the colour of bulls' meat. The lack of such differences may prove

TABLE 4. Effect of feeding on the formation of selected parameters of the quality of *M. longissimus lumborum*

Traits	Feeding group				P-value
	D		K		
	X	SD	X	SD	
	(N = 13)		(N = 13)		
Roast beef area (cm <sup>2</sup> )	101.28	12.27	108.02	17.07	0.089
Tenderness (N/cm <sup>2</sup> )	56.28	16.05	57.79	16.98	0.215
Thermal loss (%)	26.97	3.12	30.18	2.19	0.034
WHC (%)	32.87	3.58	34.61	2.98	0.196
Marbling (pts)	1.89	0.63	2.23	0.48	0.028

the reduction of the energy level in the final period of fattening to be a favourable solution due to lower consumption of high energy fodder. Similar results were obtained by Wajda et al. (2014), where feeding intensity exerted a slight influence on the colour of bulls meat.

The data contained in Table 4 showed that *MLL* specimens from group D showed smaller weight loss, with an average of 3.21% ( $P < 0.05$ ). This constituted valuable information most of all in terms of the culinary importance of this trait and consumer assessment. Similar thermal loss values, at an average level of 30.01%, were obtained by Domaradzki et al. (2011), whereas significantly higher values, at a level of 34.32%, were demonstrated by Chavez et al. (2012). However, the study conducted by Chmielnik et al. (2005) did not confirm the observed trends since the meat of animals whose dietary energy levels were decreased at the end of the fattening period showed a higher loss during heating.

Another characteristic trait of *MLL* that ought to be considered as significant in technological terms was WHC. However, it should be noted that the applied nutritional model did not have a significant influence on WHC values since the obtained difference was 1.74% and was not confirmed statistically. Nevertheless, the meat obtained from group D bulls showed a higher value of this indicator. In practice, this may have a significant effect on the efficiency of meat processing and storage. Similar findings were obtained by Daszkiewicz et al. (2005) where this was also connected with a higher loss of meat juice, thus a more intense loss of water-soluble ingredi-

ents. The authors of the said study also demonstrated the resulting worsening of sensory properties. Lower WHC values of the meat of Polish Holstein-Friesian bulls, at an average level of 30.00%, were observed by Litwińczuk et al. (2006). However, in this case the trait in question showed significant variability, which may be proved by the obtained value of  $SD = 7.59$ .

As far as the commercial value of carcasses is concerned, an important indicator of the assessment was the share of valuable parts of the carcass, including roast beef. According to Wajda et al. (2014), morphological analysis and the weight of primal cut may constitute a good basis for carcass pricing and beef quality. In the present study, a correlation between bulls' diet and the cross-section area of roast beef was not established. This finding should be regarded as positive since, in practical terms, the costs of fattening can be lowered with no reduction of the quality of this trait.

In the case of beef, the traits affecting its tenderness are of great importance. According to Kołczak (2008) and Młynek et al. (2014), tenderness is one of the most significant features of culinary assessment. Meat tenderness is, among others, conditional upon animal nutrition (Domaradzki et al. 2010) and muscle microstructure (Młynek et al. 2014). The research conducted by Młynek (2014) involving the *biceps brachii* muscle showed that this was primarily connected with the area of muscle fibres. In the said studies the cutting value was lower by an average of 12.4 N/cm<sup>2</sup> in the case of muscles of the bulls which were subject to more intense feeding, with lower values of the area of muscle fibres. The

results contained in Table 4 didn't show any significant influence of animal nutrition on meat tenderness. The difference between the study group and the control group was 1.51 N/cm<sup>2</sup>, on average.

## CONCLUSIONS

Reduction of energy level in the feeding ration during the last 60 days of fattening of young bulls decreased the fat content in meat, thereby leading to a decreased concentration of dry matter as well as slightly lower marbling and thermal loss. It is of key importance that no significant influence on the acidity and clarity of the colour of the meat, or on the protein content, tenderness and the area of roast beef was observed. The obtained results suggest that the reduction of the energy level at the end of the fattening period may be used in the production of culinary beef.

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**Streszczenie:** *Wpływ obniżenia poziomu energii w dawce pokarmowej buhajów na jakość mięsa.* Badano wpływ wprowadzenia pod koniec opasu, okresu żywienia z obniżonym poziomem energii w dawce pokarmowej. W doświadczeniu wydzielono grupę kontrolną (K) oraz grupę, w której ograniczenie poziomu energii wynosiło 80% zapotrzebowania bytowego (D). Zmianę diety stosowano w ostatnich 60 dniach opasu i nie obejmowała ona poziomu białka, związków mineralnych i witamin. Ich bilansowanie było zgodne z zapotrzebowaniem zwierząt. Opasy ubijano w wieku 25 miesięcy. Celem badań było przeanalizowanie wpływu ograniczenia poziomu energii na cechy mięsa, świadczące o jego przydatności kulinarnej i jakości żywieniowej. Założono hipotezę, że ograniczenie podaży energii w diecie pod koniec opasu, nie wpłynie znacząco na pogorszenie analizowanych wyróżników jakościowych. Opasy z grupy D uzyskały mniejszy przyrost masy ciała, przeciętnie o 35,1 kg. Efekt ten, przy pełnym pokryciu potrzeb białkowych, powodował uruchomienie rezerw energii z tłuszczu wewnętrznego. Nie stwierdzono jednak pogorszenia się jakości tusz. Uzyskano większy odsetek tusz zaliczanych do lepszych klas EUROP. Mięśnie *M. longissimus lumborum* miały mniejszą zawartość suchej masy i tłuszczu w ( $P < 0.05$ ). Nie odnotowano zasadniczych zmian jasności barwy (L) oraz kwasowości mięsa. Odnotowano natomiast różnice dotyczące wycieku cieplnego, który w mięsie grupy K okazał się istotnie większy ( $P < 0.05$ ). Jednak z praktycznego punktu widzenia, zmiany te na-

leży uznać za niewielkie. Istotny jest fakt, że nie odnotowano znaczącego wpływu na cechy podlegające najczęściej ocenie konsumenckiej. Mianowicie barwy i marmurkowości, które kształtowały się na akceptowalnym poziomie. Nie bez znaczenia pozostaje brak pogorszenia się jakości żywieniowej, za której wyznaczniki przyjęto udział białka i tłuszczu. Bowiem mięso buhajów z grupy D miało porównywalną zawartość białka oraz mniejszą zawartość tłuszczu. Stwierdzono również, że zastosowane rozwiązanie nie pogorszyło cech kulinarnych mięsa – kruchości i powierzchni rostbefu. Można uznać, że przyjęte działanie może być z pozytywnym efektem wykorzystywane do produkcji kulinarnego mięsa wołowego.

*Słowa kluczowe:* opas, bydło, poziom energii, jakość, wołowina

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