Original Paper

Slaughter performance, chemical composition and physical technological parameters of Holstein veal fed with total mixed ration (TMR) and alfalfa hay

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This study was conducted to evaluate the selected fattening characteristics, carcass parameters and analysing of parameters associated with the meat quality of twenty Holstein male calves fed with different diets. Calves were after weaning divided into two groups with respect of feeding; control group fed with untreated total mixed ration (TMR) and experimental group, which received industrially dried alfalfa hay. Calves of both groups were after about 193 days slaughtered in the experimental abattoir. Subsequently, after chilling for 24 hours, detailed dissection of the right – carcass half was performed. For the nutritional characteristics, physical technological parameters and sensory properties, slices of loin (*M. longissimus thoracis*) and top round (*M. semimembranosus*) muscles were taken 24 hours *post mortem*. The average daily gains were higher in the experimental group of calves (P >0.05). Although calves of the control group had higher dressing percentage (50.23%; P >0.05), no significant differences were determined in the carcass weight (P >0.05). Proportions of some of intraabdominal fats were influenced by feeding concept; calves of alfalfa hay treated group had lower proportion of intestinal fat (P >0.05) and higher proportion of kidney fat (P >0.05). Differences in total amount of meat from right – half carcass were not significant (P >0.05); proportion of separable fat was higher in the experimental group of calves. In terms of individual valuable meat cuts, higher proportion of tenderloin was determined in the group fed with alfalfa hay (1.80%); however results were no significant. Statistical significant variety at the level P <0.05 were revealed in the moisture content, intramuscular fat content and energy value. The loin muscle from experimental group was lighter (CIE L^*; P >0.05) 24 hours *post mortem*.

Keywords: different diet, veal quality parameters, bull calves, meat colour, right – half carcass

1 Introduction

The definitions for the term ´veal´ vary according to the country of provenance. In many countries for calves raised for meat production are limited age of 7 months and a weight of 250 kg. However, in accordance with current European Union legislation, veal is defined as a meat from bovine animals aged less than 8 months at slaughter (category V). Animals aged between 8 and 12 months at slaughter are marketed as category Z (EC, 2008). In European market veal derived from dairy herds is an important part of the meat industry. The economic efficiency of this production is dependent on increasing growth rate of calves and efficient feed utilization, as well (Santos et al., 2013). In terms of the health and wellbeing of calves is significant to optimise the growth of calves for meat production, following weaning. Furthermore, for producers is important the smoothly transition of calves from liquid to solid feeding and effective utilising of solid feed, which relies mainly on pre-weaning and post-weaning management (Drake, 2017). Meat production is based on the animal growth rate, which depends on several environmental factors as well as management practices. Animals for the meat production, such as livestock differ in genetics, age, sex, nutritional and environmental effects (Irshad et al., 2013).

There is currently no consensus about precise explanation of the concept of meat quality, because is

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generally considered to be a combination of two main elements. On the one hand, the overall quality of meat and meat products includes measurable properties – microbiological state, tenderness, colour, juiciness, shelf life, pH value. On the other hand, meat quality includes personal consumers´ perception of the value of meat and meat products (Feiner, 2006). In addition to the quality of the carcass itself, the priority interest of consumers as well as meat producers is the inherent quality of the meat, hence pure muscle or fat tissue, respectively. This quality is expressed by chemical composition, physical technological properties and sensory properties (Foltys and Mojto, 2009). Nutrition contributes to the quality of meat directly or indirectly, in particular by increasing of intramuscular fat content (Brewer, 2010). Intramuscular fat content and also composition is influenced by the feeding method, sex of animals, slaughter weight and slaughter age, as well as the duration of suckling (Moreno, 2006). Nowadays, when dairy breeds predominate in cattle population whose milk is the main market commodity, males of these breeds will be the main source of beef (Lengyel et al., 2003). Meat from milking breeds shows the good quality in lower slaughter weights and therefore it is possible to cover the lack of veal mainly with meat from calves of dairy breeds.

The aim of this work was to bring knowledge about the possibilities of veal production and baby beef, respectively, which is in accordance with legislation, welfare rules and is economically acceptable to the farmer as well.

2 Material and methods

For this experiment twenty bulls of Holstein calves ($n = 20$) were studied. Calves were born in about the same period, within a week in a local milking farm. During first stage of the experiment calves were housed in individual outdoor crates. Calves were fed a milk replacer and a starter concentrate *ad libitum*. Calves had free access to fresh drinking water. After about two months, calves were moved to group igloos, ten bulls each. Subsequently, the period of habit for solid feeding began. The calves of both groups – control and experimental were fed with liquid milk replacer once per day with *ad libitum* access to the starter feed mixture. Gradually they received a small amount of solid feed; control group received a small amount of total mixed ration (TMR) and experimental group obtained a small amount of industrially dried alfalfa hay. The experimental fattening period started at about 70 days of age.

2.1 Housing and feeding of calves during experiment

The fattening period was carried out from weaning (about 70 days of age) to the final live weight of 180 kg. After weaning and addictive period (from 70 days) calves were divided at random into two groups with different diets, ten calves each. Calves of the control group was fed an untreated feed mixture TMR (total mixed ration) with 6.25% of hay, 43.25% alfalfa hay, 18.75% maize silage and 31.75% starter feed mixture HD-02. The net energy fattening of TMR diet was 6.80 MJ kg^{-1} of dry matter (DM); organic matter was 824 g kg^{-1} of DM. Calves of the experimental group received the diet with 31.75% of industrially dried alfalfa hay, 3.16% barley straw, 1.59% beet molasses, 31.75% water and 31.75% starter feed mixture HD-02. The net energy fattening of experimental diet was 6.1 MJ kg^{-1} of DM; organic matter was 853.9 g kg^{-1} of DM. Calves were housed under the same conditions with daily straw landings with *ad libitum* access to fresh drinking water. After reaching required weight about 192.58 days of treatment the calves were slaughtered in the Experimental abattoir which is a part of the Department of Animal Husbandry, Slovak University of Agriculture in Nitra.

2.2. End of experiment

Immediately after slaughter, carcasses were split into right – half carcass (RHC) and left – half carcass (LHC) and subsequently on the forequarter and hindquarter. The weight of the meat (carcass weight) includes headless half-carcasses, without the limbs separated in the elbow or heel joint, without the thoracic and abdominal organs (except the kidneys) and without the genital organs. After chilling for 24 hours on 2–5 °C, the detailed dissection of the right – half carcass was performed. Individual valuable meat cuts were weighted with and without bone. Moreover, individual tissues of right – half carcass – trimmed fat, muscles and bones (marrow, technical, pelvis and scapula) were weighted on scale. Physicochemical and sensory properties of the meat were observed from a sample of *Longissimus lumborum* et *thoracis* (MLT). The individual chemical and physical technological parameters were determined using laboratory techniques of SUA in Nitra from samples taken from the tenderloin (*M. longissimus thoracis*) and top round (*M. semimembranosus*) muscles. Samples were taken 24 hours after slaughter. The pH value and electrical conductivity values were measured 1 hour and 24 hours *post mortem* using pH meter Titan and a Biotech instrument. The free bound water was determined 24 hours after slaughter and after chilling at 4 °C as a percentage of drip loss from a 50 g sample of the loin muscle. The chemical composition of the veal was analyzed from 100 g of sample from MLT using a Spectrometer Nicolet 6700. The energy value (*EV*) of the meat was calculated from the protein and intramuscular fat content according to the equation, as follows: *EV* (kJ 100 g^{-1}) = 16.75 * protein content (g 100 g^{-1}) + 37.68 * IMF content (g 100 g^{-1}).

2.3 Statistical evaluation

Basic variability and statistical characteristics of fattening, slaughter, physical, technological and sensory properties reported as means and standard deviations were analyzed using a two-factor analysis of variance. The significance of the differences between the individual treatment groups was tested using the t-test at the levels of significance *P* >0.05; *P* <0.05; *P* <0.01 and *P* <0.001. All statistical analyzes were calculated using statistical package (SAS) version 9.3 (TS1M2) Enterprise Guide 5.1. (SAS INSTITUTE Inc., 2011).

3 Results and discussion

The fattening and slaughter parameters of monitored groups of calves are shown in Table 1. Differences were found in the average daily gains from birth to the end of fattening, whereas control group fed with maize silage had lower gains at 197 days than experimental group at 185 days of fattening (687 vs. 748 g). Dias et al. (2018) found in Holstein calves fed with corn silage slaughtered at 179.8 kg average daily gain of 811 g. Noon et al. (1998) noted higher ADG (1.55) in calves fed with 50% corn and 50% barley. In general, dressing percentage of Holstein cattle is lower than from beef breeds (Schaefer, 2007). Higher, but statistically not significant differences were found in carcass weight with higher weight in the control group (84.19 kg). These differences were also reflected in the calculated dressing percentage; calves of the first group had higher dressing percentage than second group (*P* >0.05). Yim et al. (2015a) found lower carcass weight (83.4 kg) and higher dressing percentage (59.1%) at higher slaughter weight of Holstein calves (270 kg). According to Bartoň et al. (2003), the carcass value is significantly decreased with increasing utility and genotype representation in dairy herds. Compared to Czech Pied cattle, the Holstein breed have a lower proportion of muscle (79.03 vs. 76.61%) as well as a lower dressing percentage (57.29 vs. 54.88%). González et al. (2014) evaluated veal quality of Rubia Gallega calves fattening with oil supplement. Calves with linseed oil supplement had carcass weight 178.71 kg and dressing percentage 50.04%.

Feeding concept influenced proportion of kidney and intestinal fat (Figure 1); however results were not significant. Calves of control group had lower proportion of kidney fat (1.07%) and higher proportion of intestinal fat (0.68%) than second group (1.19% and 0.51%). Slightly higher proportion of kidney fat (1.61%)

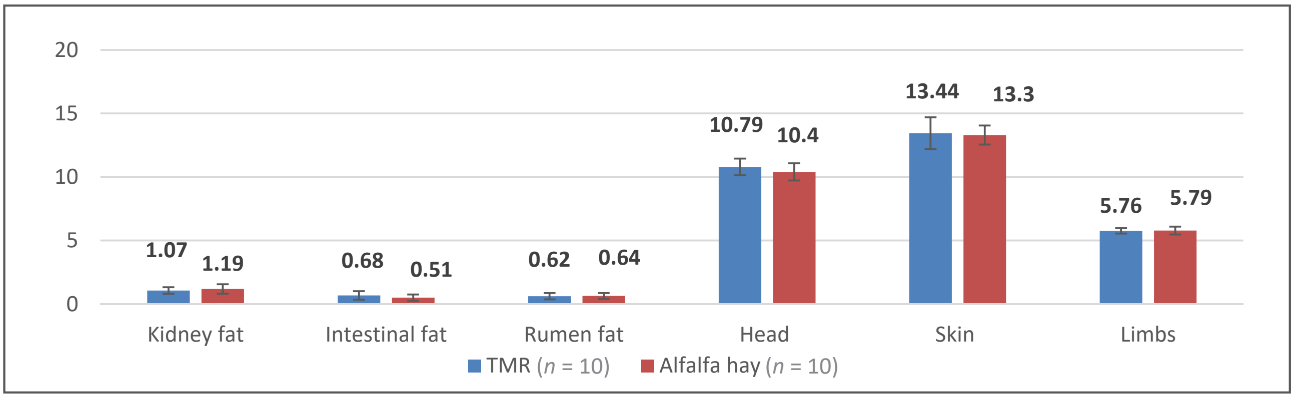

Figure 1 Proportions of by-products of veal carcasses from Holstein calves not included to the carcass weight (%)

Table 1 Fattening and slaughter parameters of veal from Holstein male calves fed TMR or alfalfa hay ($\bar{x} \pm s_x$)

	TMR (*n* = 10)	Alfalafa hay (*n* = 10)	*Sign.*
Birth weight (kg)	39.17 ±1.40	38.38 ±1.81	*ns*
Final live weight (kg)	174.33 ±12.97	175.25 ±9.59	*ns*
Starved live weight (kg)	167.67 ±10.68	169.60 ±11.26	*ns*
Number of feeding days	197.33 ±7.87	184.83 ±18.87	*ns*
Hot carcass weight (kg)	84.19 ±5.48	82.87 ±6.77	*ns*
Hot dressing percentage (%)	50.23 ±1.39	48.44 ±1.24	*ns*
ADG (g)	687 ±89	748 ±96	*ns*

ADG – average daily gain from birth to slaughter; *ns* – not significant; % – values were calculated from slaughter weight

Table 2 Proportion of tissues from right – half carcass from Holstein calves fed TMR or alfalfa hay ($\bar{x} \pm s_x$)

		TMR (*n* = 10)	Alfalfahay (*n* =10)	*Sign.*
Right – half carcass	(kg)	41.67 ±2.58	41.25 ±3.62	*ns*
RHC forequarter	(kg)	18.62 ±0.86	18.55 ±1.53	*ns*
RHC hindquarter	(kg)	22.75 ±2.02	22.41 ±1.81	*ns*
Meat from RHC	(kg)	27.17 ±2.24	26.67 ±2.63	*ns*
	(%)	65.17 ±2.29	64.62 ±2.05	*ns*
Bones	(kg)	11.29 ±0.53	11.13 ±0.90	*ns*
	(%)	27.14 ±0.68	27.04 ±1.71	*ns*
Separable fat	(kg)	2.89 ±0.55	3.16 ±0.58	*ns*
	(%)	6.95 ±1.19	7.70 ±1.54	*ns*

ns – not significant; % values were calculated from right – half carcass; RHC – right – half carcass

was noted for Buffalo calves in Holló et al. (2013) at slaughter weight of 196.06 kg. In Holstein calves with carcass weight of 187.8 kg found Titi et al. (2008) 1.7 kg of kidney fat. As noted in Schaefer (2007), Holstein cattle as a dairy type require 20% more maintenance energy. High milk production as ´lactability´ is associated with liver and intra-abdominal fat proportions. On the other hand, minimal differences in weight and proportion of rumen fat were found. Likewise, all other non-carcass component measurements were not different the two feeding groups (*P* >0.05).

Dressing data (%) of Holstein calves after manual dissection are presented in Table 2. No significant differences in the weight of right – half carcass between monitored groups were revealed. Our results are similar to those of Moran et al. (1992), who reported for milk – fed calves weight of forequarter 18.94 kg from side weight predicted at 40 kg. They found higher proportion of meat (69.3%) and lower proportion of bones (25.6%) and separable fat (6.0%). Furthermore, differences in weights and proportions of individual carcass quarters were not significant (*P* >0.05). When calculate the amount of the meat to percentage from weight of right halves of the carcasses, between two feeding groups were minimal differences (65.17%, resp. 64.62%; *P* >0.05). The nutrition contributes to the meat quality directly or indirectly, mainly by fat content increasing (Brewer, 2010). The percentage of bones in the carcasses (spiked, technical, scapula and pelvis) were similar between groups; whereas proportion of trimmed fat was higher in the experimental group (*P* >0.05). In comparison to Buffalo male calves slaughtered at higher weight (Holló et al., 2013), our Holstein calves had higher content of muscle tissue, similar proportion of bone and fat tissues in the carcass.

In table 3 and Figure 2 are presented amounts of most commercially valuable beef cuts of Holstein calves fed with different diets. We did not found significant differences between the two feeding groups. The average amount of whole round and tenderloin were similar (*P* >0.05). Holstein calves tend to have poorer conformation of the hindquarters and therefore carcasses are often of lower in conformation (Moran and Curie, 1992). In contrast Holló et al. (2013) reported that Buffalo calves compare to bovines have a higher percentage of forequarter in the carcass. Concerning our results, the proportion of meat from hindquarter was greater. Our values are different from those of Yim et al. (2015b); in Holstein male calves slaughtered at 159 kg they found proportion of tenderloin 2.67%, sirloin 2.67%, shortloin

Table 3 Proportion of boneless commercial meat cuts from fore quarter of right-half carcass from Holstein calves ($\bar{x} \pm s_x$)

	TMR (*n* = 10)	Alfalfahay (*n* = 10)	*Sign.*
Shoulder (%)	6.80 ±0.37	6.71 ±0.26	*ns*
Neck (%)	4.51 ±0.47	4.47 ±0.46	*ns*
Chuck (%)	4.95 ±0.29	4.69 ±0.33	*ns*
Short plate (%)	10.19 ±0.76	10.26 ±1.05	*ns*
Brisket (%)	5.29 ±0.69	5.09 ±1.03	*ns*
Fore shank (%)	4.64 ±0.31	4.93 ±0.27	*ns*

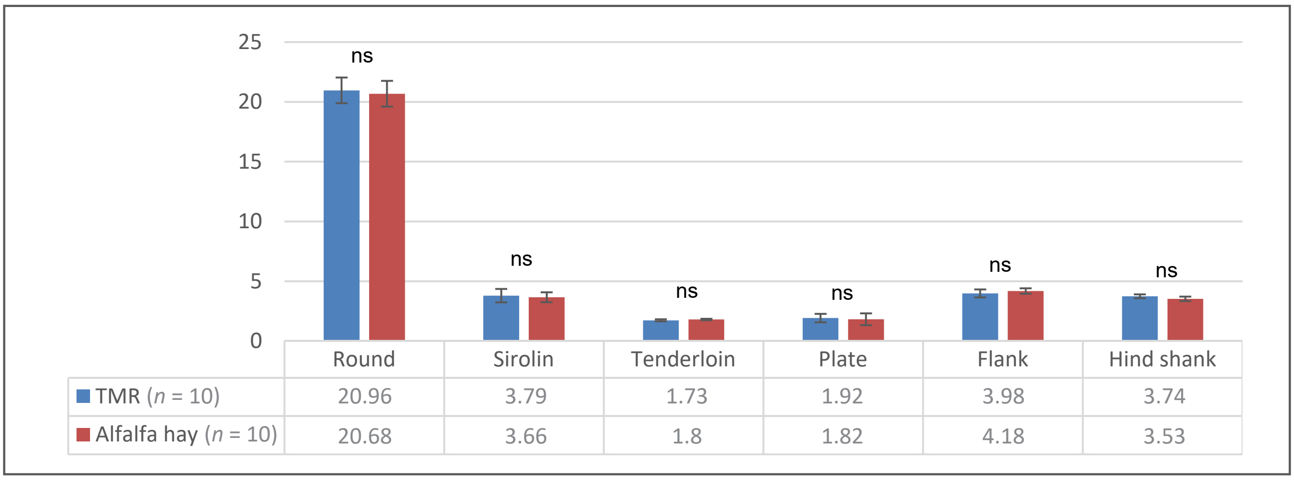

Figure 2 Proportion of boneless commercial meat cuts from hind quarter of right-half carcass from Holstein calves (%)

17.76%. Our calves had a lower proportion of tenderloin compare to Maciel et al. (2016).

Table 4 represents the moisture, intramuscular fat and protein contents as well as calculated energy value of 100 g of Holstein veal. The nutritional composition of the meat vary depending on the breed, the feeding concept, the season of slaughter and the meat cuts of carcass. In general, however, red meat has a low fat content, an adequate content of cholesterol and it is rich in contents of protein, vitamins and minerals (Williams, 2007). Energy value of loin samples increased with an increase in intramuscular fat content (P <0.05). The moisture content of loin muscle from the TMR fattened group (73.20%) was significantly higher than those from experimental group (68.91%; P <0.05). Moisture content of the muscles varies depending on the species, breed, age of animal, as well as its morphological-anatomical origin and nutrition of animal (Huff-Lonergan, 2010). Biel et al. (2019) found in *Musculus semitendinosus* muscle moisture content of 67.67% in calves weighing 95 kg. High levels of nutrition, especially during the final phase, may increase the intramuscular fat content to a greater or lesser extent depending on the species, breed, age of the animals and other factors. Moreover, the IMF content is influenced by type of muscle, as describe Gálvez et al. (2018); while higher IMF content is associated with higher physical activity of muscle and content of red oxidative muscle fibre. Authors reported values for individual muscles from Rubia Galega x Holstein cross calves slaughtered at 9 months of age – shoulder (1.29%), inside round (0.94%), eye of round (1.10%), bottom round (1.25%), heel of round (0.75%), knuckle (1.15%) and tenderloin (2.80%). Highly marbled meat is traditionally considered ideal because of the effect of fat on taste and tenderness (Brewer, 2010). Similar to our results, Holló et al. (2013) found in loin muscle from Buffalo calves protein content of 20.99%.

The mean values of selected physical technological parameters of *M. longissumus lumborum* et *thoracis* associated with the quality of veal are presented in Table 5. Numerical differences in drip loss values between monitored groups of calves were determined; however results were not significant (P >0.05). According to Ripoll et al. (2013) values of drip loss is a result of *post mortem* lateral contraction of myofibrils, causing the secretion of free water into the extracellular space of the muscles. Moreover, content of free water is associated with the content of dry matter in meat (Gariépy et al., 1998). Slightly higher results (1.38%) reported Skřivanová et al. (2007) in Holstein male calves fed with TMR. In contrast, Campbell et al. (2013) determined in grain-fed calves drip loss values 4.40% for *Longissimus* muscle and 3.56% for *M. semitendinosus*.

Table 4 Chemical composition of loin muscle from Holstein calves of different feeding group ($\bar{x}$ ±s_x)

	TMR (n = 10)	Alfalfahay (n = 10)	*Sign.*
Water (g 100 g^{-1})	73.20 ±2.59	68.91 ±2.55	*
Protein (g 100 g^{-1})	20.34 ±1.31	19.41 ±0.39	*ns*
IMT (g 100 g^{-1})	5.26 ±1.19	6.69 ±0.66	*
Energy value (kJ 100 g^{-1})	538.73 ±27.23	576.95 ±28.20	*

* P ≤0.05;**P ≤0.01; *** P ≤0.001; *ns* – not significant

The pH value measured 24 hours *post mortem* did not vary significantly; in case of *M. semitendinosus* (Table 6) there were no numerical differences between monitored feeding groups of calves. Different results reported Yim et al. (2015b), who found in Holstein calves slaughtered at 5 months of age pH values 5.77 in MLT muscle and 5.73 in *M. semimembranosus*. Ultimate pH is influenced by animal nutrition, as noted in Pateiro et al. (2013). On the other hand, the effect of pH is often referred to by other veal quality characteristics, especially color, and is generally measured as a consecutive factor; the rate of pH decline influences the meat color to a greater or lesser extent depending on the pigment content in each muscle (Ngapo and Gariépy, 2006). In addition, decline in muscle pH and temperature could influence meat color of veal carcasses when pigment concentrations do not significantly differ. Depending on muscle type, pigment content and rate of pH fall influence the meat color, i. e. pigment content in the loin muscle is more important than the rate of pH decline (Klont et al., 2000).

The differences in color parameters of the loin and top round muscles measured 24 hours and 7 days *post mortem* are presented in Tables 5 and 6. Significant differences ($P < 0.05$) in the yellowness (b^*) of the loin muscle 24 h after slaughter were observed. The most of differences in color parameters between meat cuts are associated with anatomical location, proportions of red fibres and haemoglobin content in blood (Gálvez et al., 2018; Cho et al., 2014).

Furthermore, anatomical location of muscles influences most of the color parameters, including pigment content, reflectivity, redness and rate of meat decolorization (Ngapo and Gariépy, 2006). The top round muscle

Table 5 Physical technological parameters of loin muscle associated with the veal quality of Holstein breed ($\bar{x} \pm s_x$)

		TMR (n = 10)	Alfalfahay (n = 10)	Sign.
pH_1		7.02 ±0.19	6.95 ±0.13	*ns*
pH_{24}		6.00 ±0.05	5.97 ±0.06	*ns*
Drip loss (%)		1.22 ±0.76	2.01 ±0.56	*ns*
Electrical conductivity – 1 (μS)		2.68 ±0.42	3.28 ±0.68	*ns*
Electrical conductivity – 2 (μS)		2.18 ±0.17	3.23 ±0.68	**
Meat color 24 h	CIE *L**	46.3 ±3.29	44.41 ±4.29	*ns*
	CIE *a**	7.38 ±1.71	7.06 ±2.56	*ns*
	CIE *b**	10.36 ±0.62	9.22 ±0.70	*
Meat color 7 d	CIE *L**	46.33 ±3.47	47.17 ±3.87	*ns*
	CIE *a**	8.01 ±0.78	7.33 ±2.22	*ns*
	CIE *b**	10.39 ±1.23	9.96 ±0.80	*ns*

* $P \leq 0.05$;** $P \leq 0.01$; *** $P \leq 0.001$; *ns* – not significant

Table 6 Physical technological parameters of top round muscle associated with the veal quality of Holstein breed ($\bar{x} \pm s_x$)

		TMR (n = 10)	Alfalfahay (n = 10)	*Sign.*
pH_1		6.98 ±0.10	6.88 ±0.11	*ns*
pH_{24}		5.91 ±0.08	5.91 ±0.11	*ns*
Electrical conductivity – 1 (μS)		4.02 ±0.23	4.10 ±0.60	*ns*
Electrical conductivity – 2 (μS)		3.17 ±0.30	3.32 ±0.43	*ns*
Meat color 24 h	CIE *L**	48.51 ±3.33	49.79 ±3.39	*ns*
	CIE *a**	10.16 ±3.39	9.87 ±2.49	*ns*
	CIE *b**	12.13 ±0.84	12.42 ±1.43	*ns*
Meat color 7 d	CIE *L**	47.81 ±3.83	48.30 ±3.19	*ns*
	CIE *a**	9.73 ±3.21	9.79 ±2.68	*ns*
	CIE *b**	11.98 ±1.52	11.70 ±0.98	*ns*

ns – not significant

had greater lightness (L^*) 24 hours *post mortem* than loin muscle (48.51 and 49.79 vs. 46.3 and 44.41). These results are consistent with those reported by Gálvez et al. (2018), in which L^* values were greater in the eye of round muscle. No significant and numerical differences were found in the color measurements 7 days after slaughter for both – loin and top round muscles (P >0.05). For consumers is meat color very important attribute of satisfaction, while dark and pale color is associated with loss of freshness (Vieira et al., 2005). The lightest meat characterized 7 days *post mortem* with higher L^* values (49.79) were determined in samples from top round muscle of the experimental group of calves (P >0.05). The loin muscle from experimental group was also pinkest (a^* – 7.33). Slightly higher values than our results for meat lightness reported Yim et al. (2015b) in MLD from 5-months old Holstein calves (50.44). Mojto et al. (2009) determined in cows to 4 years of age L^* value 29.20.

4 Conclusions

Analysing of growth, carcass characteristics, veal quality and mutual correlation between analysed characteristics of Holstein calves differentiated according feeding concept has become an object of concern. Bull calves of the control group had higher dressing percentage than those of experimental group (P >0.05). Proportion of kidney and intestinal fat was influenced by feeding concept; control group of calves had lower proportion of kidney fat (P >0.05) and higher proportion of intestinal fat (P >0.05). Differences in weights and proportions of individual carcass quarters as well as in terms of individual retail meat cuts were not significant. Statistical significant variety of the moisture content, intramuscular fat content and energy value as well, were revealed (P <0.05). Physical technological parameters of both the muscles (pH, drip loss, electrical conductivity) showed similarity among the two feeding groups. In colour spectrum of *M. longissimus thoracis* measured 7 days after slaughter we observed lighter (L^* 47.17; P >0.05) and pinker (a^* 7.33; P >0.05) meat in group fed with alfalfa hay. No significant differences in the fattening, carcass characteristics as well as in chemical and physical technological parameters of Holstein veal fed with these feeding concepts were revealed.

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