Chemical composition and fatty acid profile of the *longissimus dorsi* muscle in Simmenthal bulls

**M Lukic**, **D Trbovic**, **R Petronijevic**, **V Djordjevic**, **D Karan**, **J Babic Milijasevic** and **Z Petrovic**

1 Institute of Meat Hygiene and Technology, Belgrade, Serbia

E-mail: mirjana.lukic@inmes.rs

**Abstract.** The aim of this paper was to evaluate the carcass traits (live weight at slaughter, hot and cold carcass weights, dressing percentage, chilling loss), chemical composition and fatty acid profile of *longissimus dorsi* muscle (MLD) of Simmenthal bulls. The investigation was carried out on 10 Simmenthal bulls fattened in intensive conditions. The live, hot and cold carcass weights at slaughter were 597.9±29.53 kg, 326.9±17.06 kg and 319.4±16.64 kg, respectively. Dressing percentage was 54.6±1.17% and chilling loss was 2.3±0.26%. The mean muscle chemical composition was: dry matter 24.14 ±0.19%, water 75.86 ±0.59%, protein 20.78 ±0.30%, intramuscular fat 2.35 ±0.39%, ash 1.01±0.05%. High correlation was detected between live weight, hot carcass weight and cold carcass weight. The fatty acids of intramuscular fat consisted of 48.02 ±0.99%, 46.47±1.30% and 5.51±0.28% saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), respectively. The PUFA/SFA ratio was low (around 0.1), but the n-6/n-3 PUFA ratio was 4.24 and close to the recommended value. The level of MUFA correlated highly with the Δ9-desaturase (18) index (r=0.82 p<0.05) and oleic acid (C18:1n-9) (r=0.90 p<0.05), as did PUFA and linoleic acid (C18:2n-6) (r=0.96 p<0.05). Correlations (p<0.05), between major fatty acids, live weight and intramuscular fat were weak.

1. **Introduction**

Over recent decades, growing attention has been paid to dietary aspects of bovine meat consumption. Health concerns have been directed at the fat content and fatty acid composition of beef, particularly due to the high content of saturated fatty acids (SFA) which are believed to be associated with some human diseases [1]. The fatty acid composition of beef is influenced by a number of factors, including diet, breed, genotype, age and gender. Genetic and nutritional approaches have been widely studied in relation to fatty acid composition of beef, although it is acknowledged that genetic factors generally provide smaller differences than animal dietary factors. Increasing the content of n-3 polyunsaturated fatty acids (PUFA) and reducing SFA with the net effect of increasing the PUFA/SFA ratio and reducing the n-6/n-3 PUFA ratio in beef intramuscular fat are important priorities [2].

Simmenthal cattle are the most common dual-purpose breed in Serbia that accounts for up to 75% of the overall cattle population [3]. A common diet used for beef cattle production under indoor conditions consists of maize silage and a concentrate including soybean. The objective of this paper was to analyse the carcass characteristics (live weight at slaughter, hot and cold carcass weight,
dressing percentage, chilling loss), the chemical composition and fatty acid profile of the *longissimus dorsi* muscle in young Simmental bulls and compare them with results from the literature for the same and different breeds of cattle.

2. Materials and Methods

2.1. Sample collection

The investigation was carried out on 10 Simmental bulls, fattened in intensive conditions, approximately 16 months old. We analysed carcass characteristic (live weight at slaughter, hot and cold carcass weight, dressing percentage, chilling loss), chemical composition and fatty acid profile of *longissimus dorsi* muscle (MLD). Cattle were slaughtered at a commercial slaughterhouse. Live weight at slaughter (LWS) and hot carcass weight (HCW) were recorded on the slaughter day. After a chilling period of approximately 24 hours at 4°C, cold carcass weight (CCW) was measured and samples of the *longissimus dorsi* muscle were collected at the 9th-10th thoracic vertebrae. Dressing percentage was calculated as the ratio of HCW to LWS. Chilling loss was calculated as the ratio of HCW to CCW.

2.2. Chemical and fatty acid analysis

Moisture content was calibrated by the standard an oven drying method [4], fat content by Soxhlet extraction [5], protein content according to ISO [6] and ash content according to ISO [7].

FA analysis was by capillary gas chromatography. In brief, the total lipids were extracted from the meat by accelerated solvent extraction (ASE), (ASE 200, Dionex, Sunnyvale, CA, USA) with petroleum ether and isopropanol mixture (60:40, v/v) (as proposed by Dionex Application Note No. 345) at 100°C over three static cycles under nitrogen at 12 MPa. The solvent from the collected extracts was removed under a stream of nitrogen (Dionex Solvent evaporator 500) at 50°C until dry. Fatty acid methyl esters (FAMEs) in the extracted lipids were prepared by esterification using 0.5 M sodium methoxide in anhydrous methanol as proposed by Christie *et al.* [8]. FAMEs were determined by gas-liquid chromatography (Shimadzu 2010, Kyoto, Japan) equipped with a flame ionization detector and capillary HP-88 column (length 100m, i.d. 0.25 mm, film thickness 0.20 µm). Injector and detector temperature were 250ºC and 280ºC, respectively. Nitrogen was used as the carrier gas at a flow rate of 1.87 mL min⁻¹. The injector split ratio was set at 1:50. A programmed column oven temperature starting at 50ºC and ending at 230ºC was applied. Total analysis time was 66.5 min. The chromatographic peaks in the samples were identified by comparing relative retention times of FAME peaks with peaks in Supelco 37 Component FAME mix standard (Supelco, Bellefonte, PA) and a standard mixture of methyl esters of cis-9,11 and trans-10,12 isomers of conjugated linoleic acid (CLA) (O5632 ≥99%, Sigma-Aldrich, USA). Each sample was analysed in duplicate. Results were expressed as a percentage by weight of the total identified fatty acids. Indexes of ∆9-desaturase enzyme activity were calculated using formulas described by Bureš *et al.* [9].

2.3. Statistical analysis

Statistical analyses of the results were conducted using software GraphPad Prism version 7.0 for Windows (GraphPad Software, San Diego California USA, [www.graph.com](http://www.graph.com)). All parameters were described by descriptive statistics (mean, standard deviation). Pearson’s correlation was used to determine relationships between means of the examined parameters. Statistical differences between means of the examined parameters were determined on the level p <0.05.

3. Results and discussion

The present study was conducted to evaluate the carcass traits, chemical and fatty acid composition of the *longissimus dorsi* muscle of Simmental bulls, fattened in intensive conditions. The live weight at slaughter, carcass traits (hot and cold weight, dressing percentage chilling loss) and the chemical composition of the *longissimus dorsi* muscle are presented in Table 1. The mean live weight recorded
was 597.9±29.53 kg, which is slightly lower than found for Czech Fleckvieh cattle, fattened to approximately same age [10]. However, our young bulls had a higher average final mass compared to the mass recorded by Štoković et al. [11] for Croatian Simmental cattle.

Table 1. Mean live weight, carcass quality traits and chemical composition of the longissimus dorsi muscle in 10 Simmental cattle

| Trait                        | \(\bar{x}\) | SD     |
|------------------------------|-------------|--------|
| Live weight at slaughter (kg)| 597.9      | 29.53  |
| Hot carcass weight (kg)      | 326.9      | 17.06  |
| Cold carcass weight (kg)     | 319.4      | 16.64  |
| Dressing percentage (%)      | 54.6       | 1.17   |
| Chilling loss (%)            | 2.3        | 0.26   |

**Longissimus dorsi composition**

| Trait                | \(\bar{x}\) | SD |
|----------------------|-------------|----|
| Dry matter (%)       | 24.14       | 0.19 |
| Moistur (%)          | 75.86       | 0.59 |
| Intramuscular fat (%)| 2.35        | 0.39 |
| Protein (%)          | 20.78       | 0.30 |
| Ash (%)              | 1.01        | 0.05 |

\(\bar{x}\): mean; SD: standard deviation

High correlation was detected between LWS, HCW and CCW, as expected. However, LWS had no influence on the chemical composition of the MLD. The dressing percentage was 54.6±1.17% and this result accorded with those in other studies [12,13,14].

The chemical analysis of the *longissimus dorsi* muscle showed lower intramuscular fat content, 2.35±0.39%, than in literature records [15,11]. According to our findings, this Simmental beef could be classified as lean meat, because intramuscular fat content of 2-5% in many countries is accepted as being low in fat [2].

The results of the evaluations fatty acid composition showed that the total fatty acid content of the intramuscular fat consisted, on average, of 48.02±0.99% SFA, 46.47±1.30% MUFA and 5.51±0.28% PUFA (Table 2).

The predominant SFAs were myristic acid (C14:0), palmitic acid (C16:0) and stearic acid (C18:0). Palmitic acid (C16:0) made up the greatest proportion of SFA, which is in agreement to the literature records [2,16]. The medium-chain SFAs, lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acid, are nutritionally undesirable because they adversely affect plasma cholesterol level. They increase the level of blood low-density lipoproteins, which are thought to be associated with an increased risk of coronary heart disease [17]. Among the monounsaturated fatty acids detected in the intramuscular fat in the current study, and those with the highest percentages were oleic (C18:1cis-9) and palmitoleic (C16:1n-7) fatty acids (42.89±1.16% and 3.58±0.10%, respectively). Oleic (C18:1cis-9) and stearic (C18:0) fatty acids constituted more than 50% of the total fatty acid in all reported studies. MUFA's of the cis-configuration are hypocholesterolemic with the added advantage of not reducing high-density lipoprotein that protects against coronary heart disease (CHD) [18]. Stearoyl-CoA desaturase (\(\Delta^9\)-desaturase) is the enzyme responsible for conversion of SFA into MUFA in mammalian adipocytes. In case of ruminants, fatty acids in the feed are chemically reduced by microorganisms in the rumen and are adsorbed as SFAs. The composition of fatty acids stored in the fat depots reflects the previous action of \(\Delta^9\)-desaturase on substrates such as C18:0 or C16:0. In our experiment, the scores for \(\Delta^9\)-desaturase (16) index and \(\Delta^9\)-desaturase (18) index (11.87±0.32 and 72.16±0.77 respectively), were similar to values found in literature for Simmental cattle [10,9]. As expected, the level of MUFA
correlated highly with $\Delta 9$-desaturase (18) index ($r=0.82$ $p<0.05$) and oleic acid (C18:1n-9) ($r=0.90$ $p<0.05$).

**Table 2.** Fatty acid profile (% of total fatty acids), fatty acid ratios and desaturase indexes of the *longissimus dorsi* muscle from 10 Simmental cattle

| Fatty acid        | $\bar{x}$ | SD |
|------------------|----------|----|
| C14:0            | 1.70     | 0.63 |
| C15:0            | 0.48     | 0.13 |
| C16:0            | 26.56    | 0.04 |
| C17:0            | 0.71     | 0.02 |
| C18:0            | 16.54    | 0.15 |
| C20:0            | 0.09     | 0.02 |
| C16:1n-7         | 3.58     | 0.10 |
| C18:1n-9         | 42.89    | 1.16 |
| C18:2n-6         | 4.18     | 0.12 |
| C18:3n-3         | 0.96     | 0.04 |
| C20:4n-6         | 0.28     | 0.03 |
| C22:5n-3         | 0.06     | 0.08 |
| C22:6n-3         | 0.03     | 0.01 |
| SFA             | 48.02    | 0.99 |
| MUFA            | 46.47    | 1.30 |
| PUFA            | 5.51     | 0.28 |
| PUFA/SFA ratio  | 0.11     | 0.02 |
| n-6/n-3 ratio   | 4.24     | 0.72 |
| $\Delta 9$-desaturase (16) index | 11.87 | 0.32 |
| $\Delta 9$-desaturase (18) index | 72.16 | 0.77 |

Total PUFA in our Simmental muscle was notably lower than values reported for Simmental cattle [9,16], but slightly higher than found by [11] for Croatian Simmental cattle. A high correlation was detected between total PUFA and linoleic acid (C18:2n-6) ($r=0.96$ $p<0.05$). In our study, the P/S ratio was 0.11, which is highly unfavourable from a human dietary aspect. The minimum P/S ratio advised for human nutrition is at least 0.45 [19] and generally should be around 0.7 [20]. Nevertheless, the P/S index is of limited significance as not all SFAs increase cholesterol, as has already been pointed out. Additionally, the positive effects of MUFAs like oleic acid are not considered when this index is used. From the human nutrition point of view, one of the most important indices widely used to evaluate the nutritional value of fat is the n-6/n-3 PUFA ratio, which should have a value of below 4 [21].

### 4. Conclusion

The present study showed that the meat produced by young Simmental bulls is characterized by a low intramuscular fat content. Sex, age and weight are probably the main reason for this low fat content in the muscle studied. The fat content in muscle has an effect on the fatty acid composition, independent of animal dietary factors. Generally, it can be concluded that the relatively low proportion of intramuscular fat did lead to a suitably high proportion of PUFA and favourable balance n-6/n-3 PUFA, which was close to the recommended value in our study.
Acknowledgment
This work was supported by grants from the Ministry of Education, Science and Technological Development of the Republic of Serbia (project no. III46009).

References
[1] Hocquette J F, Richardson R I, Prache S, Medale F, Duffy G and Scollan N D 2005 The future trends for research on quality and safety of animal products J. Animal Sci. 4 49–72
[2] Scollan N, Hocquette J F, Nuernberg K, Dannenberger D, Richardson I and Moloney A 2006 Innovations in beef production system that enhance the nutritional and health value of beef lipids and their relationship with meat quality Meat Sci. 74 17–33
[3] Petrović M M, Petrović M P, Petrović M, Aleksić S, Ostojić-Andrić D, Pantelić V and Novaković Ž 2011 How to increase production of beef, lamb and pork in Serbian domestic market and export Biotechnol. Anim. Husb. 27(3) 293–303
[4] ISO 1998 Determination of moisture content ISO1442:1998 standard In: International standards meat and meat products Geneva Switzerland: International Organisation for Standardisation
[5] ISO 1992 Determination of total fat content ISO1443:1992 standard In: International standards meat and meat products Geneva Switzerland: International Organisation for Standardisation
[6] ISO 1992 Determination of nitrogen content ISO 937:1992 standard In: International standards meat and meat products Geneva Switzerland: International Organisation for Standardisation
[7] ISO 1998 Determination of total ash ISO 936:1998 standard In: International standards meat and meat products Geneva Switzerland: International Organisation for Standardisation
[8] Christie W W, Sebedio J L and Juaneda P 2001 A practical guide to the analysis of conjugated linoleic acid (CLA) Inform. 12 147–52
[9] Bureš D, Barton L, Teslík V and Zahradkova R 2006 Chemical composition, sensory characteristics and fatty acid profile of meat from Aberdeen Angus, Charolais, Simmental and Hereford bulls Czech J. Anim. Sci. 51 279–84
[10] Zapletal D G, Chladek J and Šubrt J 2009 Breed variation in the chemical and fatty acid compositions of the longissimus dorsi muscle in Czech Fleckvieh and Montbeliarde cattle Lives. Sci. 123 28–33
[11] Štoković I, Starčević K, Karadžije I, Križanović D, Božić P and Maurić M 2013 The chemical compositions and fatty acid profile of the longissimus dorsi muscle in young Simmental bulls Vet. Arhiv 83 135–44
[12] Petričević M, Stanišić N, Sretenović Lj, Petrović M M, Stajić S and Nikšić D 2011 Properties and composition of carcass of domestic spotted young cattle of two preslaughter weights Biotechn. Anim. Husb. 24 (4) 1443–50
[13] Warithitham A, Lambertz C, Langholz H J, Wicke M and Gauly M 2010 Assessment of beef production from Brahman x Thai native and Charolais x Thai native crossbred bulls slaughtered at different weights I:Growths performance and carcass quality Meat Sci. 85 191–5
[14] Sanudoa C, Maciea E S, Ollata J L, Villarroel M, Panea B and Albert P 2004 The effects of slaughter weight, breed type and ageing time on beef meat quality using two different texture devices Meat Sci. 66 925–32
[15] Barton L, Bureš D and Kudrna V 2010 Meat quality and fatty acid profile of the musculus longissimus lumbarum in Czech Fleckvieh, Charolais and Charolais x Czech Fleckvieh bulls fed different types of silages Czech J. Anim. Sci. 55 479–87
[16] Nuernberg K, Dannenberger D, Nuernberg K, Ender J, Voigt N D, Scollan J D, Wood J D et al. 2005 Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds Lives. Prod. Sci. 94 137–47
[17] Trbović D, Spirić D, Lukić M, Petrović Z, Parunović N, Djordjević V and Milićević D 2017 Fatty acid composition of cow’s milk: opportunities and challenges for Serbian dairy
producers *Meat Technol.* **58**(2) 118–24

[18] Cifuni G F, Napolitano F, Riviezzzi A M., Braghieri A and Girolami A 2004 Fatty acid profile, cholesterol content and tenderness of meat from Podolian young bulls *Meat Sci.* **67** 289–97

[19] Simopoulos A P 2004 Omega-6/Omega-3 essential fatty acid ratio and chronic disease *Food Rev. Int.* **20** 77–99

[20] Raes K, Balcean A, Dirinck P, De Wienne A, Claeys E, Demeyer D and Smet S D 2003 Meat quality, fatty acid composition and flavour analysis in Belgian retail beef *Meat Sci.* **65** 1237–46

[21] De la Fuente J, Diaz M T, Alvarez I, Oliver M A, Font i Furnols M, Sanudo C, Campo M M, Montossi F, Nute G R and Caneque V 2009 Fatty acid and vitamin E composition of intramuscular fat in cattle reared in different production systems *Meat Sci.* **82** 331–7