Nutritional value of horse meat and products on the Slovenian market

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SUMMARY

The nutritional value of three muscles (Longissimus lumborum, Biceps femoris and Triceps brahii) sampled from six horses of breed Posavec and two meat products were determined by the physicochemical, instrumental and sensory analysis. The basic chemical composition (water, fat, protein and ash content as well as fatty acid profile) and the pH value on raw muscles and two meat products were analysed. Horse meat steaks of 2.5 cm thickness were thermally treated on a double hot-plate grill at a temperature of 220 °C to the internal temperature of 65 °C. Sensory evaluation of the heat-treated samples and meat products were followed by quantitative descriptive analysis using a structured scale. The instrumental measurements of colour (CIE L, a*, b*) and texture (shear force on muscles and the Texture Profile Analysis test on products) were carried out. On average, 100 grams of meat contains 72.44 ± 1.94 g of water, 1.96 ± 2.33 g of fat, 21.52 ± 1.30 g of proteins, and 1.02 ± 0.06 g of ash, and pH value of 5.64 ± 0.05. Horse meat express an extremely beneficial fatty acid composition (containing 37.8 wt. % of saturated, 36.8 wt. % of monounsaturated and 17.6 wt. % of polyunsaturated fatty acids), the P/S ratio of 0.5 and the n-6/n-3 ratio of 3.6. The tenderer texture is found in the Longissimus lumborum muscle, followed by the Triceps brahii muscle and the Biceps femoris muscle. The colour is defined by the low L* value and high a* and b* values in comparison with the meat of other animals. On average, 100 g of horse hot dog contains 56.27 ± 0.82 g of water, 25.48 ± 0.85 g of fat, 14.04 ± 0.73 g of proteins, 2.47 ± 0.28 g of ash, and pH value of 6.23 ± 0.06, the P/S ratio of 0.5 and the n-6/n-3 ratio of 2.2. On average, 100 g of Posavska sausage contains 55.93 ± 1.28 g of water, 22.13 ± 2.56 g of fat, 18.52 ± 0.97 g of proteins, 3.01 ± 0.09 g of ash, and pH value of 6.16 ± 0.09, the P/S ratio of 0.5 and the n-6/n-3 ratio of 5.8. The panel assessed both products as good with specific characteristic due to the presence of horse meat.*

Keywords: *horse meat, chemical analysis, Posavec breed, horse meat products, fatty acids*

INTRODUCTION

Horse meat has a unique aroma and is a pinkish red in colour. Meat from older horses is even darker because it contains more myoglobin, meat pigment, than younger horses; oxygenated meat is dark to black red colour. Texture of horse meat is quite tough, stringy and firm, because it is low in intramuscular fat. Thermally treated meat of calves become soft, at complete doneness is lean and crumbly or saw-dusty. Floury aftertaste can be felt even at lower levels of doneness. Starchy aftertaste due to presence of noticeable level of glycogen is perceptible in meat of horses of all ages, with the years the aftertaste grow up significantly (Renčelj, 2008).

Horse meat is long established as an important dietary source of protein and essential nutrients with many culinary and processing options to make a lot of interesting and high-quality products (Žlender, 2000). The advantages of horse meat compared to beef are in contents of some nutrients, particularly in content of essential amino acids (which are similar to the egg; the perfect balance of essential amino acids), in favourable composition of fatty acids (more C18:2, C18:3 and C18:4) and in ratio once- and polyunsaturated fatty acids (horse fat contains more than 50% unsaturated fatty acids, of which 20% are the linoleic and linolenic acids) (Žlender, 2000).

Horse meat is in content of water (75 g/100 g), protein (23 g/100 g) and fat (2 g/100 g) similar to beef and all other types of lean meat (Žlender, 2000). The exception here was relatively high content of carbohydrates in

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the form of glycogen, which gives horse meat a specific sweet taste. In well-bred animals also marbled muscles can be found. Especially meat from older animals has high content of iron, so it is appreciated in the diet of anemic patients. The horse meat is also better source of vitamin A than other types of meat. Shelf life of horse meat is slightly shorter compared to beef.

Therefore, the aim of present study was to determine the main physico-chemical, instrumental and sensory characteristics of horse meat and some horse meat products, as well as conducting a comparison with literature data on red meat and products.

MATERIAL AND METHODS

Sampling and sample preparation for analysis

The horse muscles samples of Posavec breed and two meat products used in this study were collected 21st May 2010 from small workshop named PAG Kapele d.o.o. (Brežice, Slovenia). On the second day after slaughter muscles were sampled from six cold horse halves (4 ± 1 °C). The Longissimus lumborum (LL), Biceps femoris (BF) and Triceps brachii (TB) muscles in average weight of 1 kg (surface fat trimmed out) were removed from left halves of carcasses and used in further study. Samples were then vacuum packed in polyethylene bags, labelled and transferred in refrigerated transport bag to a controlled freezer (temperature of -20 ± 1 °C) at Biotechnical Faculty. After three days of frozen storage all muscles were thawed in refrigerator (24 h at temperature of 4 ± 1 °C) and the pH values were measured directly. For instrumental and sensory analysis the muscles were cut out transversally to the muscle fibers direction by knife and 2.5 cm thick steaks were shaped. First, colour on the surface of raw formed steaks was measured instrumentally and sensory evaluated. Then the steaks were grilled on a pre-heated double hot-plate grill (temperature of plate, 220 °C) until the internal temperature reached 65 °C. The internal temperature of the sample was monitored using a thermocouple probe inserted into the midpoint of the steak. The core portions of the half of steaks were offered to panel and sensory analysis was performed; after cooling (in refrigerator at 4 ± 1 °C) the second parts of steaks were used for instrumental measuring of texture parameters. For the chemical analysis, the remaining raw parts of muscles after steaks shaping were initially homogenised (Grindomix GM 200; Retch, Germany), then vacuum packed into polyethylene bags and stored until analysis (protein, moisture, fat, ash and fatty acids content) in a freezer at -20 ± 1 °C. All chemical and physico-chemical parameters were measured twice, instrumental parameters four times and the sensory attributes were assessed by five panellists.

Samples of sausages and frankfurters were received in two parts, a total of five different batches of each product. The first three batches of horse frankfurters and Posavska sausages were sampled on 1st June 2010, while the last two batches were sampled after a week and transported in chilled bags (4 ± 1 °C). The samples were sensory evaluated on the same day, as well as instrumental colour and texture measurements were performed. For the chemical analysis, the rest of the not yet analysed samples were initially homogenised (Grindomix GM 200; Retch, Germany), then vacuum packed into polyethylene bags and stored until analysis (protein, moisture, fat, ash and fatty acids content) in a freezer at -20 ± 1 °C. All of the chemical and physico-chemical parameters were measured twice, instrumental colour parameters four times and texture parameters six times with the sensory attributes assessed by five panellists.

METHODS

Determination of basic chemical composition and pH value

The moisture content of the samples was determined on 5 g minced samples that were dried in an oven at 105 °C (according to Association of Official Analytical Chemists (AOAC) 950.46; AOAC 1997). The total protein content (crude protein, N × 6.25) was determined by the Kjeldahl method (according to AOAC 928.08; AOAC 1997), and the ash content was determined by mineralization of the samples at 550 °C (according to AOAC 920.153; AOAC 1997). The fat content was determined by the method described as AOAC Official Method 991.36. Fat (crude) in Meat and Meat Products (AOAC 1997), and the total lipids were extracted using hot treatment with petroleum ether as solvent. Data from the chemical analyses were expressed on a wet matter basis.

The pH was measured directly using a combined glass-gel spear electrode (type 03, Testo pH electrode) with a thermometer (type T, Testo penetration temperature probe) connected to a pH meter (Testo 230, Testo). The pH meter was calibrated with pH 4 and pH 7 buffers, and re-calibrated after every 20 readings. The calibration and reading were carried out at 4 °C, to ± 0.01 pH unit. The pH was measured twice, in the middle of each sample.

Determination of fatty acid profile

The fatty acid (FA) composition of the samples was determined using gas chromatography (GC). The method used was in-situ transesterification (Park and Goins, 1994), as modified by Polak et al. (2008). Briefly, homogenized samples were weighed into glass tubes. After adding 3 ml 0.5 M NaOH (Merck, Germany, 1.06498) in methanol (Merck, Germany) and 0.3 ml methylene chloride (CH2Cl2; Merck, Germany, 1.06044), in situ transesterification was performed by heating lipid-containing foods

at 90 °C for 40 min. Samples were cooled and 3 ml of 14% BF3 (Sigma Aldrich, Germany, B1252) in methanol was added. Heating (90 °C) was continued for 10 min. After cooling, the fatty acid methyl esters (FAMEs) were extracted into hexane (Merck, Germany, 104371). The contents of the FA methyl esters (FAMEs) were determined by GC, on a gas chromatograph (Agilent Technologies 6890, USA) with a flame ionisation detector and an HP-88 capillary column (Agilent Technologies; Cat. No. 112-88A7; 100 m × 0.25 mm × 2 µm). Separation and detection were performed under the following conditions: temperature programme, 150 °C (hold 10 min), 2 °C min−1 to 180 °C (hold 40 min), 3 °C min−1 to 240 °C (85 min); injector temperature, 250 °C; detector temperature, 280 °C; injector: split:splitless, 1:30; volume, 1 µL; carrier gas, He, 2.3 mL min−1; make-up gas, N2, 45 mL min−1; detector gases, H2, 40 mL min−1; synthetic air (21% O2), 450 mL min−1.

The FAMEs were determined through their retention times in comparison to the relevant standard mixtures, using: FAME mix (37 components; Supelco, Cat. No. 18919-1AMP); PUFA No.1: animal source (Supelco, Cat. No. 47015-U); Linoleic Acid Methyl Ester cis/trans Isomer Mix (Supelco, Cat. No. 47791); *cis-7-octadecenoic* methyl ester (Supelco, Cat. No. 46900-U) and cis-11-octadecenoic methyl ester (Supelco, Cat. No. 46904); methyl stearidonate (Fluka, Cat. No. 43959); natural ASA CLA 10t, 12c in CLA 9c, 11t (NuChek standards GLC-68D, GLC-85, GLC-411, GLC-546). The GLC-68D and GLC-85 standard mixtures were used to determine the response factor, Rfi, for each FA. The weight portion of each FA in the sample was determined using the Rfi and the factor of transformation of the FA content from the FAME content. The determination of the reliability and accuracy of the analytical method for the detection of the FAs was ensured by the use of the CRM 163 certified reference matrix (blended beef-pork fat), and this was in good agreement with the certified values. The FAMEs were expressed as percentages of the total FA content.

Atherogenic index (IA) was expressed as (C12:0 + 4 x C14:0 + C16:0)/(n-6 + n-3 + C18:1 + other MUFA) (Ulbricht and Southgate, 1991).

Texture measurement

Instrumental measurements of textural parameters were made by apparatus Texture Analyser TA.XT Plus (Stable Micro Systems Ltd., Surrey, UK) with a permissible load of 50 kg. On the heat-treated muscles the measurement of shear force was performed, while on meat products the Texture Profile Analysis (TPA) was carried out.

For measuring the shear force the thermal treated and cooled steaks/samples were used (described in section Sampling and preparation of samples for analysis); strips of 1 cm × 1 cm × 5 cm along to the muscle fibres were obtained (Su et al., 2000). The shear force was measured perpendicular to the length of each strip, using a texture analyser (TA.XT plus, Stable Micro Systems, UK) equipped with Warner Bratzler Blade Set with 'V' slot blade (HDP/WBV). The cross-head speed was 3 × 10–3 m/s. Four replicates were placed in a cell individually and cut into smaller pieces. The shear force was measured as maximal force, necessary for cutting of the sample (expressed as N), and adhesiveness (expressed as N.s).

Sample (horse frankfurters and Posavska sausage) preparation for TPA test was based on a study of Morales et al. (2007). Frankfurters were cut into cylinders 2 cm long, the Posavska sausages into cylinders 3 cm long. Particular attention has been given to the fact that the cylinders were cut as straight as possible. Diameter of frankfurters ranged from 1.3 to 1.4 mm, the diameter of the sausages was from 2.8 mm to 3.0 mm. As contact attachment cylindrical probe 100 mm (P100) was used. For TPA, the samples were compressed twice to 50 % of their original length (t = 5 s between 1st and 2nd compression cycle) and at a crosshead speed of 5 mm/s; analysis was repeated in six replicates. The force vs. time curves were recorded and the following parameters were calculated: firmness, cohesiveness, gumminess, springiness, chewiness and resilience.

Colour measurements

A CR 200b colorimeter (Minolta, Japan; Illuminant C, 0° viewing angle) was used to determine the Comission Internationale de l'Eclairage (CIE; International Commission on Illumination) L* (lightness), a* (±, red to green) and b* (±, yellow to blue) values on the surface of the sample. A white ceramic tile with the specifications of Y = 93.8, x = 0.3134, y = 0.3208 was used to standardise the colorimeter. The CIE L*, a*, b* colour values were measured at four different locations on the surface of thawed (24 h in refrigerator at 4 ± 1 °C) 2.5 cm thick steaks, as well as on cross-section and casings surface of horse frankfurters and Posavska sausages.

Sensory evaluation

To evaluate the sensory qualities, a panel of five qualified and experienced panellists in the field of meat products was appointed (Gašperlin et al., 2014). Evaluation was carried out in defined, precisely prescribed, controlled and reproducible operating conditions. This includes: arrangement of laboratory, samples, accessories and organization of assessment (ISO 8589:2007). To neutralise the taste, the panel used the central dough of white bread.

On the basis of preliminary tasting for the purpose of the evaluation, the panel decided in favour of, and applied, the analytical-descriptive test (Golob et al., 2005). The analysis was performed by scoring the sen-

sory attributes on a structured scale from 1 to 7 points, where a higher score indicated greater expression of a given property. The exceptions here were for the texture, colour of sausage surface and saltiness, which were evaluated by scoring on a structured scale of 1 to 4 to 7 (1-4-7). Here, a score of 4 points was considered optimal, with scores of 4.5 or higher indicating greater expression of a property (to hard/rubbery, dark or too salty), and those of 3.5 or lower indicating insufficient expression of a property (to soft, too light or not salty).

Horse meat: Sensory analysis were performed on raw and thermally treated 2.5 cm thick steaksThe core portions of the steaks were cut into pieces of 2 cm × 2 cm × 1 cm and were offered to panellists. Five panellists were asked to assess meat colour on the raw steaks as well as softness, juiciness, smell and aroma on grilled samples by a 7-point scale as described above.

Horse frankfurters and Posavska sausage: For the sensory evaluation of the external appearance (colour of sausage surface) and slice cross-section (characteristic of colour and mosaic), the samples were cold (not thermally regenerated). One of the paired sausages was given to the panellists, which was cut longitudinally by knife, with two strips of approximately 1 cm thick and 12-16 cm long evaluated. For the sensory evaluation of the other attributes, like characteristic of colour on cross-section, mosaic, harmony of smell, horse meat smell, harmony of aroma, horse meat aroma, mouth feeling and juiciness, the samples of Posavska sausage were heated for 10 min and samples of horse frankfurters for 5 min in hot water at approximately 90 °C, and then the 1-cm-thick slices were cut for the panellists to evaluate. The panel evaluated the sensory attributes in the order that they were perceived.

Data Analysis

The data were analysed for normal distributions using the UNIVARIATE procedure (SAS/STAT, USA). The differences according to the muscles were analysed through a general linear model procedure and Duncan test (SAS/STAT), with a 0.05 level of significance. The experiments had six replications.

RESULTS AND DISCUSSION

Basic chemical composition and pH value of some horse muscles

On average, the protein content in horse meat was 21.52 g/100 g, moisture 72.44 g/100 g, fat 1.96 g/100 g, and ash 1.02 g/100 g with significant differences in moisture and ash content between muscles (Table 1). Data on LL muscle in this study are in relatively good agreement with those of Litwińczuk et al. (2007), who reported for LL muscle similar moisture (69.78 g/100 g), and ash (1.10 g/100 g) content, and slightly lower protein (19.67 g/100 g) and higher intramuscular fat (6.59 g/100 g) content. The average pH value of horse meat (5.64) varied within a range between 5.62 and 5.66 and was consistent with the findings of researchers Sarries and Bariain (2005), Lanza et al. (2009) and Litwińczuk et al. (2007). They emphasize that the pH after slaughter eventually equalize and remain stable.

Table 1. Basic chemical composition and pH values (BF – Biceps femoris; LL – Longissimus lumborum; TB – Triceps femoris) (n = 6)

Parameter determined	Value of parameter regarding to the type of muscle				Average
	BF	LL	TB	S.	
Moisture (g/100 g)	72.63 ± 1.78b	70.79 ± 1.63c	73.91 ± 0.90a	***	72.44 ± 1.94
Fat (g/100 g)	1.94 ± 2.73	2.88 ± 2.83	1.07 ± 0.34	Ns	1.96 ± 2.33
Protein (g/100 g)	21.25 ± 1.31	21.70 ± 1.73	21.60 ± 0.74	Ns	21.52 ± 1.30
Ash (g/100 g)	1.03 ± 0.05a	0.97 ± 0.08b	1.04 ± 0.03a	**	1.02 ± 0.06
pH	5.65 ± 0.05	5.62 ± 0.04	5.66 ± 0.07	Ns	5.64 ± 0.05

n – number of animals; S. – significance: *** P ≤ 0.001 very highly statistically significant; **P ≤ 0.01 highly statistically significant; Ns – P > 0.05 statistically not significant; data with different superscript letters within a row (a, b, c) differ significantly (P ≤ 0.05)

Fatty acid profile of some horse muscles

The main fatty acids present in horse muscles were saturated (SFA; 37.8%), monounsaturated (MUFA; 36.8%) and polyunsaturated (PUFA; 17.67%) fatty acids; calculated nutritional informations of fat were relatively high PUFA/SFA (P/S; 0.5) ratio and atherogenic (IA; 0.8) index, meanwhile horse fat has relatively favourable ratio of n-6 and n-3 PUFA (3.6). The principal SFA in horse meat were palmitic (C16:0) (28.02%), (C18:0) stearic (5.45%) and miristic (C14:0) (3.39%) fatty acids, the most prevalent MUFA were oleic (C18:1) (27.16%) and palmitoleic (C16:1c-9) (6.19%) fatty acids, and the main PUFA component were linoleic acid (C18:2n-6) with share of 12.26%, α-linolenic acid (C18:3n-3) with 54.57% and arachidonic (C20:4n-6) fatty acids with 1.70%. Other fatty acids were presented in shares under 0.1% of total fatty acids.

It can be focused that the different muscles of horse meat in fatty acid profile significantly differ (Table 2). On average, horse LL muscles had a higher proportion of MUFA than SFA; conversely, the BF and TB muscles had higher shares of SFA than the MUFA. As for fatty acid profile of individual muscle it can be said, that LL and BF muscles shared similar profile, and significantly differ from profile of TB muscle. LL and BF muscles in comparison to TB muscle contained significantly higher shares of palmitic (C16:0) (for 6.7% and 5%), oleic (C18:1) (for 7.4% and 7.7%), α-linolenic acid (C18:3n-3) (for 1.1% and 1.7%), miristic (C14:0) (for 1% and 1.7%) and lower shares of linoleic (C18:2n-6) (for 12.5% and 9.6%), stearic (C18:0) (for 2.8% and 2.6%), arachidonic (C20:4n-6) (for 2.2% and 2.4%) and pentadecanoic (C15:1c-5) (for 2.1% and 2.5%) fatty acids.

The average P/S ratio for horse meat in this study was relatively high (0.5), with value of 0.3 for LL, 0.4 for BF and 0.7 for TB muscle. Results are lower than in foals' meat of Sanfratellano (0.82), Haflinger (0.85), Burguete (0.72) and Hispano-Bretón (0.61) breeds (Lanza et al., 2009; Juarez et al., 2009). Golob et al. (2006) for pork LL and BF muscles cited significantly lower P/S ratio (0.31 and 0.36) and even lower ratio for bovine TB muscle (0.25). Nutritionally favourable ratio should be higher than the value of 0.5, which means that horsemeat can be added among the types of meat with a quite favorable P/S ratio.

The average n-6/n-3 ratio for horse meat was relatively low (3.6), with value of 1.4 for LL, 2.4 for BF and 7.0 for TB muscle. Results for LL muscle are lower than Longsissimuss dorsi muscles in Sanfratellano (6.7) and Haflinger (4.1) breeds (Lanza et al., 2009). Golob et al. (2006) cited for pork LL and BF muscles significantly higher n-6/n-3 ratio (13.7 and 12.4) and lower n-6/n-3 ratio for bovine TB muscle (2.9).

In this study the average IA index for horse meat was relatively high (0.8), with value of 0.9 for LL and BF muscles, and 0.6 for TB muscle. Golob et al. (2006) cited for pork LL and BF muscles lower IA index (0.59 and 0.56). The lower is the index, less burdensome are fatty acids on health.

Sensory attributes of some horse muscles

Different muscles of horse meat significantly differ in all assessed attributes; exception was the colour (Table 3). From the results of sensory analysis it can be concluded that the LL and TB muscles were significantly softer, juicier, with more distinctive smell and flavor in comparison with BF muscle.

Colour and texture of some horse muscles

For two Spanish local breeds (Burguete and Hispano-Bretón) reared following the same traditional production system (24 months old) Juarez et al. (2009) measured L* (34.6 vs. 28.4), a* (24.2 vs. 19.8) and b* (9.6 vs. 7.0) values on Rectus abdomini muscle. In a similar study (Franco et al., 2011) measured a significantly higher L* values and significantly lower a* and b* values for LD muscle of "Galician Mountain" foals breed as indicated by Juarez et al. (2009). They also reported that the males had the slightly brighter (L*), redder (a*) and yellower (b*) muscle than female due to their greater physical activity. Sarries and Beriain (2005) reported significantly higher values of L* and b* values and lower a* in the Longissimuss lumborum muscle than in the Rectus abdominis muscle. Results obtained in this study showed that there were significant differences between the muscles; the brightest (the highest L* value) and the reddest and yellowest (the highest a* and b* values) was LL muscle, followed by BF and TB muscles (Table 4).

Table 2. Fatty acid composition of different horse muscle (BF – Biceps femoris; LL – Longissimus lumborum; TB – Triceps femoris) (n = 6)

FA	Mass fractions of fatty acids (%)[a] regarding to the type of muscle				Average
	BF	LL	TB	S.	
C8:0	0.02 ± 0.01b	0.05 ± 0.01a	0.03 ± 0.03b	*	0.03 ± 0.02
C10:0	0.05 ± 0.01a	0.04 ± 0.01a	0.03 ± 0.02b	***	0.04 ± 0.02
C11:0	0.00 ± <0.01a	0.00 ± <0.01b	0.00 ± <0.01b	***	0.00 ± <0.01
C12:0	0.18 ± 0.02a	0.15 ± 0.03b	0.12 ± 0.05c	***	0.15 ± 0.04
C12:1c-5	0.00 ± <0.01a	<0.01 ± 0.01a	0.00 ± <0.01b	*	0.00 ± <0.01
C13:0	0.05 ± 0.04b	0.04 ± 0.03b	0.16 ± 0.09a	***	0.08 ± 0.08
C14:0	4.18 ± 0.64a	3.48 ± 0.57b	2.51 ± 1.20c	***	3.39 ± 1.09
C14:1t-7	0.04 ± 0.01a	0.03 ± 0.01a	0.02 ± 0.01b	***	0.03 ± 0.02
C14:1c-7	0.26 ± 0.27b	0.45 ± 0.16a	0.32 ± 0.23b	***	0.34 ± 0.23
C15:0	0.24 ± 0.08a	0.18 ± 0.02b	0.15 ± 0.03b	***	0.19 ± 0.07
C15:1c-5	0.63 ± 0.61b	1.08 ± 0.41b	3.17 ± 1.61a	***	1.64 ± 1.51
C15:1c-10	0.02 ± 0.01b	0.03 ± 0.01b	0.07 ± 0.04a	***	0.04 ± 0.03
C16:0	29.25 ± 1.25a	30.91 ± 0.32a	24.24 ± 4.79b	***	28.02 ± 4.08
C16:1t-9	0.03 ± 0.01b	0.22 ± 0.27a	0.19 ± 0.21ab	*	0.15 ± 0.21
C16:1c-9	3.90 ± 4.69b	9.26 ± 1.51a	5.67 ± 3.54b	***	6.19 ± 4.10
C17:0	0.13 ± 0.13b	0.23 ± 0.02a	0.29 ± 0.06a	***	0.22 ± 0.11
C17:1t-10	0.34 ± 0.15b	0.30 ± 0.13b	0.97 ± 0.54a	***	0.54 ± 0.45
C17:1c-10	0.10 ± 0.03	0.14 ± 0.09	0.09 ± 0.02	Ns	0.11 ± 0.06
C18:0	4.55 ± 0.47b	4.36 ± 0.49b	7.15 ± 2.22a	***	5.46 ± 1.91
C18:1total	29.86 ± 1.97a	29.62 ± 1.44a	22.19 ± 3.17b	***	27.16 ± 4.29
C18:2n-6	9.38 ± 2.26b	6.51 ± 4.05b	18.96 ± 6.02a	***	12.26 ± 6.89
C18:3n-6	0.05 ± 0.05b	0.11 ± 0.01a	0.07 ± 0.07b	**	0.07 ± 0.06
C20:0	0.01 ± 0.01a	0.00 ± 0.01ab	0.00 ± <0.01b	*	0.00 ± 0.01
C18:3n-3	5.36 ± 1.74a	4.74 ± 1.12a	3.63 ± 1.66b	**	4.57 ± 1.67
C20:1c-8	0.04 ± 0.03b	0.09 ± 0.15	0.00 ± <0.01b	Ns	0.04 ± 0.09
C20:1c-11	0.48 ± 0.09a	0.37 ± 0.12b	0.36 ± 0.05b	***	0.41 ± 0.10
C21:0	0.00 ± <0.01a	0.00 ± <0.01b	0.00 ± <0.01b	*	0.00 ± <0.01
C20:2n-6	0.23 ± 0.06b	0.16 ± 0.01b	0.32 ± 0.14a	***	0.24 ± 0.11
C20:3n-6	0.00 ± <0.01	0.01 ± 0.04	0.00 ± <0.01	Ns	0.00 ± 0.02
C22:0	0.16 ± 0.13b	0.25 ± 0.11b	0.60 ± 0.31a	***	0.34 ± 0.28
C20:3n-3	0.00 ± <0.01a	0.00 ± <0.01b	0.00 ± <0.01b	**	0.00 ± <0.01
C20:4n-6	0.79 ± 0.50b	1.04 ± 0.24b	3.22 ± 1.90a	***	1.70 ± 1.59
C22:1c-13	0.01 ± 0.01a	0.01 ± 0.02a	0.00 ± <0.01b	**	0.01 ± 0.01
C23:0	0.05 ± 0.02b	0.06 ± 0.02b	0.14 ± 0.09a	***	0.08 ± 0.07
C22:2n-6	0.03 ± 0.02b	0.07 ± 0.07a	0.02 ± 0.05b	*	0.04 ± 0.05
C20:5n-3	0.07 ± 0.06b	0.08 ± 0.08b	0.33 ± 0.18a	***	0.16 ± 0.17
C24:0	0.01 ± 0.01	0.01 ± 0.02	0.01 ± 0.02	Ns	0.01 ± 0.02
C22:3n-6	0.01 ± 0.01	0.01 ± 0.02	0.01 ± 0.02	Ns	0.01 ± 0.02
C22:4n-6	0.05 ± 0.03b	0.08 ± 0.02b	0.12 ± 0.05a	***	0.09 ± 0.04
C22:5n-3	0.04 ± 0.03b	0.05 ± 0.04b	0.11 ± 0.10a	*	0.06 ± 0.07
C22:6n-3	0.07 ± 0.07a	<0.01 ± 0.01b	0.00 ± <0.01b	***	0.02 ± 0.05
SFA/ ZMK	37.9 ± 2.1b	39.7 ± 0.4a	35.8 ± 3.1c	***	37.8 ± 2.7
MUFA/JNMK	35.3 ± 3.9b	41.6 ± 2.1a	33.7 ± 4.1b	***	36.8 ± 4.8
MUFA/JNMK	16.1 ± 1.8b	11.1 ± 4.1c	25.7 ± 6.8a	***	17.6 ± 7.6
P/S	0.4 ± 0.1b	0.3 ± 0.1c	0.7 ± 0.3a	***	0.5 ± 0.2
n-6	10.2 ± 2.6b	5.9 ± 4.6c	21.1 ± 7.1a	***	12.3 ± 8.0
n-3	5.5 ± 1.8a	4.8 ± 1.1ab	3.9 ± 1.6b	*	4.7 ± 1.6
n-6/n-3	2.4 ± 2.0b	1.4 ± 1.2b	7.0 ± 5.7a	***	3.6 ± 4.2
IA	0.9 ± 0.1a	0.9 ± 0.1a	0.6 ± 0.2b	***	0.8 ± 0.2

a-mass fraction of fatty acid is expressed as the total proportion of fatty acids; n – number of animals; S. – significance: *** P ≤ 0.001 very highly statistically significant; **P ≤ 0.01 highly statistically significant; *P ≤ 0.05 statistically significant; Ns – P > 0.05 statistically not significant; data with different superscript letters within a row (a, b, c) differ significantly (P ≤ 0.05); saturated fatty acids – SFA: C8:0, C10:0, C11:0, C12:0, C13:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0, C21:0, C22:0, C23:0, C24:0; monounsaturated fatty acids – MUFA: C12:1c-5, C14:1t-7, C14:1c-7, C15:1c-5, C15:1c-10, C16:1t-9, C16:1c-9, C17:1t-10, C17:1c-10, C18:1total, C20:1c-8, C20:1c-11, C22:1c-13; polyunsaturated fatty acid – PUFA: C18:2n-6, C18:3n-6, C18:3n-3, C20:2n-6, C20:3n-6, C20:3n-3, C20:4n-6, C20:5n-3, C22:2n-6, C22:3n-6, C22:4n-6, C22:5n-3, C22:6n-3; P – VNMK; n-6: C18:2n-6, C18:3n-6, C20:2n-6, C20:3n-6, C20:4n-6, C22:2n-6, C22:3n-6, C22:4n-6,; n-3: C18:3n-3, C20:3n-3, C20:5n-3, C22:5n-3, C22:6n-3; atherogenic index – IA.

Table 3. Sensory attributes of the different horse muscles (BF – Biceps femoris; LL – Longissimus lumborum; TB – Triceps femoris) (n = 6)

Property determined (1-7)	Value of property regarding to the type of muscle				Average
	BF	LL	TB	S.	
Colour	6.1 ± 1.3	6.3 ± 0.3	6.3 ± 0.3	Ns	6.2 ± 0.8
Smell	5.4 ± 1.2b	5.9 ± 0.3a	5.9 ± 0.2a	*	5.7 ± 0.8
Aroma	5.4 ± 1.2b	5.9 ± 0.3a	5.8 ± 0.3ab	*	5.7 ± 0.8
Softness	4.2 ± 1.1b	5.5 ± 0.7a	5.7 ± 0.5a	***	5.2 ± 1.0
Juiciness	5.2 ± 1.2b	5.8 ± 0.5a	5.6 ± 0.4ab	*	5.5 ± 0.8

n – number of animals; S. – significance; *** P ≤ 0.001 very highly statistically significant; **P ≤ 0.01 highly statistically significant; Ns – P > 0.05 statistically not significant; data with different superscript letters within a row (a, b, c) differ significantly (P ≤ 0.05)

Table 4. Instrumentally measured colour and texture parameters of the different horse muscles (BF – Biceps femoris; LL – Longissimus lumborum; TB – Triceps femoris) (n = 6)

Property determined (1-7)	Value of property regarding to the type of muscle				Average
	BF	LL	TB	S.	
Colour of raw muscle					
L*	33.2 ± 1.7b	34.5 ± 2.2a	31.7 ± 2.2c	***	33.1 ± 2.3
a*	16.9 ± 1.8b	18.0 ± 1.6a	16.1 ± 1.8b	**	17.0 ± 1.8
b*	3.8 ± 1.8b	5.0 ± 1.1a	3.9 ± 1.2b	**	4.2 ± 1.5
Texture of thermally treated muscle					
Shear force (N)	46.4 ± 10.2a	33.9 ± 11.1b	38.8 ± 24.6ab	**	39.7 ± 17.3
Adhesiveness(Ns)	151.4 ± 35.2a	123.0 ± 36.8b	130.1 ± 63.5ab	*	134.9 ± 48.1

n – number of animals; S. – significance: *** P ≤ 0.001 very highly statistically significant; **P ≤ 0.01 highly statistically significant; Ns – P > 0.05 statistically not significant; data with different superscript letters within a row (a, b, c) differ significantly (P ≤ 0.05)

Lanza et al. (2009) have found that the acceptable shear force for foals meat for two different breeds was at 58.45 N and 55.80 N, respectively; meanwhile Franco et al. (2011) found significantly lower values for shear force, from 25.3 N to 30.3 N. Different authors interpret the measurements of tenderness differently; authors (Litwińczuk et al., 2007) proposed that measurements have to be taken three times, 48 h following the slaughter on the raw meat, after the thermal treatment in a water bath (at a temperature of 75 ± 1 °C for 1 h) and after 7 days of aging at the cooling (2 ± 1 °C) conditions. For each sample of muscle, a minimum of eight replications have to be tested. In general, tenderness expressed by the shear force means that a higher value indicates tougher meat. Berry (1993) reported that a consumer was sure of getting the loin steaks of suitable tenderness (meat after thermal processing) if the shear force did not exceed 39 N. For cooked Longissimus lumborum muscles from in average 10 years old horses Litwińczuk et al. (2007) measured shear force 64 N, which is in all respects higher compared to the same muscle in this study (33.9 N).

Basic chemical composition and pH value of horse frankfurters and Posavska sausage

Horse frankfurters, cooked meat products, according to the label contain 53% of horse meat, pork fat, water, edible salt, dextrose, stabilizer di sodium di phosphate (E450), spices, extract of spices (red pepper), antioxidant ascorbic acid (E300), preservative sodium nitrite (E250). According chemical analysis on average, protein content of horse frankfurters was 14.04 g/100 g, moisture 56.27 g/100 g, fat 25.48 g/100 g, and ash 2.47 g/100 g, as well as pH value was 6.23 (Table 5). Posavska sausage is produced from 75% medium/coarse minced horse meat of the highest quality, combined with solid back fat. The meat was cured (E250), and the meat-fat mixture was seasoned and some additives were added (dextrose, E450 and E300), and filled exclusively in to the pig small intestine (i.e., hog casing), smoked and pasteurised to a core temperature of at least 70 °C. According chemical analysis on average, the protein content of Posavska sausage was 18.52 g/100 g, moisture 55.93 g/100 g, fat 22.13 g/100 g, and ash 3.01 g/100 g, as well as pH value was 6.16 (Table 5).

Table 5. Basic chemical composition and pH values of horse frankfurters and Posavska sausage (n=5)

Property determined	Value of parameter regarding the product	
	Horse frankfurters	Posavska sausage
Moisture (g/100 g)	56.27 ± 0.82	55.93 ± 1.28
Fat (g/100 g)	25.48 ± 0.85	22.13 ± 2.56
Protein (g/100 g)	2.47 ± 0.28	3.01 ± 0.09
Ash (g/100 g)	14.04 ± 0.73	18.52 ± 0.97
pH	6.23 ± 0.06	6.16 ± 0.09

n – number of samples in each experimental group

Fatty acid profile of horse frankfurters and Posavska sausage

The main fatty acids present in horse frankfurters and Posavska sausage were SFA (37.7 vs. 27.3%), MUFA (33.8 vs. 39.8%) and PUFA (17.8 vs. 14.7%); consequently calculated nutritional informations of fat were limit P/S index (0.5) and relatively high IA index (0.9 vs. 0.6), meanwhile horse frankfurters fat has almost three times better ratio of n-6 and n-3 PUFA (2.2 vs. 5.8) than Posavska sausage. Both horse products had higher (better) P/S index, comparable IA index and higher (worse) ratio of n-6 and n-3 PUFA than Kranjska sausage (0.09, 0.83 and 0.9) (Golob et al., 2006).

The principal SFA in horse products were palmitic (C16:0) (27.71 vs. 24.75%) and miristic (C14:0) (4.34 vs. 2.07%) fatty acids, the most prevalent MUFA was oleic (C18:1) (31.55 vs. 37.63%) fatty acid, and the main PUFA component were linoleic acid (C18:2n-6) with shares of 31.55% and 37.63% and α-linolenic acid (C18:3n-3) with 5.46% and 2.10%. Other fatty acids were presented in shares under 0.1% of total fatty acids.

Sensory attributes of horse frankfurters and Posavska sausage

On average, these horse frankfurters showed almost optimal colour on the surface, with slightly less distinc-

Table 6. Fatty acid composition of horse frankfurters and Posavska sausage (n = 5)

FA	Mass fractions of fatty acids (%)[a]	
	Horse frankfurters	Posavska sausage
C8:0	0.03 ± <0.01	0.02 ± 0.01
C10:0	0.05 ± <0.01	0.07 ± 0.01
C11:0	0.01 ± <0.01	<0.01 ± 0.01
C12:0	0.19 ± 0.01	0.11 ± 0.01
C12:1c-5	0.00 ± <0.01	<0.01 ± 0.01
C13:0	0.01 ± <0.01	<0.01 ± 0.01
C14:0	4.34 ± 0.59	2.07 ± 0.15
C14:1t-7	0.08 ± 0.13	0.01 ± 0.01
C14:1c-7	0.02 ± 0.01	0.13 ± 0.03
C15:0	0.31 ± 0.04	0.12 ± 0.01
C15:1c-5	0.13 ± 0.02	0.22 ± 0.04
C15:1c-10	0.01 ± <0.01	0.01 ± 0.01
C16:0	27.71 ± 2.20	24.75 ± 0.74
C16:1t-9	0.02 ± <0.01	0.01 ± 0.01
C16:1c-9	0.79 ± 0.07	0.50 ± 0.03
C17:0	0.01 ± <0.01	0.02 ± 0.01
C17:1t-10	0.42 ± 0.06	0.35 ± 0.04
C17:1c-10	0.12 ± 0.01	0.06 ± 0.01
C18:0	1.87 ± 2.45	<0.01 ± 0.01
C18:1total	31.55 ± 1.65	37.63 ± 1.07
C18:2n-6	11.45 ± 3.34	11.71 ± 1.12
C18:3n-6	0.02 ± <0.01	0.03 ± 0.01
C20:0	0.01 ± <0.01	0.02 ± 0.01
C18:3n-3	5.46 ± 1.08	2.10 ± 0.45
C20:1c-8	0.05 ± 0.01	0.04 ± 0.01
C20:1c-11	0.59 ± 0.05	0.77 ± 0.02
C21:0	0.01 ± <0.01	0.02 ± 0.01
C20:2n-6	0.16 ± 0.14	<0.01 ± 0.01
C20:3n-6	0.00 ± <0.01	0.02 ± 0.01
C22:0	0.12 ± 0.17	0.11 ± 0.01
C20:3n-3	0.02 ± 0.03	0.01 ± 0.01
C20:4n-6	0.38 ± 0.06	0.53 ± 0.05
C22:1c-13	0.01 ± 0.01	0.02 ± 0.01
C23:0	0.04 ± 0.01	0.02 ± 0.01
C22:2n-6	0.03 ± <0.01	0.02 ± 0.01
C20:5n-3	0.02 ± 0.01	0.03 ± 0.01
C24:0	0.03 ± 0.01	0.02 ± 0.02
C22:3n-6	0.01 ± <0.01	0.01 ± 0.01
C22:4n-6	0.02 ± 0.02	0.11 ± 0.02
C22:5n-3	0.03 ± 0.03	0.02 ± 0.01
C22:6n-3	0.12 ± 0.04	0.06 ± 0.03
SFA/ ZMK	34.7 ± 4.7	27.3 ±0.9
MUFA/ JNMK	33.8 ± 1.6	39.8 ± 1.1
PUFA/ VNMK	17.8 ± 2.9	14.7 ± 1.2
P/S	0.5 ± 0.2	0.5 ± 0.1
n-6	12.0 ± 3.3	12.3 ± 1.2
n-3	5.6 ± 1.1	2.2 ± 0.4
n-6/n-3	2.2 ± 0.8	5.8 ± 1.4
IA	0.9 ± 0.2	0.6 ± 0.0

a Mass fraction of fatty acid is expressed as the total proportion of fatty acids; n – number of samples; saturated fatty acids – SFA: C8:0, C10:0, C11:0, C12:0, C13:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0, C21:0, C22:0, C23:0, C24:0; monounsaturated fatty acids – MUFA: C12:1c-5, C14:1t-7, C14:1c-7, C15:1c-5, C15:1c-10, C16:1t-9, C16:1c-9, C17:1t-10, C17:1c-10, C18:1total, C20:1c-8, C20:1c-11, C22:1c-13; polyunsaturated fatty acid – PUFA: C18:2n-6, C18:3n-6, C18:3n-3, C20:2n-6, C20:3n-6, C20:3n-3, C20:4n-6, C20:5n-3, C22:2n-6, C22:3n-6, C22:4n-6, C22:5n-3, C22:6n-3; P – VNMK; n-6: C18:2n-6, C18:3n-6, C20:2n-6, C20:3n-6, C20:4n-6, C22:2n-6, C22:3n-6, C22:4n-6,; n-3: C18:3n-3, C20:3n-3, C20:5n-3, C22:5n-3, C22:6n-3; atherogenic index – IA.

tive colour on cross-section, a bit too bright, with less satisfactory harmony of smell and aroma due to more expressed saltiness, smell and aroma of horse meat. The texture in the mouth was evaluated according to characteristics, as overall texture, juiciness and toughness, where horse frankfurters was not optimal in texture, with slightly too tough texture, with noted porousness, slightly too dry (not juicy enough) and mouth feel was penalized because floury feeling.

Panel has estimated that the Posavska sausage showed some speciality such as well-expressed aroma of horse meat and too much expressed saltiness. At the same time sausage showed almost optimal colour on the surface, with slightly less distinctive colour on cross-section, again a bit too bright, with not optimal mosaic due to uneven distributed particles of meat and fat on slice, but with quite satisfactory harmony of smell and aroma. The texture was somewhat coarse and rubbery, observed slightly too dry (not juicy enough) due to noticeably leaking fluid, and strongly expressed floury feeling.

Table 7. Sensory attributes of horse frankfurters and Posavska sausage (n = 5)

Property determined (1-7)	Value of parameter regarding the product	
	Horse frankfurters	Posavska sausage
Colour of sausage surface (1-4-7)	4.0 ± 0.1	4.1 ± 0.2
Characteristic of colour on cross-section (1-7)	6.0 ± 0.2	6.0 ± 0.2
Mosaic (1-7)	-	5.9 ± 0.3
Harmony of smell (1-7)	5.3 ± 0.4	5.6 ± 0.4
Horse meat smell (1-7)	5.6 ± 0.6	5.8 ± 0.4
Harmony of aroma (1-7)	5.6 ± 0.4	5.7 ± 0.5
Horse meat aroma (1-7)	6.0 ± 0.4	6.0 ± 0.3
Saltiness (1-4-7)	4.3 ± 0.3	4.4 ± 0.4
Texture (1-4-7)	5.0 ± 0.2	5.0 ± 0.5
Mouth feeling (1-7)	3.7 ± 0.5	4.0 ± 0.6
Juiciness(1-7)	5.3 ± 0.3	5.6 ± 0.3

n – number of samples in each experimental group

Colour and texture of horse frankfurters and Posavska sausage

The results of instrumental measurements of colour parameters of horse frankfurters and Posavska sausage are given in Table 8. Samples of frankfurters in average on surface showed L* value at 53.2, a* value at 15.7 and b* value at 19.0, as well as on cross-section L* value at 60.2, a* value at 16.4 and b* value at 14.5. Dingstad et al. (2005) were found that consumer defined acceptability limits of lightness as 60%, purchase criterion were found to be between 62 and 68 (L*-CIE colour scale) and our results on horse frankfurters almost fitted.

On the other hand samples of Posavska sausage in average on surface showed slightly lower values: L* value at 43.4, a* value at 16.5 and b* value at 12.5, as well as on cross-section L* value at 49.5, a* value at 17.7 and b* value at 9.7. Lorenzo and Franco (2012) were found that high

Table 8. Instrumentally measured colour and texture parameters of the horse frankfurters and Posavska sausage (n = 5)

Property determined	Value of parameter regarding to the type of muscle	
	Horse frankfurters	Posavska sausage
Colour		
Casings		
L*	53.2 ± 4.8	43.4 ± 3.2
a*	15.7 ± 1.3	16.5 ± 2.0
b*	19.0 ± 1.0	12.5 ± 1.5
Cross-section		
L*	60.2 ± 2.4	49.5 ± 2.0
a*	16.4 ± 1.1	17.7 ± 1.4
b*	14.5 ± 0.5	9.7 ± 1.1
Texture		
Firmness (N)	89.4 ± 19.2	159.8 ± 21.8
Cohesiveness	0.54 ± 0.09	0.51 ± 0.12
Gumminess(N)	47.7 ± 9.5	81.2 ± 17.6
Springiness	0.97 ± 0.04	0.83 ± 0.04
Chewiness (N)	46.2 ± 9.0	66.9 ± 13.7
Resilience	0.5 ± 0.2	0.9 ± 0.3

n – number of samples in each experimental group

fat foal dry-cured sausages at production stage showed values: L* 50.80, a* 19.30 and b* 16.70, with ripening (7 days) became darker, redder and yellower (L* 47.28, a* 13.33 and b* 11.89). When compared horse frankfurters to frankfurters-type pork sausage (Primožič, 2012), in horse frankfurters similar L* (60.2 vs 69.0), high a* (16.4 vs 10.8) and b* (14.4 vs. 12.3) values than in pork frankfurters were found.

The results of instrumental measurements of TPA parameters of horse frankfurters and Posavska sausage are given in Table 8. It is interesting to compare firmness for frankfurters (89.4 N) with results acquired by Dingstad et al. (2005), which found that the most satisfying firmness of frankfurter-type sausages was at 46.9 N; at least 60% of consumers were willing to buy when the firmness was above 35.6 N. An upper limit was still not found. When compared horse frankfurters to frankfurters-type sausage from pork Primožič (2012) it was found slightly low expressed firmness (89.4 N vs. 98.4 N), cohesiveness (0.54 vs. 0.61), gumminess (47.7 N vs 60.3 N), springiness (0.97 vs. 1.00), chewiness (46.2 N vs. 60.3 N), and slightly high expressed resilience (0.5 vs. 0.38).

Table 8 shows that firmness of Posavska sausage was on average 159.8 N, cohesiveness 0.51, gumminess 81.2 N, springiness 0.83, chewiness 66.9 N and resilience 0.9. Present results can be compared to data from study on Kranjska klobasa-type pork sausages (Lušnic Polak et al., 2016), where average firmness of samples from Slovenian market was in range 108.1-195.5 N, cohesiveness 0.37-0.42, gumminess 39.9-88.7 N, springiness 0.92-0.94, chewiness 39.9-84.7 N, and resilience 0.13-0.18. Therefore, horse Posavska sausages are more cohesive in comparison with those pork sausages, less springy and more resilient.

CONCLUSION

In the past fifteen years, horse meat is losing popularity on Slovenian market, consequently its consumption decreased. For this reason we decided to evaluate nutritional value of horse meat and some products. In present study we confirmed that horse meat still have a great potential as an alternative meat, due to its relatively low content of fat and high content in PUFA. Also the P/S ratio of horse meat was found higher than in beef, pork, lamb and veal. Those facts, together with its relatively high contents of protein and specific aroma make horse meat a functional food. For the evaluation of entire nutritional profile of horse meat and products some data still missing, e.g. the cholesterol content. Maybe this is one of the tasks for the future.

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Every discussion must have a short summary in Croatian and English. Below the summary three to five key words must be stated.
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should be arranged alfabetically, as follows:

a) Article in the journal:
Abu-Ruwaida, A. S., W. N. Sawaya, B. H. Dashti, M. Murard, H. A. Al-Othman (1994): Microbiological quality of broilers during processing in a modern commercial slaughterhouse in Kuwait. J. Food Protect. 57, 887-892.

b) Proceedings:
Guerra, M., F. Bernardo (1997): Occurrence of Listeria spp. in traditional cheeses from Alentejo, Portugal. World Congress of Food Hygiene. The Hague, The Netherlands, 1997 August 24-29. Proceedings, p.214.

c)Book of abstracts:
Hadžiosmanović, M., L. Kozačinski, Ž. Cvrtila (2002): Shelf life of fresh poultry meat. Technology - food - nutrition - health, CEFOOD Congress, Ljubljana, September 22-25, 2002. Book of Abstracts, p. 99.

d) Book:
Gracey, J., D. S. Collins, R. J. Huey (1999): Meat hygiene. Tenth edition. W. B. Saunders company Ltd London, Edinburg, New York, Philadelphia, Sydney, Toronto.

The original (up to 15 typed pages) should have all the pictures, drawings, and diagrams. Supplements (charts, diagrams and pictures) are enclosed separately, at the end of the work. All appendices, graphs, photos and pictures must be bilingual (Croatian and English). Charts and photographs should be delivered in one of the graphic or image formats (.xls, *.tif or * .jpg)*
It is recommended to write in Word (Microsoft) programme, to use Word (Microsoft) or Excel (Microsoft) for charts.

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