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EFFECT OF GENOTYPE, AGE AT SLAUGHTER AND SEX ON CHEMICAL COMPOSITION AND SENSORY PROFILE OF RABBIT MEAT

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Abstract: A study was conducted to evaluate the chemical composition (moisture, protein, ash, fat, cholesterol, fatty acid composition) and sensory profile of meat from rabbits of both sexes belonging to two genotypes (Slovenian male line – SIKA and commercial hybrid breed imported from Italy – Hybrid) and slaughtered at different ages (77 and 90 days). Rabbits were fed a commercial diet *ad libitum*. The *Longissimus lumborum* muscles, abdominal wall and hind leg were sampled from thirty-two animals. On average, homogenized rabbit meat contains 72.7% moisture, 22.1% proteins, 1.31% ash, 4.1% fat, 76.6 mg cholesterol/100 g of fresh meat. Fatty acids are composed of 28.7% monounsaturated, 28.9% to polyunsaturated and 42.4% saturated fatty acids. The Polyunsaturated/Saturated ratio (0.69), the atherogenic index (0.64), the n-6/n-3 ratio (6.7) and the cholesterol content show that rabbit meat can be included in a balanced diet. The genotype had significant impact on the chemical composition: moisture (SIKA 72.3%, Hybrid 73.1%; $P<0.01$), ash (SIKA 1.34%, Hybrid 1.30%; $P<0.01$), protein (SIKA 22.0%, Hybrid 22.3%; $P<0.05$) and fat (SIKA 3.8%, Hybrid 4.3%; $P<0.05$). Meat originating from females contains more fat (4.3 *vs.* 3.7%; $P<0.05$) and lower ash (1.30 *vs.* 1.43%; $P<0.05$) than that originating from males. A very few differences due to genotype, sex and age were found in the sensory profile of roasted rabbit meat (after-taste, mouth feel and colour). With increased age, from 77 to 90 days, rabbit meat quality did not significantly improve.

Key words: Rabbit meat, chemical composition, fatty acid composition, cholesterol, sensory traits.

INTRODUCTION

As in some European countries, especially in the Mediterranean area, the breeding and consumption of rabbit meat is still rising in Slovenia. At the present time it has reached a value of 0.3 kg/per capita (Èepin *et al.*, 1997).

Meat is a major source of fat in the diet, especially of saturated fatty acids, which are as a rule considered a risk for the diseases associated with modern life, especially in developed countries. These include various cancers and especially coronary heart diseases (Wood *et al*., 2003). The World Health Organization recommends that daily fat intake should be reduced to 30% of total energy intake and that only 10% of energy intake should come from saturated fatty acids (SFA) (WHO, 1990). At the same time, the recommended ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (P/S) should be above 0.4 (Wood *et al*., 2003). The ratio n-6/n-3 PUFA is considered a risk factor in cancers and coronary heart disease and this ratio is recommended to be less than 4 (Enser *et al.*, 2001). Ulbricht and Southgate (1991) suggest that the atherogenic index (AI) is a more suitable measure of the atherogenicity of foods than the P/S ratio; IA being highest for the most atherogenic dietary components.

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It is well-known that the chemical composition of rabbit meat, especially fat content and the fatty acids profile, is largely influenced by a variety of factors including genotype, sex, feeding, age, breeding and/or physical activity of the animals as well as on the muscle type.

From the nutritional viewpoint, rabbit meat is appreciated for its favourable properties: it is lean, rich in unsaturated fatty acids (60% of all fatty acids) and low in cholesterol (Dalle Zotte, 2002). Besides nutritional parameters, the sensory properties of meat are crucial for consumer choice. Consumers consider that rabbit meat has good sensory properties: it is tender, lean and delicately flavoured (wild taste). The main cause of a potential refusal is its typical taste of wild game meat sometimes perceived by consumers (Dalle Zotte, 2002).

This study aimed at providing chemical and sensory data of rabbit meat from a local breed (SIKA) compared to a widespread European hybrid breed, and to find the optimal age at slaughter for this local breed for both technological, nutritional and sensory quality traits.

We anticipated that genotype (SIKA *vs.* Hybrid), age at slaughter (77 *vs.* 90 days) and sex (male *vs.* female) could largely affect the lipid composition (fat, cholesterol content and fatty acid profile) as well as the sensory profile of rabbit meat and consequently systematic comparisons were made.

MATERIAL AND METHODS

Animals

A total of thirty-two rabbits were included in the study. Rabbits were fed *ad libitum* a commercial diet (170 g crude protein/kg, 140 g crude fibre/kg, 10.4 MJ digestible energy/kg). The study included two different genotypes of rabbits (Slovenian male line - SIKA and commercial hybrid breed imported from Italy - Hybrid), two ages at slaughter (77 and 90 days) and both sexes. After electro-stunning, rabbits were slaughtered in an experimental slaughterhouse by cutting the carotid and jugular veins. Animals were fasted 2 hours before slaughter, but live weight was measured before fasting. The carcasses were prepared as recommended by Blasco and Ouhayoun (1993) by removing the skin, feet, paws, genital organs, urinary bladder and digestive tract. Live weight of 77- and 90-day old SIKA rabbits being 2558 *vs.* 2919 g and 2566 *vs.* 2765 g for Hybrids. The relatively large difference in live weight at 90-day of age between SIKA and Hybrid rabbits was not statistically significant. Slaughter yield for 77- and 90-day old SIKA rabbits being 53.4 *vs.* 56.8% and 53.8 *vs.* 57.0% for Hybrid ones.

Tissue sampling

The carcasses were eviscerated at the slaughterhouse and stored for 24 h at a temperature of (+4±1)°C. Total dissectible fat was eliminated by hand. The *Longissimus lumborum* (LL) muscle between the 1st and the 7th lumbar vertebra, the muscles of the abdominal wall (flank) and hind legs were removed from carcasses as samples for further analysis. The adipose tissue between hind leg muscles was conserved. The right LL muscles were homogenized in a blender together with hind leg muscles and the muscles of the abdominal wall, packed into polyethylene bags, frozen and stored at a temperature of -21±1°C, for determination of moisture, protein, ash, fat and cholesterol content, as well as for the analysis of the fatty acid composition. All analyses were carried out in duplicate. The left hind legs and the muscles of the abdominal wall were subjected to thermal treatment (roasting in convection oven at 175°C (accuracy ±1°C) to the internal temperature of 77°C). Roasted samples were prepared for sensory analysis.

Chemical analyses

Ultimate pH (pH_u) was measured 24 h *post mortem* directly in raw LL muscle (1st lumbar vertebra) in duplicate using a spear combined glass-gel electrode type 03 (Testo pH electrode) connected to pH

meter (Testo 230, Testo). The pH meter was calibrated using pH 5 and pH 7 buffers and re-calibrated after every 20 readings. Accuracy of reading was ±0.01 pH-unit. Moisture, protein and ash content Moisture content was determined on 5 g of minced meat sample. Samples were oven dried at 105°C to a constant weight (4h) according to AOAC 950.46 (AOAC, 1997). Total protein (crude protein, N×6.25) content was assessed by the Kjeldahl method according to AOAC 928.08 (AOAC, 1997). The ash content was determined by mineralization at 550 °C according to AOAC 920.153 (AOAC, 1997). Fat content was determined by the method described in AOAC Official Method 991.36. Fat (Crude) in Meat and Meat Products (AOAC, 1997). Total lipids were extracted by hot treatment with petroleum ether as solvent.

Fatty acid composition

The fatty acid (FA) composition of samples was determined by gas-liquid chromatography (GLC). We omitted lipid extraction and performed *in situ* transesterification (ISTE) by heating samples to 90°C for 10 min after adding 0.5 M NaOH in methanol for methanolysis and continued heating after 10 min for further methylation after adding 14 % BF_3 in methanol (Park and Goins, 1994). The content of fatty acid methyl esters (FAME) was determined by GLC, on an Agilent Technologies 6890 gas chromatograph with a flame ionisation detector (FID) and a capillary column Supelco SP-2380 (60 m × 0.25 mm × 0.2 mm). Separation and detection were performed under the following conditions: temperature programme =170°C, 8 min; 7°C/min to 250°C (19.43 min); temperature of the injector =250°C; temperature of the detector =280°C; injector: split:splitless =1:30, volume 1 ml; carrier gas: He 1 ml/min; make-up gas: N_2 45 ml/min; the gases in the detector: H_2 40 ml/min; synthetic air (21% O_2) 450 ml/min. FAME was determined through the retention times of the FAME in a standard mixture (Supelco fatty acid methyl ester mix – 37 components – Cat. No. 18919-1AMP). The same standard mixture was used to determine the response factor – Rf_i for each fatty acid. The weight portion of each FA in the sample was determined using the response factor and the factor of transformation of FA content from FAME content. Determination of reliability and accuracy of the analytical method for the detection of fatty acids was ensured by the use of the certified reference matrix – CRM 163 (Blend beef-pork fat – BCR) and is in good agreement with the certified values. The FAME were expressed in % of total FA.

The atherogenic index (Ulbricht and Southgate, 1991) based on the following equation:

AI = (C12 + 4 C14 + C16) / (PUFA + C18:1 + other MUFA),

where: other MUFA – monounsaturated fatty acids, include C14:1, C16:1 and PUFA – polyunsaturated fatty acids, include C18:2 n-6, C18:3 n-3.

Cholesterol content

The cholesterol content of the rabbit meat was determined by HPLC according to modified method from Naeemi *et al.* (1995). To an accurately weighed (2 g±0.01 g) well-ground meat sample spiked with internal standard (5 α-cholestane) 10 ml of saturated methanolic KOH was added in a 50 ml screwcapped vial. The vial was capped and than heated for 30 min at 80°C. Into the cooled vial (20°C), 10 ml hexane was added; than the vial was closed and shaken vigorously for 2 min. The vial was centrifuged at 2500 rpm for 2 min. The aliquot of the hexane extract (5 ml) was dried in a vacuum evaporator and freed of solvent by using a nitrogen flush before dissolving in 2 ml of mobile phase and injected into an HPLC system. For HPLC, Agilent technology system 1100 composed of Micro Vacuum Degasser G1379A, Binary Pump G1312A, Autosampler Thermostat G1367A, Therostatted Column Compartment G1316A, Diodearry and Multiple Wavelenght Detector G1315B was used. The analytical column was Hypersil ODS 5 mm, 150 mm × 4.6 mm. The mobile phase consisted of isopropanol/acetonitrile (45:55) the flow rate being 1.0 ml/min. Absorption was measured at 210 nm.

Sensory analyses

For the purpose of evaluating sensory qualities, a panel composed of four qualified and experienced panellists in the field of rabbit meat was appointed, while sensory properties of coded samples were tasted in a standard sensory laboratory. The same panel evaluated all samples; the trial consisted of four sessions. All the testing posts in the sensory laboratory had identical conditions. The room temperature was approximately 20°C and relative humidity was between 60 and 75%. The lighting of the room was also kept constant throughout the experiment. The samples for sensory analysis were formed as follow. Samples were roasted without salt or spices. The centres of roasted LL muscles were immediately cut into cubes of approximately 5 g. The panel assessed the warm samples separately in four sessions composed of 8 samples (both genotypes). To neutralise the taste, the panel used the middle part of white bread in tepid lemon-flavoured water (concentration 1%). The break between sessions was one hour.

The analytical-descriptive (according to Golob *et al.*, 2005) test was performed by scoring sensory properties by assigning a non-structured scale from 1 to 7 points, from mild to strong sensory properties. Colour was an exception and was evaluated by scoring on a scale 1 – 4 – 7. The score of 4 points was considered optimal (colour of rabbit meat of normal quality), scores of 4.5 or more indicated dark red meat and those of 3.5 points or less indicated pale red meat. Sensory descriptors of roasted rabbit meat are as follows:

- Smell: characteristic rabbit meat smell;
- Colour: intensity of red;
- Tenderness: ease of chewing;
- Juiciness: water release at the beginning of chewing and salivation stimulated by meat lipids content;
- Mouth feeling: smoothness of meat fibres during chewing;
- Flavour: characteristic of rabbit meat flavour;
- After-taste of rabbit flavour: intensity of rabbit meat flavour after swallowing.

Data analysis

The data for chemical parameters (four determinations of each treatment) were analysed by the method of least squares using the GLM procedure (SAS, 1999). The data for sensory traits, which were not normally distributed were analysed using the NPAR1WAY procedure (nonparametric Wilcoxon test). The statistical model for analysed parameters of rabbit meat included the effects of genotype (G), age (A) and sex (S):

$$y_{ijkl} = \mu + G_i + A_j + S_k + e_{ijkl}$$

where y_{ijkl} = the ijklth observation, μ = general mean, G_i = effect of ith genotype (i=l SIKA, i=2 Hybrid), A_j = effect of jth age at slaughter (j=l 77 days, j=2 90 days), S_k = effect of kth sex (k=1 male, k=2 female); and e_{ijkl} = residual random term with variance s^2_e.

The means for the experimental groups were obtained using the Duncan or Wilcoxon tests (SAS, 1999).

RESULTS AND DISCUSSION

pH_u value

Ultimate pH values were significantly different for genotype (P=0.002), sex (P=0.036) and slaughter age (P=0.009) of the animals (Figure 1). Higher pH_u values of rabbit meat originating from Hybrid breed and male animals respectively compared to SIKA breed and female animals were observed.

There is evidence in the literature of slight effects of breed and diet on the pH value of meat (24 h *post mortem*), which theoretically depends on the balance of muscle energy metabolism (Dalle Zotte and Ouhayoun, 1998; Barron *et al.*, 2004).

Moisture, protein and ash content

Table 1 shows the composition (moisture, ash and protein content) of right LL muscles homogenized together with hind leg and abdominal wall muscles. The rabbit meat included in this investigation contains on average about 72.7 % moisture, 22.1 % proteins and 1.31 % ash.

Moisture content was significantly lower in the SIKA than in the Hybrid group, and higher in males than in females. Samples from different ages at slaughter showed no significant differences in the moisture content. These results disagree with the conclusions of Gondret *et al.* (1998); namely that chemical composition of *Longissimus lumborum* muscle is markedly affected by age, water content declining with increasing age providing that a large difference (7 weeks) between age groups was considered. Generally, our results on water content agree with other researchers who found a similar percentage of water in the hind leg (Dalle Zotte *et al.*, 1996; Hernández *et al.*, 1998; Pascual *et al.,* 2004) and in back muscles (Dalle Zotte *et al.*, 1996; Hernández *et al.*, 1998; Gondret *et al*., 1998). Ash content exhibited significant differences due to genotype, age and sex; this content was higher in SIKA than in the Hybrid breed and higher in male than in female samples, while it decreased with increasing age. Results about effect of age at slaughter and sex on the ash content are contradictory with literature data: our results differ from those of Gondret *et al*. (1998) and agree with those of Dalle Zotte *et al.* (1996). It should be taken into consideration that the differences in chemical composition are probably explained by sampling procedure (blended meat in the current study *vs.* LL *per se* in some studies).

Rabbit meat is also rich in proteins (20.0–21.9 %), its amino acids have high biological value, its energy values are relatively low (427–849 kJ/100 g fresh meat) compared to other widely consumed red meats (Štruklec and Kermauner, 1997; Dalle Zotte, 2002). Statistically, lower protein content was found in SIKA compared with the Hybrid genotype. No differences were found in the protein content due to age at slaughter and sex. Reports exist that found that the protein content in back muscles significantly decreases (Dalle Zotte *et al.,* 1996) or increases with increasing age at slaughter (Gondret *et al.*, 1998).

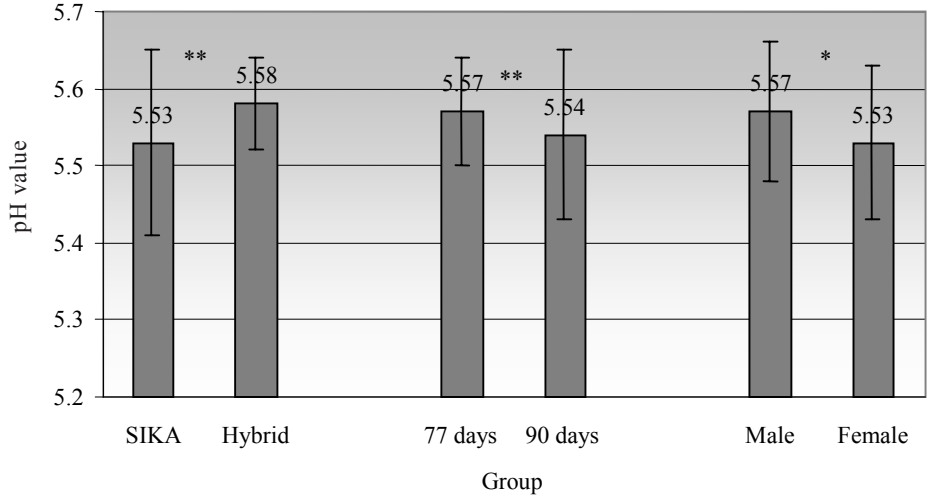

Figure 1: Effect of genotype (SIKA and Hybrid breed), slaughter age (77 and 99 days-old) and sex on ultimate pH values of rabbit LL muscles (mean ± standard deviation) (* P<0.05 and ** P<0.01).

Table 1: Effect of genotype (SIKA and Hybrid breed), slaughter age (77 and 99 days-old) and sex on chemical composition and fatty acid profile of rabbit meat (LL + abdominal wall + hind leg) (mean ± standard deviation)

		Genotype			Age at slaughter (days)			Sex		
		SIKA	Hybrid	Sign.	77	90	Sign.	Male	Female	Sign.
No.		16	16		16	16		16	16	
Moisture (%)		72.3±1.0^{B}	73.1±1.1^{A}	**	72.7±0.8	72.7±1.3	ns	72.9±1.1	72.4±1.1	ns
Ash (%)		1.34±0.09^{A}	1.30±0.06^{B}	**	1.34±0.06^{A}	1.30±0.06^{B}	**	1.43±0.07^{a}	1.30±0.06^{b}	*
Protein (%)		22.0±0.5^{b}	22.3±0.6^{a}	*	22.2±0.6	22.0±0.5	ns	22.2±0.5	22.1 ±0.6	ns
Fat (%)		3.8±1.1^{b}	4.3±1.1^{a}	*	3.9±0.9	4.2±1.3	ns	3.7±1.1^{b}	4.3±1.1^{a}	*
Cholesterol (mg/100 g)		75.7±27.3	77.6±24.9	ns	77.9±24.4	75.3±27.7	ns	82.0± 4.1	71.2± 1.8	ns
Fatty acids (% of total FAs)										
Myristic	C14:0	2.71±0.81	2.77±0.48	ns	2.83±0.47	2.66±0.81	ns	2.86±0.35	2.62±0.85	ns
Myristoleic	C14:1 n-5	0.17±0.26	0.31±0.33	ns	0.22±0.32	0.26±0.29	ns	0.24±0.30	0.24±0.31	ns
Pentadecanoic	C15:0	0.49±0.34	0.56±0.33	ns	0.46±0.33	0.58±0.34	ns	0.55±0.35	0.50±0.33	ns
Palmitic	C16:0	29.4±1.6	30.2±2.4	ns	29.6±1.9	30.0±2.2	ns	30.1±2.4	29.5±1.7	ns
Palmitoleic	C16:1 n-7	4.52±1.53	4.77±1.48	ns	4.03±1.15^{B}	5.21±1.57^{A}	**	4.15±1.12^{b}	5.10±1.67^{a}	*
Margaric	C17:0	0.35±0.34	0.40±0.34	ns	0.33±0.35	0.41±0.33	ns	0.42±0.36	0.33±0.32	ns
Stearic	C18:0	6.94±1.60	7.02±0.85	ns	6.98±0.69	6.97±1.67	ns	7.13±0.86	6.84±1.58	ns
Trans oleic	C18:1 n-9t	0.61±0.67	0.44±0.63	ns	0.66±0.68	0.41±0.61	ns	0.68± .70	0.39±0.58	ns
Cis oleic	C18:1 n-9c	23.7±1.3	23.0±6.2	ns	24.1±1.5	22.6±5.9	ns	22.3±5.9	24.3±1.8	ns
Linoleic	C18:2 n-6	25.3±3.6	24.9±4.1	ns	25.3±3.0	25.0±4.5	ns	25.8±3.4	24.6±4.2	ns
α -linolenic	C18:3 n-3	3.89±0.72	3.66±0.51	ns	3.63±0.25	3.92±0.82	ns	3.72±0.49	3.84±0.74	ns
Behenic	C22:0	1.91±0.99	1.99±0.71	ns	1.98±0.51	1.92±1.10	ns	2.12±0.96	1.79±0.73	ns
SFA		41.8±3.4	42.9±3.2	ns	42.2±2.0	42.5±4.3	ns	43.2±3.2	41.6±3.4	ns
MUFA		29.0±2.4	28.5±6.3	ns	29.0±2.3	28.5±6.2	ns	27.4±5.8^{b}	30.0±3.0^{a}	*
PUFA		29.2±4.2	28.6±4.5	ns	28.9±3.2	29.0±5.2	ns	29.5±3.8	28.4±4.7	ns
P/S		0.71±0.19	0.67±0.10	ns	0.69±0.09	0.69±0.19	ns	0.68±0.08	0.70±0.19	ns
AI		0.64±0.23	0.64±0.25	ns	0.64±0.24	0.64±0.25	ns	0.63±0.28	0.65±0.20	ns
n-6/n-3		6.58±0.69	6.83±0.85	ns	6.97±0.72^{a}	6.45±0.76^{b}	*	6.95±0.65^{a}	6.47±0.83^{b}	*

No.: number of animals; SFA: saturated fatty acids, include C14:0, C15:0, C16:0, C17:0, C18:0, C22:0. MUFA : monounsaturated fatty acids, include C14:1, C16:1, C18:1. PUFA: polyunsaturated fatty acids, include C18:2 n-6, C18:3 n-3. P/S: PUFA/SFA. AI: Atherogenic index = (C12 + 4 C14 + C16) / (PUFA + C18:1 + other MUFA) (Ulbricht and Southgate, 1991). n-6/n3: C18:2 n-6 / C18:3 n-3. Means with a different superscript within groups differ significantly (a,b= $P<0.05$; A, B= $P<0.01$). Sign.: Levels of significance (not significant: ns $P> 0.05$, *$P< 0.05$ and **$P<0.01$).

Fat content

Fat content in rabbit meat varies between 0.6 and 14.4 % (Pla *et al.,* 1998; Kaic-Rak and Antonic, 1990; Elmadfa *et al*., 2001; Dalle Zotte, 2002).

Fat content in rabbit meat differed according to genotype and sex (Table 1). The content of fat in the SIKA was significantly lower compared with the Hybrid breed, while in males the fat content was significantly lower compared with females. On the basis of literature data we expected a significant

effect of age on fat, but differences in age range (20 days in the current study *vs.* 49 days in the study of Gondret *et al.* (1998)) probably explained such discrepancies.

Fat content (mean values of 32 observations ± standard deviation being 4.1 ± 1.8%) in the present study is not in accordance with the findings of other researchers (Dalle Zotte *et al.*, 1996; Gondret *et al.*, 1998; Pascual *et al*., 2004; Ramírez *et al*., 2005) who showed fat content of rabbit meat to be lower, which was probably due to differences in sampling. We emphasize that the chemical analysis in the present study was made on average samples obtained by mixing the LL with hind leg and abdominal wall muscles of each rabbit carcass.

The composition of meat generally depends on species and population of animals, muscle location and rearing system as well as on their diet; for this reason the comparison of rabbit meat to meat of other species is neither straightforward nor easy. However, reports mention higher values for fat content of beef, pork and dark chicken meat.

Fatty acid composition

Fatty acid composition varies a lot and is expressed as share of SFA (saturated fatty acids), MUFA, PUFA, P/S and n 6/n-3 indexes (Kaic-Rak and Antonic, 1990; Gondret *et al.,* 2000; Szabó *et al*., 2001; Dalle Zotte, 2002; Szabó *et al*., 2004).

Generally speaking, no important differences due to genotype, age at slaughter and sex were found in the fatty acid composition, with one exception: the content of palmitoleic FA (C16:1 n-7) was found to be statistically significantly higher in the experimental group of female rabbits compared to male rabbits and in 90-day old group compared to 77-day old, respectively. On the average intramuscular lipids of rabbit meat contain a larger proportion (29.8%) of palmitic (C16:0), 25.1% linoleic (C18:2 n-6) and 23.3% cis-oleic (C18:1 n-9c) FA. Stearic (C18:0, 6.98%), palmitoleic (C16:1 n-7, 4.64%), á-linolenic (18:3 n-3, 3.78%), myristic (C14:0, 2.74%), behenic (C22:0, 1.95%) and trans-oleic (C18:1 n-9t, 0.53%) FA are present as minor components.

Some nutritional indices for rabbit meat are reported in the lower part of Table 1 (LL + abdominal wall + hind leg). The nutritional quality of fat has been evaluated in terms of the ratio polyunsaturated:saturated fatty acids (P/S), the atherogenic index (AI), and the n-6/n-3 fatty acids ratio. In a balanced diet, the recommended ratio for P/S is 0.4 or higher (Wood *et al.*, 2003), IA as low as possible, and ratio n-6/n-3 less than 4 (Enser *et al.,* 2001).

Meat is often considered rich in saturated fatty acid (SFA) and several epidemiological studies have shown a relationship between SFA intake and cardiovascular diseases (Ravnskov, 1998; Lefevre *et al.,* 2004). However, fat content of rabbit muscles is rather low and fatty acids are not all saturated. This study showed that in the case of lean rabbit meat SFA represent 42.4% of the total FA; the amount of polyunsaturated fatty acids (PUFA) represents about 29% of the total FA and is much higher than some other meats (Dalle Zotte, 2002; Zlender *et al.*, 2001). However, data on PUFA vary as to muscle, selection and dietary manipulation (Dalle Zotte, 2002; Szabó *et al.*, 2004; Dal Bosco *et al.*, 2004; Ramírez *et al.*, 2005). Due to the high content of linoleic acid (C18: 2 n-6) the P/S ratio (0.69) in rabbit meat is higher than in pig, beef or veal, but lower than in red deer meat (Table 2). The determined atherogenic index (AI = 0.60) is also quite favourable.

Our findings agree with those that maintain that rabbit meat could provide a useful contribution to the human diet. Rabbit meat, as Gandemer (1998) emphasizes, has a relatively high content of PUFA and a relatively low fatty acid n-6/n-3 ratio in comparison to meat of other species. Data on n-6/n-3 ratio are different (Dal Bosco *et al*., 2004; Ramírez *et al*., 2005; Szabó *et al*., 2004) and vary from 2.95, in *Longissimus dorsi* from rabbit fed with dietary α-linolenic acid (Dal Bosco *et al.*, 2004), to higher

values of about 11.6 for hind leg (Dalle Zotte, 2002; Ramírez *et al*., 2005). Our values 6.70 ± 0.78 (Table 2) are similar to the results reported by Dalle Zotte (2002) who reported a n-6/n-3 index of 6.7 for the pooled meat from rabbit carcass.

Cholesterol content

Data on cholesterol content are between 45 and 85 mg/100g (Lukefahr and Ozimba, 1991; Souci *et al*., 2000; Dalle Zotte, 2002). From the data presented in Table 1 we can see that cholesterol content was not affected by any considered experimental fixed effect, and is on average 76.6 mg/100g of fresh boneless rabbit meat (LL + abdominal wall + hind leg). According to the statement of Dalle Zotte (2002), among the more popular meats, rabbit meat contains the lowest levels of cholesterol. Our results disagree with data reported by other researchers who found significantly lower content of cholesterol in whole rabbit carcass (45 mg/100 g meat) and hind leg (60 mg/100 g meat) (Dalle Zotte, 2002) as well as in back muscles (from 45 to 48 mg/100g meat Hernández *et al.*, 1998; 57.5 mg/100g meat Kessler and Pallauf, 1994). These differences are probably due to the use of different analytical methods, different anatomical parts of the muscles taken as representative samples and, last but not least, the evaluation of analytical results. Data on cholesterol content vary by up to ± 100% (Arneth and Alahmad, 1995).

Sensory traits

Genotype has no affect on the main characteristic of rabbit meat, such as smell, colour, tenderness, juiciness and mouth feel, but does have a significant effect on the after-taste of rabbit meat (Table 2). The intensity of rabbit meat after-taste is significantly stronger in SIKA than in the Hybrid group. For this reason, the SIKA genotype was given lower scores for flavour. We can therefore conclude that the SIKA genotype has certain undesirable aroma characteristics, which could be disagreeable to consumers.

The meat from 77-day-old rabbits had a higher mouth feeling score than that from 90-day-old rabbits, whereas other traits of the meat were not affected by age at slaughter. Our results do not agree with the study of Gondret *et al*. (1998), who have shown that the meat from older (18 weeks) rabbits was tenderer than that from 11-week old rabbits. This could be due to the smaller difference in slaughter age adopted in the present study.

Table 2: Effect of genotype (SIKA and Hybrid breed), slaughter age (77 and 99 days-old) and sex on sensory traits of roasted rabbit meat (LL) (mean ± standard deviation).

	Genotype			Age at slaughter (days)			Sex		
Traits (points)	SIKA	Hybrid	Sign.	77	90	Sign.	Male	Female	Sign.
No.	16	16		16	16		16	16	
Smell (1-7)	5.3 ± 0.6	5.4 ± 0.4	ns	5.4 ± 0.5	5.3 ± 0.5	ns	5.4 ± 0.5	5.3±0.5	ns
Colour (1-7)	5.5 ± 0.4	5.7 ± 0.4	ns	5.6 ± 0.3	5.5 ± 0.5	ns	5.5 ± 0.4^{b}	5.7±0.4^{a}	*
Tenderness (1-7)	5.4 ± 0.4	5.5 ± 0.5	ns	5.6 ± 0.5	5.4 ± 0.5	ns	5.5 ± 0.5	5.5±0.4	ns
Juiciness (1-7)	5.2 ± 0.3	5.3 ± 0.4	ns	5.3 ± 0.4	5.2 ± 0.3	ns	5.3 ± 0.3	5.2±0.4	ns
Mouth feel (1-7)	5.3 ± 0.4	5.4 ± 0.4	ns	5.4 ± 0.4^{a}	5.3 ± 0.4^{b}	*	5.4 ± 0.4	5.3±0.4	ns
Flavour (1-7)	5.3 ± 0.3	5.4 ± 0.3	ns	5.4 ± 0.3	5.3 ± 0.3	ns	5.4 ± 0.4	5.3±0.3	ns
After-taste of rabbit flavour (1-7)	1.9 ± 0.5^{a}	1.6 ± 0.4^{b}	*	1.7 ± 0.4	1.8 ± 0.5	ns	1.8 ± 0.6	1.7±0.3	ns

No.: number of animals; Means with a different superscript within groups differ significantly ($P \leq 0.05$). Sign.: Levels of significance (not significant: ns, $P>0.05$, *$P<0.05$.

Meat from female rabbits showed a better colour than that from male rabbits, however this could be a consequence of the significantly higher weight loss during roasting observed in meat samples from male rabbits (data not shown).

CONCLUSIONS

The aim of the present study was to find the optimal animal age for the appropriate meat quality of Slovenian SIKA rabbit male line. For this purpose this line was compared with commercial Italian hybrids slaughtered at two different ages. The influence of sex was also evaluated. The main emphasis was on meat quality characteristics and fatty acid composition. In spite of the well-known effect of genotype and sex on the chemical composition and sensory traits of rabbit meat, no important differences were found in this study regarding these characteristics, considering rabbits of different genotype and sex. Fatty acid composition varied slightly with slaughter age, content of palmitoleic FA increased and n-6/n-3 ratio decreased with increasing age. However age had no profound effect on chemical composition (water, protein, fat and cholesterol content) or on sensorial quality. From the results obtained it can be concluded that rabbit meat quality does not significantly improve when age at slaughter is increased age from 77 to 90 days.

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REFERENCES

AOAC, 1997. *In: Cunniff P. (ed). Official methods of analysis (16th ed.). Association of Official Analytical Chemists Int., Wash*ington.

Arneth W., Alahmad H., 1995. Cholesterol – its determination in muscle and adipose-tissue and in offal using HPLC. *Fleischwirtschaft, 75, 1001-1003.*

Barron G., Rosas G., Sandoval Ch., Bonilla O., Reyes G., Rico P., Cardona L., Zamora F., 2004. Effect of genotype and sex on pH of *Biceps femoris* and *Longissimus dorsi* muscles in rabbit carcasses. *World Rabbit Sci., 14 (sp),62.*

Blasco A., Ouhayoun J., 1993. Harmonization of criteria and terminology in rabbit meat research. Revised proposal. *World Rabbit Sci., 2, 93-99.*

Dal Bosco A., Castellini C., Bianchi L., Mugnai C., 2004. Effect of dietary alinolenic acid and vitamin E on the fatty acid composition, storage stability and sensory traits of rabbit meat. *Meat Sci., 66, 407-413.*

Dalle Zotte A., 2002. Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. *Livest. Prod. Sci., 75, 11-32.*

Dalle Zotte A., Ouhayoun J., 1998. Effect of genetic origin, diet and weaning weight on carcass composition, muscle physicochemical and histochemical traits in the rabbit. *Meat Sci., 49, 471-478.*

Dalle Zotte A., Ouhayoun J., Parigi Bini R., Xiccato G., 1996. Effect of age, diet and sex on muscle energy metabolism and on related physicochemical traits in the rabbit. *Meat Sci., 43,:15-24.*

Èepin S., Èepon M., Šalehar A., Holcman A., Kompan D., Pohar J., 1997. Meat production and consumption in the world and in Slovenia. *In: Zlender B., Gašperlin L. (eds). Meat in nutrition and health. Biotehniška fakulteta, Ljubljana, 29-39.*

Elmadfa I., Aign W., Muskat E., Fritzche D., 2001. Die grosse GU Nährwert Kalorien Tabelle. *Universität Wien, Wien, 128.*

Enser M., Scollan N., Gulati S., Richardson I., Nute G., Wood J., 2001. The effects of ruminally-protected dietary lipid on the lipid composition and quality of beef muscle. *In: Future of meat: Congress Proceedings of the 47th International Congress of Meat Science and Technology. Meat and Fat Research Institute, Kraków, 186-187.*

Gandemer G., 1998. Lipids and meat quality – lipolysis – oxidation and flavour. In Proc.: *44th International Congress of Meat Science and Technology. IRTA, Eurocarne, Barcelona, I, 106-119.*

Golob T., Jamnik M., Bertoncelj J., Doberšek U., 2005. Sensory analysis: methods and assessors. *Acta agric. Slov., 85, 55-66.*

Gondret F., Juin H., Mourot J., Bonneau M., 1998. Effect of age at slaughter on chemical traits and sensory quality of *Longissimus lumborum* muscle in the rabbit *Meat Sci., 48, 181-187.*

Gondret F., Lebas F., Bonneau M., 2000. Restricted feed intake during fattening reduces intramuscular lipid deposition without modifying muscle fiber characteristics in rabbits. *J. Nutr., 130, 228-233.*

Hernández P., Pla N., Blasco A., 1998. Carcass characteristics and meat quality of rabbit lines selected for different objectives: II. Relationships between meat characteristics. *Livest. Product. Sci., 54, 125-131.*

Kaiæ-Rak A., Antoniæ K., 1990. Tablice o sastavu namirnica i piæa. *Zavod za zaštitu zdravlja SR Hrvatske, Zagreb, 10.*

Kessler B., Pallauf J., 1994. Fatty-acid composition and cholesterol content of the musculus *longissimus-dorsi* of meat rabbits fed oil from coconut, rape or soybean. *Zuchtungskunde, 66, 242-251.*

Lefevre M., Kris-Etherton P. M., Zhao G., Tracy R. P., 2004. Dietary fatty acids, hemostasis, and cardiovascular disease risk. *J. Am. Dietetic Assoc., 104, 410-419.*

Lukefahr S.D., Ozimba C.E., 1991. Prediction of carcass merit from

live body measurements in rabbits of four breed-types. *Livest. Prod. Sci., 29, 323-334.*

Naeemi E.D., Ahmad N., Al-Sharrah K.T., Behbahani M., 1995. Rapid and simple method for determination of cholesterol in processed food. *J. AOAC Int., 6, 1522-1524.*

Park W., Goins R.E., 1994. *In Situ* Preparation of Fatty Acid Methyl Esters for Analysis of Fatty Acid Composition in Foods. *J. Food Sci., 59, 1262-1266.*

Pascual M., Aliaga S., Pla M., 2004. Effect of selection for growth rate on carcasses and meat composition in rabbits. *World Rabbit Sci., 14(sp), 68.*

Pla M., Guerrero L., Guardia G., Oliver M.A., Blasco A., 1998. Carcass characteristics and meat quality of rabbit lines selected for different objectives: I. Between lines comparison. *Livest. Prod. Sci., 54, 115-123.*

Ramírez J.A., Díaz I., Pla M., Gil M., Blasco A., Oliver M.À., 2005. Effect of selection for growth rate on biochemical, quality and texture characteristics of meat from rabbits. *Food Chem., 90, 251-256.*

Ravnskov U., 1998. The Questionable Role of Saturated and Polyunsaturated Fatty Acids in Cardiovascular Disease. *J. Clin. Epidemiology, 51, 443-460.*

SAS, 1999. *Version 8.01. SAS Institute Inc., Cary.*

Souci S.W., Fachmann W., Kraut H., 2000. Food composition and nutrition tables. *6th revised and completed ed. Scherz H., Senser F. (eds). Medpharm, Stuttgart, 309.*

Štruklec M., Kermauner A., 1997. Rabbit breeding in Slovenia: productive and economical possibilities. In Proc.: *Stipiæ N. (ed). 5th International Symposium "Animal Science Days". Agronomski fakultet Sveuèilišta u Zagrebu, Zagreb, 50-55.*

Szabó A., Romvari R., Febel H., Nagy I., Szendrö Z., 2001. Fatty acid composition of two different muscles in rabbits: Alterations in Response to saturated or unsaturated dietary fatty acid complementation. *World Rabbit Sci., 9, 155-158.*

Szabó A., Mézes M., Dalle Zotte A., Szendr Zs., Romvári R., 2004. Changes of the fatty acid composition and malondialdehyde concentration in rabbit *Longissimus dorsi* muscle after regular electrical stimulation. *Meat Sci., 67, 427-432.*

Ulbricht T.L.V., Southgate D.A.T., 1991. Coronary hearth disease: seven dietary factors. *Lancet 338, 985-992.*

WHO: Diet, Nutrition, and the Prevention of Chronic Diseases. 1990. *In: Report of a WHO Study Group. World Health Organization, Geneva, 100-111.*

Wood J.D., Richardson R.I., Nute G.R., Fisher A.V., Campo M.M., Kasapidou E., Sheard P.R., Enser M., 2003. Effects of fatty acids on meat quality: a review. *Meat Sci., 66, 21-32.*

Zlender B., Gašperlin L., Polak T., 2001. Fatty acid composition of fat in three muscles of Simmental and Brown bulls. In Proc.: *47th International Congress of Meat Science and Technology. Meat and Fat Research Institute, Kraków, 190-191.*