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EXAMINATION OF CERTAIN BEEF QUALITY TRAITS UNDER THE INFLUENCE OF FLAXSEED DIET

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Invited paper

Abstract: The experiment was set up with the objective of examining the effect of adding flax seeds to the cattle diet on the quality of meat, in the final phase of fattening. Thirty Simmental young bulls of uniform initial body weight were selected for the experiment and divided into 2 groups (CON (control) and LS (experimental)). The control group did not consume flaxseed as a dietary supplement. Flaxseed was added to the experimental group in the amount of 3.75% (300 g per day) of the concentrated part of the meal in the final 90 days of fattening. The research included the examination of certain traits of beef meat quality. The results of the study show that the addition of flaxseed in the diet did not have a statistically significant effect on pH, water binding capacity (WBC), weight loss during cooking and meat tenderness. The chemical composition of the selected muscles, as well as the content of total pigments did not change significantly in the experimental animals compared to the control group. It was found that the addition of flax seeds to the diet during the final phase of fattening had an effect on the colour change of the meat reflected in the brightness L* of the muscles of *M. longissimus dorsi* and *M. semitendinosus.*

Key words: meat quality, meat colour, water binding capacity, flax seed

Introduction

Meat consumption is related to standard of living, eating habits and livestock production. Compared to other products, meat is characterized by high production costs and high product prices. Higher demand for meat in the diet is associated with changes in food consumption that favours increased protein intake deriving from animal products. Beef consumption is the third most common type of meat consumption with 15.1 kg per capita, after consumption of poultry and pork, 6.3, 11.8 and, respectively (*OECD, 2021*). The demand for beef grows proportionally with the increase of the population, as well as with the increase in household income. Beef consumption is estimated to be 8% higher in developed countries and 21% higher in developing countries by 2027 (*Mwangi et al., 2019*). Beef is rich in macro- and micro-nutrients - 100 g of beef provides more than 25% of the recommended dietary intake of protein, vitamin B6, vitamin B12, zinc and selenium and more than 10% of phosphorus, iron and riboflavin (*Troy et al., 2016*), and also has certain antioxidant properties (*Asp et al., 2012*).

Meat quality is defined by various technological and physical-chemical properties, such as pH value, water binding capacity, colour intensity, firmness and uniformity of meat structure and reflects the potential of this food for different processing operations. Postmortem changes take place in muscle, connective and adipose tissue and significantly affect the quality of meat (tenderness, structure, ability to bind water, sensory properties and digestibility). In the first stage of meat ripening, the pH value of the meat decreases (*Mancini and Hunt, 2005;Dalmau et al., 2009).* The final pH value is reached in 18 to 40 hours after slaughter. Immediately after slaughter, the pH value of meat ranges from 7.2 to 7.3, and with the transition of glycogen to lactic acid, the pH gradually decreases to 5.6 to 5.7. The pH value affects various meat quality parameters, including WBC. As the pH drops to values close to 5.2, WBC decreases and the amount of released meat juice increases. A decrease in pH leads to stabilization in muscle colour (*Aalhus et al., 2001*).

Muscle tissue contains about 75% water. The characteristic of meat to retain its own water, as well as water added under certain conditions, to a greater or lesser extent, and when an external force, such as pressure or heating, is applied, is referred to as water binding capacity (WBC) (*Rede and Petrović, 1997*). WBC is an important characteristic of meat quality. Loss of water from fresh meat is one of the most common quality problems of this food stuff, which results in numerous economic losses - from weight loss before sales and lower sales of meat, to reduced nutritional value of meat due to loss of valuable water-soluble proteins and vitamins (*Dalmau et al., 2009*).

Sensory quality of meat (colour, tenderness) has a great influence on the attractiveness of these products and consumer satisfaction with them (*Dransfield et al., 2003).* In order to be able to assess the quality of meat, a good knowledge of these characteristics is required. Meat quality is affected by the characteristics of the animal's muscles and the post-mortem biochemical reaction (*Ouali, 1990; Dransfield et al., 2003*). Colour intensity depends on: species, age and diet; the method of rearing and the function that the muscle has in a living organism (*Coleman et al., 2016*), as well as on the gender (*Muir et al., 2000*). Fresh beef is usually dark red in colour. The extremely dark (purple) red colour of beef is an undesirable sign and is most often a consequence of the action of premortal factors, among which stress is of great importance. The more desirable meat colour can be achieved by resting the animal before slaughter and better preparation for slaughter.

Materials and Methods

The research was performed in the experimental cattle farm and experimental slaughterhouse of the Institute of Animal Husbandry in Zemun (Serbia). Male animals of the domestic Simmental breed were used in the experiment. 30 Simmental cattle of uniform body weight were selected for the experiment. At the age of 390 days, two groups of 15 cattle were formed: control group (CON) in which the cattle did not consume heat-treated flaxseed and experimental group (LS) in which part of the concentrate was replaced by heat-treated flaxseed, so that each animal consumed 300 g of flax seeds per day. The final pre-slaughter weight was about 570 kg. Slaughter and primary processing were performed in the experimental slaughterhouse of the Institute of Animal Husbandry.

The pH of meat (*M. longissimus dorsi*) was determined in a muscle sample 45 minutes and 24 hours post mortem, with a pH meter with a combined prick electrode Hanna HI 83141 (Hanna Instruments, USA). The pH meter was pre-calibrated using standard buffer solutions, pH 4.0 and 7.0.

The water-binding capacity (WBC) of meat (*M. longissimus dorsi*, *M. triceps brachii* and *M. semimebranosus*) was determined by two methods: according to *Grau and Hamm (1953)* where the WBC value is expressed in cm^2 of wetted area and according to *Rede and Rahelić (1969),* where the WBC value is expressed in ml of released fluid.

Weight loss during cooking of meat (*M. longissimus dorsi, M. triceps brachii* and *M. semimebranosus)* was determined based on the difference in weight of a piece of meat size: 3 x 4 x 1.5 cm before and after cooking in a closed glass jar at 100°C for 10 minutes in distilled water (meat to water ratio 1: 2). It is expressed as a percentage in relation to the weight of the sample before cooking (*Official Gazette of the SFRY, No. 2/85, 12/85 and 24/86*).

The meat tenderness (*M. longissimus dorsi, M. triceps brachii* and *M. semimebranosus*), expressed by cutting force (kg), was determined after cooking at 100°C for 10 minutes and cutting the meat into pieces of 0.5 x 1 x 2 cm in the direction of extending muscle fibres using the consistometer by *Volodkevich (1938).*

The water content (*M. longissimus dorsi, M. triceps brachii* and *M. semimebranosus*) was determined by drying the sample to constant weight at 102°C ± 2°C *(SRPS ISO 1442, 1998*) and expressed as a percentage of the weight. The fat content (*M. longissimus dorsi, M. triceps brachii* and *M. semimebranosus*) was determined by the Soxhlet extraction method with petroleum ether as solvent (*SRPS ISO 1444, 1998)* on a Soxtherm multistat apparatus (Gerhardt, Germany). The fat content is expressed as a percentage of the weight. The protein content (*M. longissimus dorsi, M. triceps brachii* and *M. semimebranosus*) was determined by the Kjeldahl method (*SRPS ISO 937, 1992*) on the Kjeltec system 1026 (Foss Tecator, Denmark) and expressed as a percentage of the weight. The ash content (*M. longissimus dorsi, M. triceps brachii* and *M. semimebranosus*) was determined by burning the sample to a constant weight at 550°C ± 25 ° C (*SRPS ISO 936, 1999*) and is expressed as a percentage of the weight.

The content of total pigments (*M. longissimus dorsi, M. triceps brachii* and *M. semimebranosus*) was determined by the Hornsey method (Bunning and Hamm, 1970) and expressed in mg/kg (ppm).

Instrumental measurements of meat colour (*M. longissimus dorsi, M. triceps brachii* and *M. semimebranosus)* were performed on fresh meat samples (24 hours post mortem). Meat samples were cut and left for 30 minutes to stabilize the colour (the samples were in contact with air during that time). The test was performed with the device Chroma Meter CR-400 (Minolta, Japan), which was previously calibrated in relation to the standard white surface (illumination D65, observer angle 20° and at aperture size 8 mm). The colour values are presented in the system CIE L* a* b* (*CIE, 1976*) where the measure L* indicates the lightness of the flesh, a* the relative share of red and b* the relative share of yellow. Three readings were performed on each meat sample and their mean value was used for statistical data processing. The hue angle (H° - “real red”) was calculated as: arctangent arctangent (b*/a*) * 180/3,142. The chroma value (C* - “colour intensity”) was calculated as $(a^{*2} + b^{*2})^{0,5}$.

The obtained data were processed by analysis of variance in one-way ANOVA program SPSS Statistics 20, and all results are displayed as the mean value ± standard deviation. The statistical significance of the difference between mean values was determined by t-test.

Results and Discussion

The effect of the addition of flax seeds to the cattle diet on individual meat quality traits is shown in Table 1. The use of flax seeds in the final stage of cattle fattening did not statistically significantly affect the pH value (pH_{45} and pH_{24}) in the analysed muscle *M. longissimus dorsi*.

Hernàndez-Calva et al. (2011) reports values of pH_{45} 6.89 and pH_{24} 5.68 in cattle that consumed flaxseed as a dietary supplement. *Uchockis et al. (2014)* did not find significant effects of feeding flaxseed meal to cattle on pH_{24} value (5.92), as did *Suksombat et al., (2016)* who did not determine the effect of flaxseed oil addition on the pH of *M. longissimus dorsi*. *Ragni et al. (2014)* believe that the consumption of flax seeds by cattle does not cause differences in the values of pH_{45} (6.08) and pH_{24} (5.48). Similar values for pH_{24} (5.54) are given by *Petričević et al. (2015)* for Simmental cattle. A mean pH of 5.50 reflects a low pre-slaughter stress level and thus ensures good meat quality (*De Smet et al., 2004*).

Table 1. The effect of the addition of flax seeds in the cattle diet on certain meat quality traits

	K	O-1	p
	M. longissimus dorsi		
pH_{45min}	6.50 ± 0.10	6.64 ± 0.41	ns (0.403)
pH_{24h}	5.57 ± 0.30	5.63 ± 0.12	ns (0.732)
WBC (cm^2)	11.04±0.92	10.92±0.53	ns (0.735)
WBC (ml)	8.06±0.15	8.03±0.12	ns (0.778)
WL cooking (%)	41.83 ± 1.52	41.66 ± 0.91	ns (0.633)
Tenderness (kg)	10.61 ± 3.08	10.28 ± 1.14	ns (0.722)
	M. triceps brachii		
WBC (cm^2)	11.98±0.80	12.33±0.51	ns (0.075)
WBC (ml)	8.25±0.17	8.43±0.21	ns (0.052)
cooking (%)	44.20 ± 2.27	45.20 ± 2.14	ns (0.699)
Tenderness (kg)	8.00 ± 2.19	7.95 ± 0.53	ns (0.917)
	M. semitendinosus		
WBC (cm^2)	11.20±0.38	11.68±0.03	ns (0.270)
WBC (ml)	8.12±0.10	8.23±0.06	ns (0.070)
WL cooking (%)	44.25 ± 5.27	42.63 ± 0.31	ns (0.822)
Tenderness (kg)	8.57 ± 0.63	8.18 ± 0.26	ns (0.124)

[1] WBC-Water binding capacity; [2] WL – weight loss

The cattle diet with the addition of flaxseed did not statistically significantly affect WBC, WL cooking and meat tenderness in all three muscles (*M. longissimus dorsi, M. triseps brachii* and *M. semitendinosus*) (Table 1). The water WBC in *M. longissimus dorsi* was approximately the same between the groups, while in case of *M. triseps brachii* and *M. semitendinosus* it was more favourable in the control group. WBC changes under the influence of post mortem factors (*Aalhus et al., 2001*). Higher final temperatures after slaughter can cause a decrease in protein solubility which accompanies reductions in water binding capacity (*Hernàndez-Calva et al., 2011*).

The WL cooking values in the selected muscles were approximately the same between the groups. *Uchockis et al. (2014)* reports no significant differences for the value of meat WL cooking, although cattle from the group that consumed flaxseed meal had a higher value of WL cooking (44.46%) compared to the control group (40.84%). Similar results are reported by *Hernàndez-Calva et al. (2011)* and *Corazzin et al. (2012)* who state that the WL of cooking is higher in cattle that consumed flaxseed in the diet than those that did not, but that the established difference is not significant. *Piasentier et al. (2009)* state the value of WL cooking of 33.50%.

The meat was more tender in the samples of the experimental group in all three muscles. The established differences for meat tenderness between the examined groups were not statistically significant. *Suksombat et al. (2016)* in their study find no statistically significant differences in tenderness for *M. longissimus dorsi* and *M. semitendinosus*, but state that meat tenderness was better in cattle that consumed flaxseed as a dietary supplement, which is confirmed by the results of our study.

The results of the chemical composition of meat are shown in Table 2. The chemical composition of the selected muscles did not change significantly under the influence of the cattle diet with the addition of flaxseed. It should be noted that the treatment had a slight effect on increasing the content of intramuscular fat and protein. The differences in water and protein content were not statistically significant, but the cattle of the experimental group had lower water content and higher protein content in all three muscles.

Table 2. The effect of the addition of flax seeds in the cattle diet on the chemical composition of meat

%	**K**	**O-1**	**p**
	M. longissimus dorsi		
Water	74.97 ± 0.73	74.66 ± 1.53	ns (0.769)
Fat	1.56 ± 0.52	1.55 ± 1.08	ns (0.957)
Ash	1.14 ± 0.04	1.11 ± 0.04	ns (0.335)
Protein	22.31 ± 0.27	22.66 ± 0.63	ns (0.091)
	M. triceps brachii		
Water	76.48 ± 0.58	75.60 ± 0.95	ns (0.154)
Fat	1.42 ± 0.35	1.43 ± 0.65	ns (0.997)
Ash	1.04 ± 0.06	1.19 ± 0.10	ns (0.081)
Protein	21.01 ± 0.68	21.73 ± 1.06	ns (0.202)
	M. semitendinosus		
Water	75.16 ± 0.60	74.91 ± 0.53	ns (0.778)
Fat	1.12 ± 0.46	1.15 ± 0.57	ns (0.996)
Ash	1.17 ± 0.03	1.16 ± 0.04	ns (0.656)
Protein	22.52 ± 0.25	22.75 ± 0.32	ns (0.202)

Uchockis et al. (2014) state that the use of flaxseed cake in the diet of cattle did not have a statistically significant effect on the chemical composition of *M. longissimus dorsi,* where the water content was 76.37%, fat 1.25%, ash 1.05% and protein 21.17%. *Maurić et al. (2016)* report that the water content in *M. longissimus dorsi* ranges from 74.78–76.22%, the intramuscular fat content from 1.92–4.49%, the ash content from 1.08–1.17% and protein content of 19.66–21.25% in Simmental cattle weighing 526–588 kg. In most studies, the chemical composition of meat did not change under the influence of a flaxseed diet. Similar results are reported by *Juárez et al. (2012). Bures et al. (2006)* report a lower water and fat content and a higher protein content in *M. longissimus dorsi* for cattle weighing 550 kg compared to 630 kg cattle. In contrast, *Corazzin et al. (2012)* show a higher water content in *M. longissimus dorsi* in the control group than in the group of cattle fed with the addition of flaxseed.

The effect of the addition of flax seeds to the diet of cattle on the content of total pigments and meat colour is shown in Table 3. The addition of flax seeds to the cattle diet affected the production of lighter coloured meat. No significant effect of flax seed consumption on the content of total pigments in the analysed muscles was found. Higher content of total pigments in *M. longissimus dorsi, M. triceps brachii* and *M. semitendinosus* was determined in the control group.

Table 3. The effect of the addition of flax seeds in the cattle diet on the content of total pigments and meat colour

	K	O-1	p
	M. longissimus dorsi		
TP (mg/kg) [1]	138.58 ±35.53	136.00 ± 31.87	ns (0.929)
L*	34.99± 2.71	36.15 ± 2.55	* (0.087)
a*	18.91 ± 2.67	18.52 ± 2.42	ns (0.535)
b*	7.16 ± 1.48	7.17 ± 1.50	ns (0.898)
H^0 [2]	20.57 ± 2.07	20.97 ± 1.99	ns (0.661)
C* [3]	20.23 ± 2.97	20.04 ± 3.02	ns (0.630)
	M. triceps brachii		
TP (mg/kg) [1]	213.69 ±30.18	179.97 ± 30.18	ns (0.320)
L*	39.30 ± 2.25	40.99 ± 2.99	ns (0.054)
a*	23.75 ± 2.31	23.69 ± 2.44	ns (0.984)
b*	9.91 ± 1.87	9.90 ± 2.03	ns (0.313)
H^0 [2]	22.61 ± 3.50	22.32 ± 2.44	ns (0.113)
C* [3]	25.78 ± 2.53	25.73 ± 3.00	ns (0.954)
	M. semitendinosus		
TP (mg/kg) [1]	128.01 ±33.32	82.96 ± 17.78	ns (0.104)
L*	38.82± 3.94	43.05 ± 3.66	** (0.002)
a*	20.49 ± 4.57	17.28± 2.89	* (0.042)
b*	8.66 ± 2.86	8.55 ± 1.42	ns (0.844)
H^0 [2]	22.47 ± 3.87	26.53 ± 4.69	* (0.014)
C* [3]	22.29 ± 5.19	19.34 ± 2.86	ns (0.109)

[1] UP – Total pigments; [2] H^o (Hue) = [arctangent (b*/a*) × 180/3,142]; [3] C* (Chroma) = $[(a^{*2} + b^{*2})^{0,5}]$.

The use of flax seeds in the cattle diet affected a significant change in colour, namely the light L* value in *M. longissimus dorsi* and *M. semitendinosus*. Cattle in the experimental group had a statistically significantly ($p<0.05$) higher L* value in *M. longissimus dorsi* than cattle from the control group. In *M. triceps brachii*, the L* value did not differ between the examined groups, but the higher L* value was recorded in the experimental group. The experimental group had significantly ($p<0.01$) higher L* values in *M. semitendinosus*. The proportion of red (a*) was statistically significantly ($p<0.05$) different only in *M. Semitendinosus* and was higher in the control group. The use of flax seeds in the diet of cattle in the final phase of fattening caused a statistically significant ($p<0.05$) change in the Hue (H^0) value of *M. semitendinosus*.

Hernàndez-Calva et al. (2011) report no statistically significant differences for Chroma and Hue values which were higher in cattle fed silage and flax seed compared to cattle that consumed hay instead of silage. According to the authors *Merera et al. (2010)* differences in Chroma and Hue values may be related to the presence of adipose and connective tissue on the surface of meat. In their study, *Corazzin et al. (2012)* report no statistically significant differences for the meat colour of *M. longissimus dorsi*. According to them, the L* values of *M. longissimus dorsi* are higher in the control group, while the proportions of red (a*) and yellow (b*) are lower compared to the group fed flaxseed. These results are consistent with the results of *Mach et al. (2006). Drouillard et al. (2004)* report better meat colour results when using vitamin E with flaxseed.

Conclusion

The addition of flaxseed in the diet did not have a statistically significant effect on pH, water binding capacity (WBC), weight loss during cooking and meat tenderness. Also, the chemical composition of selected muscles and the content of total pigments did not change significantly under the influence of flaxseed. It was found that the addition of flax seed to the diet during the final phase of fattening had only an effect on the colour change of the meat reflected in the light L* in the muscles of *M. longissimus dorsi* and *M. semitendinosus Semitendinosus*. The share of red (a*) colour was higher in the control group, while the change in Hue (H^0) value was higher in the experimental group. The share of red (a*) colour and the Hue value (H^0) were statistically significant ($p<0.05$) distinguished in M. Semitendinosus.

Ispitivanje pojedinih karakteristike kvaliteta mesa junadi pod uticajem ishrane sa semenom lana

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Rezime

Eksperiment je postavljen sa ciljem da se ispita efekat dodavanja semena lana u ishranu junadi na kvalitet mesa, u završnoj fazi tova. Za ogled je odabrano 30 muških junadi simentalske rase ujednačenih početnih telesnih masa, koja su podeljena u 2 grupe (CON (kontrolna) i LS (ogledna)). Kontrolna grupa nije konsumirala seme lana kao dodatak ishrani. Junadima ogledne grupe je dodavano seme lana u količini od 3,75% (300 g dnevno) koncentrovanog dela obroka u poslednjih 90 dana tova. Istraživanje je obuhvatilo ispitivanje pojedinih karakteristika kvaliteta mesa junadi. Rezultati istraživanja su pokazali da dodatak semena lana u ishrani nije imao statistički značajan uticaj na pH vrednost, sposobnost vezivanja vode, gubitak mase tokom kuvanja i pečenja i mekoću mesa. Hemijski sastav odabranih mišića, kao i sadržaj ukupnih pigmenata nisu se značajno menjali kod oglednih grla u poređenju sa kontrolnom grupom. Utvrđeno je da dodatak semena lana u ishranu tokom završne faze tova imao uticaj na promenu boje mesa koja se ogledala u svetloći L* u mišićima *M. longissimus dorsi* i *M. semitendinosus*.

Key words: kvalitet mesa, boja mesa, sposobnost vezivanja vode, lan

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Reference

AALHUS J. L., JANS A. M., TONG A. K. W., JONES S. D. M., ROBERTSON, W. M. (2001): The influence of chilling rate and fat cover on beef quality. Canadian Journal of Animal Science, 81, 321–330.

ASP M. L., RICHARDSON J.R., COLLENE A. L., DROLL K. R., BELURY M. A. (2012): Dietary protein and beef consumption predict for markers of muscle mass and nutrition status in older adults. Journal of Nutrition, Health & Aging, 16, 784–790.

BUNNING K., HAMM R. (1970): Über die Haminbestimmung in fleisch mittels der methode von Horsney. Fleischwirtschaft, 50, 1541–1545.

BUREŠ D., BARTOŇ L., ZAHRÁDKOVÁ R., TESLÍK V., KREJČOVÁ M. (2006): Chemical composition, sensory characteristics, and fatty acid profile of muscle from Aberdeen Angus, Charolais, Simmental, and Hereford bulls. Czech Journal of Animal Science, 51, 279–284.

CIE (1976): Commission Internationale de l’Eclairage. Colorimetry, 2nd ed., Vienna.

CORAZZIN M., BOVOLENTA S., SEPULCRI A., PIASENTIER E. (2012): Effect of whole linseed addition on meat production and quality of Italian Simmental and Holstein young bulls. Meat Science, 90, 99–105.

COLEMAN L. W., HICKSON R. E., SCHREURS N. M., MARTIN N. P., KENYON P. R., LOPEZ-VILLALOBOS N., MORRIS S. T. (2016): Carcass characteristics and meat quality of Hereford sired steers born to beef-cross-dairy and Angus breeding cows. Meat Science, 121, 403–408.

DALMAU A., VELARDE A., GISPERT M. (2009): Standardisation of the measure „meat quality“ to assess the welfare of pigs at slaughter, in Forkman B., Keeling L., Assesment of Animal Welfare Measures for Sows, Piglets and Fattening Pigs, Welfare Quality Reports, 10.

DE SMET S., RAES K., DEMEYER D. (2004): Meat fatty acid composition as affected by fatnes and genetic factors. Animal Research, 53, 81–98.

DROUILLARD J. S., SEYFERT M. A., GOOD E. J., LOE E. R., DEPENBUSCH B., DAUBERT R. (2004): Flaxseed for finishing beef cattle: Effects on animal performance, carcass quality, and meat composition. Proceedings, 60th Flax Institute, 108–117.

DRANSFIELD E., MARTIN J. F., BAUCHART D., ABOUELKARAM S., LEPETIT J., CULIOLI J., JURIE C., PICARD B. (2003): Meat quality and composition of three muscles from French cull cows and young bulls. Animal Science, 76, 387–399.

GRAU R., HAMM R., BAUMANN A. (1953): Über das wasserbindungsvermögen des toten Säugetiermuskels. I. Mitteilung. Der Einfluß des pH Wertes auf die Wasserbindung von zerkleinertem Rindermuskel. Biochem. Z., 325, 1–11.

HERNÀNDEZ-CALVA L.M., HE M., JUÀREZ M., AALHUS J. L., DUGAN M. E. R., MCALLISTER T. A. (2011): Effect of flaxseed and forage type on carcass and meat quality of finishing cull cows. Canadian Journal of Animal Science, 91, 613–622.

JUÁREZ M., DUGAN, M. E. R., ALDAI N., BASARAB J. A., BARON V. S., MCALLISTER T. A., AALHUS J. L. (2012): Beef quality attributes as affected by increasing the intramuscular levels ofvitamin E and omega-3 fatty acids. Meat Science, 90 (3), 764–769.

MACH N., DEVANT M., BACH A., DÍAZ I., FONT M., OLIVER M. A., GARCÍA J. A. (2006): Increasing the amount of omega-3 fatty acid of meat from intensively fed young Holstein bulls through nutrition. Journal of Animal Science, 84, 3039–3048.

MAURIĆ M., STARČEVIĆ K., ŠTOKOVIĆ I., MAŠEK T. (2016): The influence of sires selection index on the intramuscular fat fatty-acid profile of their progeny. Veterinarski Arhiv, 86 (6), 753–766.

MERERA C., ABEBE G., SEBSIBE A., GOETSCH, A.L. (2010): Effects and interactions of origin of sheep in Ethiopia (Highland vs Lowland areas), feeding, and lengths of rest and feeding on harvest measures. Journal of Applied Animal Research, 37, 33–42.

MANCINI R. A., HUNT M. C. (2005): Current research in meat color. Meat Science, 71, 100–121.

MUIR P. D., WALLACE G. J., DOBBIE P. M., BOWN, M. D. (2000): A comparison of animal performance and carcass and meat quality characteristics in Hereford, Hereford×Friesian, and Friesian steers grazed together at pasture. New Zealand Journal of Agricultural Research, 43, 193–205.

MWANGI F.W., CHARMLEY E., GARDINER C. P., MALAU-ADULI B. S., KINOBE R. T., MALAU-ADULI A. E. O. (2019): Diet and Genetics Influence Beef Cattle Performance and Meat Quality Characteristics. Foods, 8(12), 648.

PETRIČEVIĆ M., ALEKSIĆ S., PETROVIĆ M. M., PANTELIĆ V., OSTOJIĆ-ANDRIĆ D., STANIŠIĆ N., NIKŠIĆ D. (2015): Comparative study of fattening and slaughter traits of male simmental breed and crosses with charolais breed. Biotechnology in Animal Husbandry, 31 (2), 265–272.

OECD (2021): Meat Consumption (indicator) https://data.oecd.org/agroutput/meat-consumption.htm

Official Gazette of the SFRY, No. 2/85, 12/85 and 24/86)/SL. LIST SFRJ, BR. 2/85, 12/85 i 24/86: Pravilnik o kvalitetu zaklanih svinja i kategorizaciji svinjskog mesa.

OUALI A. (1990): Meat tenderization: Possible causes and mechanisms. A review. Journal of Muscle Foods, 1, 129–165.

PIASENTIER E., BOVOLENTA S., MOIOLI B., ORRÙ L., VALUSSO R., CORAZZIN M. (2009): Fatty acid composition and sensory properties of Italian Simmental beef as affected by genes frequency of Montbéliarde origin. Meat Science, 83, 543–550.

RAGNI M., TOTEDA F., TUFARELLI V., LAUDADIO V., FACCIOLONGO A., DIPALO F., VICENTI A. (2014): Feeding of Extruded Flaxseed (Linum usitatissimum L.) and Pasture in Podolica Young Bulls: Effects on Growth Traits, Meat Quality and Fatty Acid Composition. Pakistan Journal of Zoology, 46 (4), 1101–1109.

REDE R., RAHELIĆ S. (1969): Priručnik za laboratorijske vežbe. Tehnologija mesa, Novi Sad.

REDE R. R., PETROVIĆ LJ. S. (1997): Tehnolologija mesa i nauka o mesu. Tehnološki fakultet Novi Sad.

SUKSOMBAT W., MEEPROM C., MIRATTANAPHRAI R. (2016): Performance, Carcass Quality and Fatty Acid Profile of Crossbred Wagyu Beef Steers Receiving Palm and/or Linseed Oil. Asian Australasa Journal Animal Science, 29, 1432-1442.

TROY D. J., TIWARI B. K., JOO S. (2016): Health implications of beef intramuscular fat consumption. Korean Journal Food Science Animal Resources, 36, 577–582.

UCHOCKIS V., ŠVIRMICKAS G. J., BALTRUKONIENĖ G. (2014): The effects of linseed cake supplementation on the growth and quality of carcass and meat of fattening bulls. Veterinary medicine and zootechnics., 66 (88), 73–77.

VOLODKEVICH N. N. (1938): Apparatus for measurement of chewing resistance or tenderness of foodstuffs. Food Research., 3, 221–225.

(1985): Pravilnik o kvalitetu mesa stoke za klanje, peradi i divljači, Sl. list SFRJ, br. 34/74, 26/75, 13/78 - dr. pravilnik, 1/81 - dr. pravilnik i 2/85 - dr. pravilnik). https://www.scribd.com/doc/183009807/Meso-i-Proizvodi-Od-Mesa

SRPS ISO 1442 (1998): Određivanje sadržaja vode.

SRPS ISO 1444 (1998): Određivanje sadržaja slobodne masti.

SRPS ISO 936 (1999): Određivanje sadržaja pepela.

SRPS ISO 937 (1992): Određivanje sadržaja belančevina