SESSION III

INNOVATION IN FEED AND FOOD QUALITY

COMMUNICATION

Meat quality of calves obtained from organic and conventional farming

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ABSTRACT - The aim of this study was to compare meat quality of organically and conventionally raised Simmental calves. Fifteen organic and fourteen conventional carcasses were considered, 8th rib and M. *Longissimus thoracis* were sampled on each carcass. Different tissues percentage of 8th rib were evaluated and meat colour, chemical and fatty acids composition of *M. Longissimus thoracis* were analysed. Fat percentage of 8th rib of organic calves was lower (P<0.01) than conventional ones. Cooking weight losses were lower (P<0.001) in organic meat compared to the conventional ones and red index was higher in organic calves due to the high content of heminic iron (P<0.001). Ether extract (P<0.001) and cholesterol content (P<0.05) was lower in organic meat with respect to conventional one. Positive value, from a nutritional point of view, were found in organic veal about n-3 fatty acids, n-6/n-3 ratio and CLA content.

Key words: Organic farming; Meat quality, Calves, Fatty acids.

Introduction – Dairy calves obtained from organic farming could be a resource for the production system of organic beef. However only a little part of the calves born on the organic dairy farms are slaughtered and commercialised as organic products (Nielsen *et al.*, 2002). Meat characteristics of calves produced by organic system are almost unknown and in literature there are few studies about the comparison between organic and conventional meat (Woodward *et al.*, 1999). This experiment was carried out to compare meat quality of organically and conventionally raised Simmental calves.

Material and methods – Fifteen carcasses of organic calves (144.8±18.6kg) and fourteen carcasses of conventional calves (155.4±26.6kg) were considered. The average age at slaughtering was 6 months and all calves belonged to Simmental breed. Organic calves were reared at the pasture and were subjected to natural suckling. The conventional calves received milk replacers and roughage sources according to EU rule (97/2/EC). At slaughtering the 8th rib from the right side of each carcass was removed and immediately vacuum-packed. After 7 days of ageing at 4°C the samples were separated into muscle, bone and

intramuscular fat and fresh samples of *M. Longissimus thoracis* was used for the determination of pH and colour (Minolta CM500 Spectrophotometer) (ASPA, 1996) while on the freeze-dried samples the chemical composition was determined (AOAC, 2000). Cholesterol and heminic iron contents were detected according to Casiraghi *et al.* (1994) and Hornsey (1956) respectively. Cooking losses and Warner-Bratzler shear force (kg/cm^2) were estimated (ASPA, 1996). Fatty acids were analysed by GC analysis after lipid extraction (ASE® instrument, Dionex) and trans methylation (Christie, 1982). The effect of production system (organic *vs* conventional) was statistically evaluated by ANOVA (SAS, 2004).

Results and conclusions – Fat percentage of 8th rib of organic calves (Table 1) was lower (P<0.01) than conventional ones. Less state of fattening of organic carcasses was found in literature (Russo *et al.*, 2005). The lack of difference in percentage of bone observed indicate no different skeletal development in organic calves.

Table 1. Different tissues percentages of 8th rib of organic and conventional calves.

Item	ORG	CON	P-value	SEM[1]
Lean, %	69.00	64.08	*	1.38
Fat, %	2.90	7.36	**	0.90
Bone, %	28.10	28.56	ns	1.59

**: P<0.05; **: P<0.01; ns=non significant; [1]Standard error of the mean.*

Cooking losses (Table 2) were significantly lower in organic meat compared to the conventional ones (P<0.001) while tenderness did not differ between the two groups. Values of lightness and hue were lower in organic meat compared to the conventional one. Higher redness of organic meat, due to the high content of eminic iron (P<0.001), was probably

Table 2. Meat quality traits of *M. Longissimus* thoracis.

Item	ORG	CON	P-value	SEM[1]
Cooking losses, %	26.17	31.59	***	0.80
Shear force, kg/cm^2	2.94	2.73	ns	0.80
Meat colour				
L* lightness	32.56	43.09	***	0.99
a* redness	9.05	4.73	***	0.72
b* yellowness	9.80	11.68	*	0.49
H* hue	47.07	69.88	***	2.37
Chemical composition, %				
Dry matter	24.27	24.70	ns	0.26
Lipids	0.76	1.31	***	0.10
Crude protein	22.29	21.91	ns	0.24
Ash	1.11	1.08	ns	0.01
Cholesterol, mg/100g	53.95	58.52	*	1.29
Heminic iron, mg/kg	47.53	26.07	***	1.78

**: P<0.05; **: P<0.01; ***: P<0.001; ns=non significant; .[1]Standard error of the mean*

Table 3. Fatty acids composition of M. *Longissimus thoracis* (% of total FA).

Item	ORG	CON	P-value	SEM[1]
SFA	48.45	42.21	**	1.35
MUFA	29.38	39.13	***	1.02
PUFA	21.93	18.58	***	1.95
SFA/MUFA+PUFA	0.96	0.73	**	0.05
n-3	5.64	2.35	***	0.46
n-6	15.14	15.44	ns	0.56
n-6/n-3	2.66	6.77	***	0.23
CLA	1.08	0.31	***	0.13

***: P<0.01; ***: P<0.001; ns=non significant; [1]Standard error of the mean.*

due to grazing activity of organic animals. Ether extract content of *M. Longissimus thoracis* of organic calves was lower than those of conventional ones (P<0.001). The amount of cholesterol was low in organic calves (P<0.05) also respect to the standard value reported for veal by IEO (2008).

About intramuscular fatty acids (FA) composition (Table 3) the SFA and PUFA contents were higher in organic meat in comparison with conventional one. From the nutritional point of view positive values were observed in organic meat about n-3 FA and n6/n3 ratio. In addition, CLA content was very high in organic meat and similar (French *et al.*, 2000) or higher (Thomas *et al.*, 2008) respect to the results obtained for meat from grazing cattle.

In conclusion, lower fat percentage of carcasses and lower ether extract of meat, higher content of heminic iron, low cholesterol content and FA suggest a better nutritional profile of meat obtained from organic farming. Further researches are needed to confirm our findings.

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COMMUNICATION

Sensory profiling of Dalmatian dry-cured ham under different temperature conditions

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ABSTRACT - To investigate the influence of the Dalmatian ham processing conditions on weight loss and sensory characteristics, 20 hams were processed following different temperature conditions during salting and ripening. For that purpose, hams were evaluated using quantitative descriptive analysis. The weight loss was higher and all sensory traits except presence of tyrosine and phenylalanine crystals were higher rated for hams processed at higher temperatures. The most significant ($P<0.0001$) influence of temperature was established on subcutaneous fat color, muscle color and presence of tyrosine and phenylalanine, whereas no influence was established on appearance, marbling, flavor and melting. This concludes that there is overall significant effect of higher temperature on sensory characteristics most likely due to the more intense proteolysis and lipolysis.

Key words: Sensory characteristics, Dalmatian ham, Temperature conditions.

Introduction – The manufacture of dry-cured ham is based on traditional methods which rely mostly on the addition of NaCl and the dehydration process. Stabilization of the product at room temperature without the risk of spoiling and development of specific sensorial characteristics are the main aims during production process (Arnau *et al.*, 1997). The traditional and the controlled production process of Dalmatian ham consist of the same processing stages, but there is difference in temperature conditions during salting and ripening. Higher temperature during salting (8 to 10°C) and ripening (18 to 22°C) are often present in traditional production (Jerković *et al.*, 2007). The temperatures in controlled production of Dalmatian ham are lower during salting (2 to 4°C) and ripening (12 to 15°C), while the drying stage is very similar in both productions. The effect of different temperature during drying-ripening (Arnau *et al.*, 1997) and different durations of drying-ripening was thoroughly investigated (Ruiz *et al.*, 1998). However, little research has been dedicated to determine the differences of sensory characteristics of Dalmatian ham as affected by different temperature conditions.

Material and methods – A total of 20 raw hams obtained from Duroc x (Yorksire x Landrace) pigs reared under identical conditions were used in this study**.** Color (L* a* b*)

and pHu values were measured 24h *post mortem* on M. *Biceps femoris*. At processing plant two different temperature conditions during salting were considered: a group of 10 hams were kept at 8 to 10°C (traditional process - TP), while the other 10 hams were kept at 2 to 4°C (controlled process - CP). Relative humidity in both groups was 85 to 90%. After 18 days the hams were pressed with pressure of 300kg/m^2 during three days following by washing, draining and smoking of hams for 14 days at 13 to 15°C and relative humidity of 70%. During drying period the temperature and relative humidity were kept respectively at 12 to 14°C and 70 to 80% in both groups for 6 months. During ripening period (next 6 months), the TP hams were kept at 18 to 22°C, while the CP hams were kept at 13 to 15°C. The initial and final weights were obtained in order to calculate the process weight losses. After 12 months, ham samples (containing M. *Biceps femoris,* M. *Semitendinosus* and M. *Semimembranosus*) were sensory evaluated using quantitative descriptive analysis by ten assessors which had undergone a basic training program. A lexicon of assessors was consisted of nine sensory descriptors; appearance (AP), subcutaneous fat color (SFC), marbling (MA), muscle color (MC), aroma (AR), flavor (FL), melting (ME), tenderness (TE) and presence of tyrosine and phenylalanine crystals (PTC). All sensory descriptors were assessed with a 5-point structured scale (1, very low; 5, very high) except PTC which was assessed with reverse meaning scale (1, very high; 5, very low). All the samples were sliced on 1 mm thickness and order of the sample presentation was randomized. Assessors were provided with water and unsalted crackers between each sample evaluation (Ruiz *et al.*, 1998). All data were analyzed by the GLM procedure (SAS, 2001).

Results and conclusions – Physico-chemical characteristics of raw ham and dry-cured ham are given in Table 1. There were no significant differences between TP and CP group in quality traits of raw ham. Higher raw ham weight of TP group did not result in lower weight loss as expected, that can be explained by higher temperature conditions in accordance with Arnau *et al*. (1997).

Table 1. Physico-chemical traits (mean ±SD) of raw and dry-cured ham.

Traits	TP	CP	Significance
Raw ham weight (kg)	12.47 ± 0.95	11.96 ± 0.83	ns
pHu	5.76 ± 0.20	5.69 ± 0.09	ns
L*	53.35 ± 2.96	53.74 ± 1.93	ns
a*	19.41 ± 1.22	19.50 ± 1.72	ns
b*	6.21 ± 0.91	6.34 ± 0.60	ns
Final weight loss (%)	33.34 ± 2.02	31.08 ± 1.81	**

*TP: traditional process; CP: controlled process; ns: non-significant; **: P<0.001.*

Sensory descriptors of dry cured ham are presented in Table 2. All sensory descriptors, except PTC, were higher rated for TP group. Higher occurrence of PTC may be due to the increased activity of proteases with temperature that led to more intense proteolysis (Arnau *et al.*, 2007). Although marbling did not differ significantly between groups (P>0.05), there were significant differences in SFC, MC, AR and TE probably as a result of more intense lipolysis and

generation of larger amount of the volatile compounds as stated by Gandemer (2002). More intense proteolysis and lipolysis could also explain better rated flavor and melting in TP group, though not significantly different (P>0.05). Higher temperature conditions showed overall significant effect with impact mainly on the weight loss, presence of tyrosine and phenylalanine crystals and color of fat and muscle tissue.

Table 2: Sensory profiling of dry-cured ham.

Descriptors	TP	CP	Significance
Appearance	4.15 ± 0.56	4.10 ± 0.51	ns
Subcutaneous fat color	4.43 ± 0.45	4.17 ± 0.47	***
Marbling	4.44 ± 0.54	4.31 ± 0.54	ns
Muscle color	4.33 ± 0.62	3.71 ± 0.69	***
Aroma	4.30 ± 0.52	4.09 ± 0.54	*
Flavor	4.16 ± 0.50	4.08 ± 0.59	ns
Melting	4.40 ± 0.50	4.32 ± 0.55	ns
Tenderness	4.42 ± 0.50	4.22 ± 0.61	*
Presence of tyrosine and phenylalanine crystals	4.59 ± 0.92	5.00 ± 0.00	***

*TP: traditional process; cp: controlled process; ns: non-significant; *: p<0.01; ***: P<0.0001.*

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COMMUNICATION

Nutritional quality of Krškopolje and commercial fattener pig meats in Slovenia

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ABSTRACT - The nutritional quality of M. *Longissimus dorsi* in the autochthonous Krškopolje pig breed and commercial fatteners from intensive Slovenian farms was compared. Commercial fatteners were divided into two groups according to lean meat percentage: MEATY and FATTY groups. The Krškopolje pigs (KK group) and the FATTY group had higher intramuscular fat content than the MEATY group. The lowest saturated fatty acids (SFA) proportion was found in the KK group and the highest in the FATTY group. The KK and FATTY groups contained higher proportions of monounsaturated fatty acids (MUFA) as well as lower proportions of polyunsaturated fatty acids (PUFA) compared to the MEATY group. The highest n-6 PUFA proportion was found in the MEATY group. The n-3 PUFA proportion differed between the MEATY and FATTY groups. The FATTY group had the lowest ratio of polyunsaturated to saturated fatty acids as well as the highest atherogenic index.

Key words: Nutritional quality, Commercial fatteners, Krškopolje pig.

Introduction – The nutritional quality of meat has been paid considerable attention in research because of its implications for human health. The World Health Organisation (WHO, 2003) recommended an intake of 15-30% energy from fat, with less than 10% of this amount consisting of saturated fatty acids (SFA), 5-8% consisting of n-6 polyunsaturated fatty acids (PUFA) and 1-2% of n-3 PUFA. The nutritional recommendation for the n-6/n-3 PUFA ratio is less than 4:1 (Enser *et al*., 2001). The target ratio of polyunsaturated to saturated fatty acids (P/S) is 0.4 or above and the atherogenic index (AI) should be lower than 0.5 (Ulbricht and Southgate, 1991). To avoid consuming too much fat, people want to purchase lean meat. Therefore, reducing carcass fatness was one of the major breeding goals in farm animals for many years. However, it was likely to be accompanied by lower intramuscular fat levels (De Smet *et al*., 2004), and this had a negative influence on the sensory quality of meat. Dunn (1996) discussed that fattier pigs have more marbling which reflects better meat quality. This is one of the reasons for the better eating quality of meat of autochthonous breeds compared to modern breeds. Very little research has been done on the meat quality of the Slovenian autochthonous breed Krškopolje pig. The present study compares the nutritional quality of *M. Longissimus dorsi* in Krškopolje pigs and commercial fatteners in Slovenia.

Material and methods – Ten Krškopolje pigs (KK group) originating from a small organic farm in the Pomurje region, were fed with organic feed in outdoor conditions. In order to compare the nutritional quality of meat, 2 groups with 15 samples of M. *Longissimus dorsi* from commercial fatteners fed with standard fattening feed mixture in a conventional indoor environment were collected. On the slaughter line, commercial fatteners were randomly chosen and assigned to the MEATY group with high lean meat content (64.0%) and the FATTY group with low lean meat content (51.3%). The KK group had 47.8% lean meat at slaughter. Samples of M. *Longissimus dorsi* were taken 24 hrs after slaughter at the last rib. They were packed in vacuum bags and stored frozen at -21°C±1°C until chemical analyses. Fatty acids methyl esters (FAME-s) from samples were prepared using the Park and Goins method (1994). For the separation of FAME an Agilent 6890 series GC instrument equipped with an Agilent 7683 Automatic Liquid Sampler, a split injector, a flame-ionization detector and a WCOT fused silica capillary column CP-Select CB for FAME (Varian, 100m x 0.25mm i.d.) was used. Agilent GC ChemStation was used for data acquisition and processing. Separated FAME-s were identified by retention time comparison and results were calculated using response factors derived from chromatographic standards of known composition (Nu Chek Prep). The results were expressed as a percentage of total fatty acids. Intramuscular fat content (IMF) in muscle samples was determined by the Weibull-Stoldt method (AOAC, 1997). The statistical model included group effect (G_i) and adjustment for carcass weight. Analysis was carried out using the GLM procedure in SAS/STAT (SAS Inst. Inc., 2001).

Table 1. Nutritional quality parameters of *M. Longissimus dorsi.*

Variable	KK (n=10)		FATTY (n=15)		MEATY (n=15)		
	LSM	SEE	LSM	SEE	LSM	SEE	p -value
Intramuscular fat content (%)	1.96^{a}	0.15	1.94^{a}	0.13	1.43^{b}	0.16	0.0369
Fatty Acids (%)							
Saturated	33.83^{c}	0.40	38.30^{a}	0.33	35.54^{b}	0.34	<0.0001
Monounsaturated	48.39^{a}	0.97	46.21^{a}	0.80	42.21^{b}	0.83	0.0001
Polyunsaturated	17.78^{b}	1.11	15.49^{b}	0.91	22.25^{a}	0.95	<0.0001
Polyunsaturated Fatty Acids (%)							
n-6	16.54^{b}	1.03	14.55^{b}	0.85	20.79^{a}	0.89	<0.0001
n-3	1.15^{ab}	0.10	0.86^{b}	0.08	1.38^{a}	0.08	0.0004
n-6/n-3	14.35^{b}	0.91	17.48^{a}	0.75	15.93^{ab}	0.78	0.0329
Indices							
Polyunsaturated/Saturated fatty acids	0.53^{a}	0.03	0.41^{b}	0.03	0.63^{a}	0.03	<0.0001
Atherogenic index	0.40^{b}	0.01	0.48^{a}	0.01	0.41^{b}	0.01	<0.0001

LSM: least square means for effect group; SEE: standard error of estimate; a, b, c: values with different superscript within the same line are significantly different (p < 0.05).

Results and conclusions – The KK and FATTY groups contained around 2% intramuscular fat content (Table 1) and the MEATY group about 1.4% (p=0.0369) because of the selection carried out to reduce carcass fatness and consequently intramuscular fat levels (De Smet *et al*., 2004). This indicated the superior meat quality of the KK and FATTY groups compared to the MEATY group when we considered Dunn (1996) that more marbling reflected better eating quality.

The KK group had the lowest SFA proportion (Table 1). The lowest monounsaturated fatty acids (MUFA) and the highest PUFA proportion were observed in the MEATY group. The low SFA and high MUFA proportion of Krškopolje pig meat indicated good nutritional quality as recommended by WHO (2003). The MEATY group had the highest proportion of n-6 PUFA (Table 1). The n-3 PUFA proportion was higher in the MEATY than the FATTY group. The n-6/n-3 PUFA ratio was the lowest in the KK group and still much higher than recommended by Enser *et al.* (2001). There were no differences in P/S and AI between the KK and MEATY groups (Table 1). Indices which show the risk of cardiovascular disease were in agreement with recommendations by Ulbricht and Southgate (1991) in all the groups (Table 1). De Smet *et al.* (2004) discussed that contents of SFA and MUFA were increasing faster with higher fatness compared to PUFA, causing a decrease in the P/S index. Similar results were found in the commercial fattener groups. The FATTY group had higher SFA and MUFA as well as a lower PUFA proportion and consequently the lower P/S ratio compared to the MEATY group. In conclusion, the nutritional quality parameters of M. *Longissimus dorsi* in Krškopolje pigs compared to the MEATY group were higher in terms of IMF and MUFA proportions and lower in SFA, PUFA and n-6 PUFA proportions. The KK group was similar to the FATTY group in IMF, MUFA, PUFA, n-6 PUFA and n-3 PUFA proportions. Furthermore, higher P/S and lower n-6/n-3 and AI levels were noticed in the KK than the FATTY group.

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COMMUNICATION

Heavy metal concentrations in the liver of two wild duck species: influence of species and gender

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ABSTRACT - The risk of wild ducks exposure to heavy metals in the environment was assessed by analyzing 20 wild ducks shot in the hunting area at the fish farm in Donji Miholjac, Eastern Croatia. Liver samples obtained from 10 Mallards and 10 Common Pochards were examined for heavy metals (Cd, Pb, As, Hg) by using flame atomic absorption spectrophotometry (AAS). Significant difference in heavy metal content between analyzed species was confirmed only for Cd ($P \leq 0.01$), and no differences were found between genders within species. The results obtained suggest the importance of wild ducks as bioindicators of heavy metal pollution, especially Common Pochard for Cd, and Mallard for Pb accumulation.

Key words: Heavy metal, Mallard, Common Pochard, Eastern Croatia.

Introduction – Hunting is allowed at some freshwater fish farm sites in Eastern Croatia and these are important habitats for numerous waterfowl species. Mallard (*Anas platyrhynchos*) and Common Pochard (*Aythya ferina*) are very common in wetlands. Archaeologists discovered that in the Eastern Croatia (in Vučedol near Vukovar) people used meat of these ducks in 2.500 BC (Malez, 1995), and they are still using it today. Besides local hunters, the most common wild duck hunters arrive from Italy. Croatian Act on hunting prescribes that wild duck hunting must be carried out using a shotgun with shotgun pellets made mostly of lead. Consequently, the possibility of wild animals consuming lead shotgun pellets is real, as it was reported by Anderson *et al.* (2000). Also, if the available food on the water surface and at the fishpond bottom contains heavy metals, it endangers not only the fish, but also the fish-eating waterfowls. Since the wild duck meat is consumed by humans, the objective of this study was to examine the concentrations of four heavy metals (Cd, Pb, As, Hg) in liver of two wild duck species and to identify possible differences between species and/or gender.

Material and methods - As part of a broader survey on wild life exposure to heavy metals, ten Mallards (5 males, 5 females) and ten Common Pochards (5 males, 5 females) were collected in the hunting area at the fish farm in Donji Miholjac in Eastern Croatia. All birds were shot using lead shot during the hunting season in fall 2008 and individually put in labeled plastic bags. Liver samples were taken within 2 hours after death, weighted to 5g fresh weight and frozen in polypropylene containers at -20°C. The metal assays were carried out using flame atomic absorption spectrophotometry (AAS), according to Neugebauer *et al.* (2000). Statistical analyses were done using the analysis of variance, and the differences between means were analyzed using Fisher LSD. All statistical tests were performed using Statistica 7.0 software (StatSoft, 2004).

Results and conclusions –The results for heavy metal (Cd, Pb, As, Hg) contents found in liver tissue based on gender and species are shown in Table 1. It shows that concentration of heavy metals mainly does not exceed values prescribed by the Croatian law, except for lead and mercury based on population level. To determine whether the heavy metal concentrations found in the two species statistically differ, two variants of the ANOVA were introduced (Table 2). The first one is based on gender differences within species, and the second one on the differences between species. There are no significant differences between genders within species. The only significant difference between species is the cadmium content, which is highly significant (P≤0.01).

Table 1. Heavy metal contents (mg/kg) found in liver tissues of Mallards and Common Pochard by AAS.

		cadmium			lead			arsenic			mercury		
		male	female	pop[2]	male	female	pop[2]	male	female	pop[2]	male	female	pop[2]
Group 1 (Common Pochard)	min	0.016	0.001	0.001	0.001	0.001	0.001	0.040	0.046	0.040	0.001	0.001	0.001
	max	0.280	0.115	0.280	1.621	3.517	3.517	0.078	0.081	0.081	0.016	0.277	0.277
	mean	0.123	0.044	0.084	0.325	1.010	0.687	0.059	0.057	0.058	0.006	0.093	0.049
	±SD	0.121	0.046	0.096	0.724	1.525	1.182	0.017	0.014	0.015	0.006	0.115	0.089
	value[1]	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.100	0.100	0.100
Group 2 (Mallard)	min	0.108	0.083	0.083	0.001	0.007	0.001	0.021	0.045	0.021	0.072	0.037	0.037
	max	0.800	0.432	0.800	0.492	0.092	0.492	0.053	0.061	0.061	0.262	0.197	0.262
	mean	0.418	0.249	0.332	0.158	0.061	0.113	0.040	0.052	0.046	0.122	0.111	0.116
	±SD	0.336	0.131	0.256	0.198	0.033	0.143	0.014	0.007	0.012	0.082	0.062	0.069
	value[1]	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.100	0.100	0.100

[1]maximum allowable amount for internal organs in poultry by the Croatian law (Official Gazette, No. 16/2005); [2]pop=population.

Table 1 shows higher cadmium content found in Mallard. This difference is highly significant (P≤0.01) as it is presented in Table 2. The difference in Cd content can be explained by differences in feeding habit. Mallard are dabbling duck that feed mostly in agricultural

Table 2. Results of ANOVA based on gender and species as sources of variation.

Gender as source of variation				
	DF	MS	F	P
Cd	18	0.05051	0.233153	ns
Pb	18	0.77123	0.463479	ns
As	18	0.00021	0.407800	ns
Hg	18	0.00720	0.333565	ns
Species as source of variation				
	DF	Mean square	F	P
Cd	18	0.3750	0.009969	*
Pb	18	0.70866	0.155308	ns
As	18	0.00018	0.062537	ns
Hg	18	0.0635	0.076769	ns

*ns=not significant; *P≤0.01.*

areas and at fishpond dyke. They feed on seeds and vegetative parts of aquatic and crop plants as well as on terrestrial and aquatic invertebrates (Kalisińska *et al.*, 2004). Sampling place is located near a heavy traffic road, and cadmium is commonly found in oil derivatives, motor oils and tires (Gish and Christensen, 1973). Cadmium accumulation was reported in plants (Larison *et al*., 2000), which are the primary food for Mallard. Higher mercury content, which is not statistically significant, can also be explained in this migratory species in a similar way.

On the other hand, Common Pochard are diving duck which take herbal food mostly from water surface and animal food from water column and fishpond bottom. This explains that higher content of lead (Table 1) found in Common Pochard is likely caused by lead shotgun pellet consumed from the bottom of fishpond, and reabsorbed in gizzard (Clemens *et al.*, 1975). This fact supports previous research which indicates that this species have highest prevalence of lead shot ingestion (Mateo *et al.*, 2000). Our results suggest that Mallard is a good indicator of cadmium presence, and Common Pochard of lead accumulation, so these wild duck species can be used as important bioindicators of heavy metal pollution in the environment.

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COMMUNICATION

Effect of sex on the fillet quality of Nile tilapia fed varying lipid sources

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ABSTRACT - Effect of sex and three different oil supplementations on main production traits, and fatty acid composition of the fillet and gonads was investigated in Nile tilapia. Males and females had significantly different final weights owing to the occasional reproduction of fish. Diets had no significant effects on the main production traits. The percentage of ALA in the fillet was significantly higher in the males in all diets. Significant differences were found between the two sexes in the n-3 PUFA, resulting in a higher n-3/n-6 ratio in the males. MUFA and n-6 PUFA percentages and EPA/DHA ratio in the fillet were affected by the fat sources in the diet. The proportion of the main fatty acids showed significant changes in the gonads. Both sex and the diet had a significant effect on LA, AA, and DHA percentages. In case of EPA the males had significantly higher values than the females. ALA was affected by the different diets, the fillets of the LO group containing the highest percentage Regarding the main FA groups, n-3 PUFA, n-6 PUFA, n-3/n-6 ratio and the DHA/EPA ratio were affected by sex and diets.

Key words: Nile tilapia, Fatty acids, Sex, Oil supplementation.

Introduction - Meat quality of fish depends firstly on feeding (Steffens, 1989), and secondarily on many different factors such as age, sex, diet, season. Akpinar *et al.* (2009) found quantitative differences between individual fatty acids in liver and muscle tissues in trout, depending on the sex. Caponio *et al.* (2004) reported that qualitative differences exist between sexes on sardines. The aim of our investigation was to evaluate the effect of sex and three different oils in feed on main production traits and meat quality, evaluating also the fatty acid composition of the fillet and gonads in Nile tilapia.

Materials and methods - The study was carried out in the Fish Laboratory of the Kaposvár University. Treatments were repeated in 3 tanks, with a stocking density of 65 fish per tank (11kg/m^3). The experimental stock showed no signs of sexual maturity at the start of the 42 days feeding trial. The experimental feeds were supplemented with soybean oil (SO) and linseed oil (LO), the control diet contained fish oil (FO). Chemical and fatty acid composition of the feeds are shown in Table 1. At the end of the trial four fish (two males and two females) for each treatment were over-anaesthetised, dissected and the fillets and the gonads were subjected to the analysis of fatty acid profile. Tissue samples (muscle and

gonad) were extracted by the method of Folch *et al*. (1957). Gas liquid chromatography was performed on a Shimadzu 2100 apparatus. Results were evaluated by two-way ANOVA and treatment mean values were compared by Tukey's test.

Table 1. Proximate composition and most important fatty acids in the feeds.

Chemical composition	SO	LO	FO	Fatty acids (%)	SO	LO	FO
Dry matter (DM; g/kg)	871	867.6	867.2	C18:2 n-6 (LA)	23.10	30.09	19.08
Crude ash (g/kg DM)	51.4	50.7	50.3	C20:4 n-6 (AA)	0.33	0.16	0.36
Crude protein (g/kg DM)	388.8	371.4	363.4	C18:3 n-3(ALA)	4.16	24.5	3.72
Ether extract (g/kg DM)	111.9	95.3	123.4	C20:5 n-3 (EPA)	4.64	1.37	5.20
Crude fibre (g/kg DM)	24.3	23.1	22.5	C22:6 n-3 (DHA)	8.43	2.95	9.27

Results and conclusions - Main production traits were not significantly affected by the different fat sources of the diets. The low value of the specific growth rate (S.G.R.=0.7% day^{-1}) can be explained by the occasional reproduction of fish. Males and females had no

Table 2. Fatty acid composition (% of total fatty acids) of the fillets and gonads of tilapia fed different diets.

Fatty Acid	Organ	Prob. (diet)	SO		LO		FO	
			males	females	males	females	males	females
C18:2n-6	fillet	ns	15.8 ± 0.29^{B}	13.9 ± 2.06^{AB}	13.7 ± 1.00^{AB}	14.2 ± 1.27^{AB}	11.8 ± 0.73^{A}	12.6 ± 1.66^{AB}
	gonad	0.001	13.3 ± 0.39^{CD}	14.8 ± 0.36^{D}	10.9 ± 0.59^{BC}	12.2 ± 0.85^{C}	8.23 ± 1.06^{A}	9.10 ± 0.60^{AB}
C20:4n-6	fillet	ns	3.55 ± 0.11	4.15 ± 1.21	2.71 ± 0.35	3.27 ± 1.04	2.18 ± 0.51	3.02 ± 1.13
	gonad	0.016	9.98 ± 1.20^{D}	3.90 ± 0.36^{AB}	7.03 ± 1.35^{CD}	2.67 ± 0.18^{A}	6.09 ± 0.79^{BC}	2.65 ± 0.27^{A}
C18:3n-3	fillet	0.001	1.07 ± 0.10^{B}	0.79 ± 0.22^{AB}	4.51 ± 0.03^{D}	2.22 ± 0.08^{C}	1.10 ± 0.10^{B}	0.46 ± 0.15^{A}
	gonad	0.001	0.58 ± 0.11^{A}	1.18 ± 0.15^{AB}	3.01 ± 1.35^{BC}	4.66 ± 0.46^{C}	0.60 ± 0.12^{A}	0.50 ± 0.30^{A}
C20:5n-3	fillet	ns	0.35 ± 0.03	0.46 ± 0.03	0.44 ± 0.01	0.48 ± 0.15	0.96 ± 0.19	0.34 ± 0.09
	gonad	ns	0.69 ± 0.03^{A}	0.25 ± 0.02^{A}	1.02 ± 0.49^{AB}	0.39 ± 0.04^{A}	2.04 ± 0.51^{B}	0.39 ± 0.10^{A}
C22:6n-3	fillet	ns	11.97 ± 0.91	12.97 ± 2.98	11.39 ± 0.12	10.08 ± 2.98	15.22 ± 2.94	6.99 ± 2.98
	gonad	0.028	16.2 ± 1.26^{A}	13.6 ± 2.11^{A}	17.1 ± 5.19^{AB}	12.2 ± 0.40^{A}	25.3 ± 1.45^{B}	16.7 ± 1.26^{A}
DHA/EPA	fillet	0.001	34.4 ± 0.64^{C}	28.0 ± 4.95^{BC}	26.0 ± 0.82^{B}	21.2 ± 0.26^{AB}	15.8 ± 1.23^{A}	20.8 ± 2.60^{AB}
	gonad	0.031	23.5 ± 0.96^{A}	54.5 ± 9.01^{C}	17.6 ± 3.30^{A}	31.7 ± 4.12^{AB}	13.0 ± 3.82^{A}	43.4 ± 4.84^{BC}
SFA	fillet	ns	34.3 ± 1.53	33.4 ± 2.30	32.7 ± 1.35	32.9 ± 0.83	32.0 ± 1.43	33.9 ± 1.57
	gonad	ns	32.9 ± 0.56	32.8 ± 3.03	31.1 ± 0.16	30.9 ± 0.33	31.3 ± 0.40	29.6 ± 1.68
MUFA	fillet	0.036	27.6 ± 2.10^{A}	28.9 ± 0.37^{A}	29.0 ± 2.83^{A}	31.6 ± 2.48^{AB}	31.4 ± 3.24^{AB}	38.6 ± 1.43^{B}
	gonad	ns	17.3 ± 3.35^{A}	27.7 ± 0.90^{ABC}	19.9 ± 7.03^{AB}	30.5 ± 0.68^{BC}	17.9 ± 1.58^{A}	35.6 ± 0.79^{C}
n-3 PUFA	fillet	ns	16.5 ± 1.15^{AB}	17.6 ± 3.52^{AB}	19.4 ± 0.06^{AB}	15.8 ± 3.56^{AB}	21.1 ± 3.47^{B}	10.2 ± 3.54^{A}
	gonad	0.036	23.0 ± 1.87^{A}	18.3 ± 1.87^{A}	27.3 ± 5.70^{AB}	21.0 ± 0.19^{A}	34.7 ± 1.31^{B}	20.8 ± 1.03^{A}
n-6 PUFA	fillet	0.005	21.5 ± 0.59^{C}	19.9 ± 0.85^{BC}	18.7 ± 1.54^{ABC}	19.5 ± 0.25^{BC}	15.4 ± 1.37^{A}	17.2 ± 0.55^{AB}
	gonad	0.001	26.6 ± 2.04^{C}	21.1 ± 0.27^{B}	21.6 ± 1.16^{B}	17.5 ± 0.55^{AB}	15.9 ± 1.17^{A}	13.8 ± 0.41^{A}
n-3/n-6	fillet	ns	0.77 ± 0.07^{A}	0.89 ± 0.21^{AB}	1.04 ± 0.09^{AB}	0.81 ± 0.19^{AB}	1.37 ± 0.20^{B}	0.59 ± 0.20^{A}
	gonad	0.001	0.86 ± 0.00^{A}	0.87 ± 0.08^{A}	1.26 ± 0.20^{AB}	1.20 ± 0.05^{AB}	2.18 ± 0.15^{C}	1.51 ± 0.06^{B}

significant differences in the initial body weight (168.3 *vs* 177.1g) while final weights (273.4 *vs* 187.3g) differed significantly (P<0.001). Males also showed significantly (P<0.001) higher fillet percentage than females (30.4 *vs* 27.4%). Different diets did not result in significant differences in the final body weight, fillet weight and fillet percentage.

Changes of the fatty acid profile of Tilapia tissues are shown in Table 2. The incidence of ALA in the fillet was higher in the males by all diets, however it was significant only in groups FO and LO, and the latter was higher than in fish fed other diets. Differences were found between the two sexes in the n-3 PUFA of FO and LO groups, resulting in a higher n-3/n-6 ratio in the males, but these were significant only in the FO group. In case of EPA, the males had generally higher values; however the difference was significant in the gonads of FO group. Fillet MUFA, was affected by the fat source in the diet. LA, AA, and DHA and the main FA groups, n-3 PUFA, n-6 PUFA, the n-3/n-6 ratio and the DHA/EPA ratio were affected by both treatments (sex and diets). In case of n-3/n-6 ratio the interaction of the two treatments was also significant. Similarly to the fillet, females had a higher MUFA incidence in the gonads; however it was significant only in the group FO.

The higher body weight and fillet incidence make the males of tilapia more advantageous in the aquaculture production. However, the maturation process results in marked differences between the two sexes in the fatty acid composition of fish fillet. The higher level of n-3 PUFA in the muscle of male fish than in that of females resulted also in *Salmo trutta macrostigma* (Akpinar *et al.*, 2009), in *Onchorchynchus mykiss* (Görgün and Akpinar, 2007), and in *Sardinia pilchardus* (Caponio *et al.*, 2004). A diet rich in n-3 fatty acids has a positive effect on cardio-circulatory pathologies and on many other human diseases. The optimal n-3/n-6 ratio is 1/1, whereas the western human diets provide a 1/15 ratio (Simopoulos, 2002). Tilapia fillets with 1/1.7-1/1.1 n-3/n-6 ratio offer a possibility to develop health protecting functional products.

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COMMUNICATION

Slaughter performance and meat quality of three Italian chicken breeds

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ABSTRACT - A trial was carried out to study the slaughter performance and the meat quality of three Italian dual-purpose chicken breeds: Ermellinata di Rovigo (ER), Robusta lionata (RL) and Robusta maculata (RM). Females were studied from June to October from 47 days of life until slaughtered age, at 138 (I age) and 168 (II age) days of age. Each genotype had access to outdoor and indoor spaces. RL and RM birds showed a higher final body weight, and provided heavier carcass and commercial cuts than ER ($P<0.01$), at both ages. The dressing-out percentage of RL and RM females was more favourable than ER ones, in particular at II age ($P<0.01$). Differences in carcass conformation were observed at II age: the ER carcass showed a higher ($P<0.01$) proportion of leg and wing. The RM carcass had a higher ($P<0.01$) proportion of breast. The thigh meat/bone ratio was higher in RL at I age ($P<0.01$) and II ($P<0.05$) age. Significant differences in breast colour were observed among the breeds; ER thigh showed the highest ($P<0.05$) a* value. At II age, lipids were lower ($P<0.01$) in ER breast; thigh lipids were similar among the groups. Slaughtering at I age seem to be more advantageous for the ER breed since it is more precocious.

Key words: Chicken, Breed, Slaughter performance, Meat quality.

Introduction – Interest on biodiversity and non-conventional poultry production systems is progressively increasing, but data on genetic variability, productive performance and slaughter performance of Italian breeds are limited (De Marchi *et al*. 2006; Rizzi *et al*., 2007; Rizzi *et al.*, 2008). Meat quality is affected by rearing conditions as stated in Husak *et al*. (2008). A trial was carried out on three Italian dual-purpose breeds to study their slaughter performance and meat quality at 138 and 168 days of age.

Material and methods - Females belonging to three Italian dual-purpose chicken breeds, Ermellinata di Rovigo (ER), Robusta lionata (RL) and Robusta maculata (RM), were studied (June-October) from 47 days of life until slaughter age, at 138 (I age) and 168 (II age) days. They were reared outdoors, on grass. At 138 and 168 days of age, 20 females per genotype were slaughtered. Ultimate pH (pHu) and L* a* b* colour (CIE Lab colour space - CIE, 1976) measurements were performed on *Pectoralis major* (breast) and *Semitendinosus* muscles. *Pectoralis major* and thigh (all muscles) meat was analysed for lipids (AOAC, 2000). Thawing loss [(frozen weight-thawed

weight)/frozen weight x100] and Warner-Bratzler Shear Force (WBSF) were measured on *Pectoralis major*. Data were submitted to one-way ANOVA with breed as main effect (SAS, 2001). Differences between means were tested using Duncan's multiple range test (SAS, 2001).

Results and conclusions - Slaughter performance are in Table 1. At I and II age RL females showed higher (P<0.01) body weight in comparison to RM and ER. ER was lower than RM at I (P<0.05) and II age (P<0.01). At both ages RL and RM showed the heaviest (P<0.01) breasts and wings; legs showed (P<0.01) the highest value in RL and the lowest value in ER. The dressing-out percentage differed between ER and RM at I age (P<0.05), and at II age it was lower (P<0.01) in ER than RL and RM. It should be noted that in the RL and RM birds the breast and leg growth incidence on the body growth from 138 to 168 days of age was about twice that of the ER birds (data not shown). This result indicates that the ER females were more precocious than the other birds. They reached puberty earlier and thus muscular growth stopped earlier than in RL and RM. Furthermore an earlier development of the reproductive apparatus induced a lower dressing-out percentage. The breast % of the ready to cook carcass was higher in RM than in RL and ER at both ages, but at II age the differences were more significant (P<0.01). At II age, ER showed higher leg values and RL showed lower wing proportion. Thigh muscle/bone ratio (M/B) was higher in RL than ER at I age (P<0.01) and II (P<0.05) age.

Table 1. Slaughter performance.

		I age			SEM[1]	II age			SEM[1]
		ER	RL	RM		ER	RL	RM	
Live weight	g	1840^{Bc}	2134^{Aa}	1953^{Bb}	139	2054^{Cc}	2407^{Aa}	2192^{Bb}	153
Breast	g	277^{Bb}	352^{Aa}	345^{Aa}	32	291^{Bb}	396^{Aa}	383^{Aa}	36
Leg	g	429^{Cc}	502^{Aa}	467^{Bb}	39	449^{Cc}	544^{Aa}	499^{Bb}	43
Wing	g	140^{Bb}	159^{Aa}	154^{Aa}	8	141^{Bb}	165^{Aa}	159^{Aa}	11
Carcass	g	1207^{Bc}	1400^{Aa}	1321^{Ab}	114	1246^{Cc}	1551^{Aa}	1439^{Bb}	123
Dressing-out percentage	%	74.7^{b}	75.6^{ab}	77.4^{a}	3.72	70.2^{Bb}	74.3^{Aa}	74.7^{Aa}	2.45
Breast	%	22.9^{Bc}	25.2^{Ab}	26.1^{Aa}	1.17	23.4^{Cc}	25.5^{Bb}	26.6^{Aa}	1.21
Leg	%	35.6	35.9	35.4	1.39	36.0^{Aa}	35.1^{ABb}	34.7^{Bb}	1.06
Wing	%	11.6	11.4	11.77	0.702	11.3^{Aa}	10.7^{Bb}	11.1^{AaB}	0.532
Thigh M/B ratio		4.95^{Bb}	5.78^{Aa}	5.11^{ABb}	0.623	4.91^{b}	5.74^{a}	5.22^{ab}	0.555

[a, b, c]: P<0.05; [A, B, C]: P<0.01; [1] observations (n) of each group (I-II age): 20.

The pHu (Table 2) was higher (P<0.01) in RL breast than in the other groups, both at I and II age. The pHu significantly affected meat colour given that lightness (L*) was lower (P<0.05) in RL, particularly at I age. The redness index (a*) was higher in the RL breast than in the others, at I (P<0.05) and II (P<0.01) age. The yellowness index (b*) was higher (P<0.05) in RM than in ER breast at II age. The breast lipid content was lower in ER than in RL (P<0.01) and RM (P<0.05), at II age. The RL breast showed lower (P<0.05) thawing loss than the other groups as a consequence of higher lipids. At I age the ER breast showed lower (P<0.05) tenderness than RL. *Semitendinosus* muscle (Table 2) showed a higher pHu in RL group with significant (P<0.05) differences at II age. L* value was lower (P<0.05) in RL at I age. The a* value was higher (P<0.05) in the ER thigh at I

and II age. The b* value was higher in RL and lower in ER at I age (P<0.05). Thigh lipids did not show differences at both ages. It should be noted that breast meat includes one muscle, whereas thigh meat includes many muscles and the trend of lipids may depend on the muscle metabolism, on the physiological status of the animals and on a possible interaction with the environmental conditions. The results indicate that the breed affected the body weight, the slaughter performance and carcass conformation and the ER and RL females were highly differentiated; the results on meat quality indicate less tenderness in ER breast meat and higher redness in ER thigh even if these parameters do not allow for the individuation of a superior breed. Furthermore, slaughtering at I age appears to be more advantageous for ER breed since it matures earlier.

Table 2. Chemical and physical characteristics of breast and thigh meat.

		I age			SEM[2]	II age			SEM[2]
		ER	RL	RM		ER	RL	RM	
Breast:									
- pHu		5.69^{Bb}	5.79^{Aa}	5.66^{Bb}	0.077	5.68^{ABb}	5.78^{Aa}	5.64^{Bb}	0.097
- L*		56.6^{a}	54.6^{b}	57.0^{a}	2.11	57.6	55.0	57.3	3.18
- a*		0.572^{ab}	1.00^{a}	-0.074^{b}	0.969	-0.341^{Bb}	0.894^{Aa}	-0.23^{Bb}	0.789
- b*		2.88	3.16	3.93	1.47	2.49^{b}	2.99^{ab}	4.09^{a}	1.49
- Lipids[1]	%	0.501	0.714	0.621	0.190	0.263^{Bb}	0.403^{Aa}	0.368^{AaB}	0.078
- Thawing loss	%	11.5^{ab}	9.93^{b}	12.5^{a}	2.28	10.4^{a}	8.10^{b}	9.54^{ab}	2.06
- WBSF	kg/cm^2	1.75^{a}	1.40^{b}	1.53^{ab}	0.273	1.73	1.44	1.50	0.332
Thigh:									
- pHu		5.85	5.92	5.85	0.140	5.85^{b}	5.97^{a}	5.88^{ab}	0.125
- L*		51.8^{ab}	51.4^{b}	53.6^{a}	2.33	50.92	50.41	51.92	2.51
- a*		4.19^{a}	3.47^{ab}	3.10^{b}	1.12	4.49^{a}	3.72^{ab}	3.37^{b}	0.991
- b*		1.47^{b}	2.70^{a}	2.10^{ab}	1.32	0.65	0.88	1.74	1.46
- Lipids[1]	%	5.88	4.89	4.79	1.07	5.57	5.21	4.60	1.38

a, b, c: P<0.05; A, B, C: P<0.01; 1: on as is basis; 2 observations (n) of each group (I-II age): 10 (pHu and colour) – 7 (lipids, thawing loss and WBSF).

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COMMUNICATION

Comparison of the slaughter characteristics of meat-type chicks hatched from eggs with different composition

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ABSTRACT - Using the so-called TOBEC (Total Body Electrical Conductivity) method for the in vivo determination of egg composition, the effect of egg composition on the slaughter characteristics of hatched chicks was examined in the ROSS-308 meat-type genotype. Chicks hatched from eggs with low, average and high electrical conductivity were slaughtered at 42 days of age. It was found that the weight of all of the examined traits showed highest values in the case of chicks hatched from eggs with low electrical conductivity, while the lowest values could be observed in the case of chicks hatched from eggs with high electrical conductivity. Similar tendencies were observed also in the case of the ratio of the examined slaughter traits to the slaughter weight, but in this case the differences were not statistically proven (P>0.05).

Key words: Egg composition, Hatching, chicks, Slaughter characteristics.

Introduction – In some former experiments it was already established that the embryonic development is slower in the eggs of younger hens than in the eggs of older ones (Applegate, 2002). It was supposed that the reason for this could be the lower proportion of yolk in the eggs of the younger hens. However, the clarification of the effect of egg composition on the hatchability and hatched bird's development was mainly hindered by the lack of a reliable technique/equipment, capable of determining the egg composition *in vivo*. Using the so-called TOBEC (Total Body Electrical Conductivity) method in a former study it was pointed out that the eggs' composition has a significant effect on the hatchability and also on the body composition of the hatched chicks (Milisits *et al*., 2008). Based on these former results the aim of the present study was to examine the effect of egg composition on the slaughter characteristics of the hatched chicks in a meat-type genotype.

Material and methods – The experiment was carried out with 1.500 hen's eggs originated from a 36 weeks old ROSS-308 hybrid parent stock and collected on the same day. For predicting their composition *in vivo* their electrical conductivity (E-value) was measured by means of the so-called TOBEC method (EM-SCAN SA-2 type Small Animal Body Composi-

tion Analyser). Based on the measured values eggs with extreme high, extreme low and average electrical conductivity values (10-10%) were chosen for further examinations.

After the TOBEC measurements 15-15 eggs from each of the experimental groups were broken and their albumen/yolk ratio was determined. Their dry matter, crude protein and crude fat content was chemically analysed by the instructions of the Hungarian Standards (dry matter: MSZ ISO 1442, crude protein: MSZ EN ISO 5983-1:2005, crude fat: MSZ 6369-15:1982). Remaining eggs were incubated thereafter in the hatchery of the Kaposvár University.

Hatched chicks were then reared in a closed building till 6 weeks of age and slaughtered thereafter. During the slaughter procedure, the following traits were recorded: liveweight at slaughter, grill-ready weight, the weight of breast with skin and bones, the weight of thighs with skin and bones, the weight of breast muscle and the weight of abdominal fat.

For the evaluation of the effect of separation on the eggs' composition the One-Way ANOVA model was used. The significance of between group differences was tested by the LSD post hoc test. The effect of electrical conductivity of eggs of origin and sex on the slaughter traits was evaluated by the following general linear model: $Y_{ijk}=\mu+E_i+S_j+e_{ijk}$, where μ=overall mean, E_i=the effect of electrical conductivity of eggs of origin (i=1-3), S_j=the effect of sex (j=1-2) and e_{ijk}=random error. All of these statistical analyses were performed by the SPSS statistical software package (SPSS for Windows, 1999).

Results and conclusions – In Table 1 it is well visible that eggs with extreme low and extreme high electrical conductivity differ significantly from each other also in their chemical composition. The values of eggs with average electrical conductivity varied between the values of the two extreme groups in each case, but they were mainly closer to that of eggs with low electrical conductivity.

Table 1. Composition of eggs with different electrical conductivity in the ROSS-308 genotype.

	Eggs with low electrical conductivity	Eggs with average electrical conductivity	Eggs with high electrical conductivity
Albumen/yolk ratio	$2.34^{a}\pm0.33$	$2.44^{ab}\pm0.24$	$2.65^{b}\pm0.41$
Dry matter (g/kg)	$23.5^{a}\pm1.3$	$23.3^{a}\pm0.8$	$21.8^{b}\pm1.2$
Crude protein (g/kg)	$12.0^{a}\pm0.3$	$11.9^{a}\pm0.4$	$10.9^{b}\pm0.6$
Crude fat (g/kg)	9.5±0.8	9.3±0.7	8.9±1.0

^{a,b} Different letters in the same row indicate significant differences ($P<0.05$).

It was interesting to see that the composition of eggs of origin had a significant effect on the most of the slaughter traits of the hatched chicks (Table 2). The weight of all of the examined traits showed highest values in the case of chicks hatched from eggs with low electrical conductivity, while the lowest values could be observed in the case of chicks hatched from eggs with high electrical conductivity. The differences between the two extreme groups were also statistically proven almost in all cases.

Table 2. The weight of different slaughter traits and their ratio to the slaughter weight in ROSS-308 meat-type chicks hatched from eggs with different electrical conductivity.

Slaughter traits	Eggs' electrical conductivity			S. E.	Level of significance
	Low	Average	High		
Slaughter weight (g)	3264[a]	3228[a]	3125[b]	30.36	0.001
Grill-ready weight (g)	2297[a]	2267[a]	2164[b]	24.47	<0.001
Breast with skin and bones (g)	847[a]	832[a]	785[b]	9.65	0.001
Thigh with skin and bones (g)	694[a]	689[ab]	665[b]	8.92	0.059
Breast fillet (g)	652[a]	640[a]	604[b]	7.94	0.003
Abdominal fat (g)	46.8	44.0	41.1	1.69	0.370
Grill-ready weight (%)	70.4[a]	70.2[ab]	69.2[b]	0.229	0.080
Breast with skin and bones (%)	26.0[a]	25.8[ab]	25.1[b]	0.162	0.078
Thigh with skin and bones (%)	21.2	21.3	21.3	0.121	0.932
Breast fillet (%)	20.0	19.8	19.3	0.152	0.198
Abdominal fat (%)	1.45	1.37	1.32	0.056	0.594

abDifferent letters in the same row indicate significant differences (P<0.05).

Similar tendencies were observed also in the case of the ratio of the examined slaughter traits to the slaughter weight, but in this case the differences were not statistically proven (P>0.05).

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COMMUNICATION

Applicability of computer tomography in the prediction of egg yolk ratio in hen's eggs

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ABSTRACT - Applicability of computer tomography (CT) was examined for the in vivo determination of egg yolk ratio in commercial hen's eggs. Altogether 60 eggs were measured by CT, and two different evaluation methods were tested for the prediction of the egg yolk ratio. Because of the overlapping of the X-ray density values of the yolk and albumen, the evaluation based on the X-ray absorption seems not to be useful for the in vivo prediction of the egg yolk ratio. The determination of the surface of the egg yolk on the cross-sectional images resulted in a 69.3-74.1% accuracy of prediction, depending on the number of scans involved in the evaluation.

Key words: Hen, Egg, Computer tomography, Prediction.

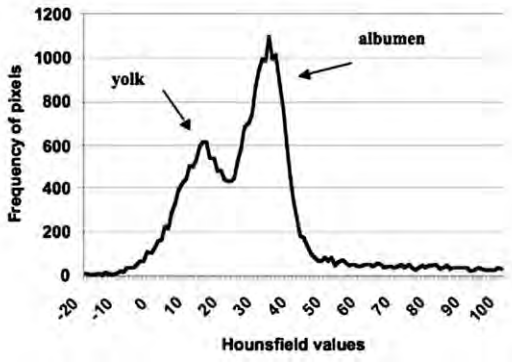
Introduction – In former experiments it has already been studied whether the size or the composition of the egg had greater effect on the viability of the offspring. However, in these examinations correlations were mainly determined between different species, therefore the available information about intra-specific correlations is scarce. The clarification of these correlations was mainly hindered by the lack of a reliable technique/equipment, capable of determining the egg composition *in vivo*. Using the so-called TOBEC (Total Body Electrical Conductivity) method for the non-destructive determination of egg composition, Williams *et al.* (1997) have found significant correlations between the measured values and some egg constituents in different species of birds. Similar results were obtained also by Milisits *et al*. (2005) using hen's eggs in their investigation. The aim of the present study was to examine, whether computer tomography (CT) is suitable for the *in vivo* prediction of egg yolk ratio.

Material and methods – The experiment was carried out with 60 hen's eggs originated from a 36 weeks old ROSS-308 hybrid parent stock and collected on the same day. All of the eggs were weighted before the CT measurements and positioned thereafter for the scanning in standing/upright position. The eggs were scanned with a SIEMENS Somatom Plus 4 Expert spiral CT scanner at the Institute of Diagnostic Imaging and Radiation Oncology

of the Kaposvár University. During each scanning session 10 eggs were measured simultaneously with the following parameters: slice thickness: 5mm, feed: 5mm, pixel spacing: 0.5859 x 0.5859mm, tube voltage: 120kV, dose: 185mAs, reconstruction algorithm: AB50. All of the obtained data were saved and stored in a DICOM file format. The images were analysed by the Medical Image Processing V1.0 software developed by the above mentioned institution.

After the CT measurements, all of the eggs were broken and their yolk and albumen were separated. After weighing the yolk, its ratio to the whole eggs was calculated. For predicting the egg yolk ratio *in vivo*, prediction equations were created by means of the linear regression method using the CT data as independent variable in the model. For the determination of the prediction equations the SPSS statistical software package (SPSS for Windows, 1999) was used.

Figure 1. X-ray density values of the egg yolk and albumen.



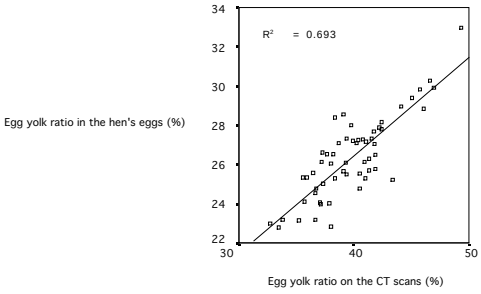
Results and conclusions – As first step of the evaluation the X-ray density values of the pixels (picture elements) were used to determine the egg yolk ratio in the hen's eggs *in vivo*. Using this evaluation method it was established that the X-ray density values of the egg yolk clearly differ from that of the animal's fatty tissues. While X-ray density values of the animal's fatty tissues ranges from -200 to -20 on the so-called Hounsfield-scale, the values of the egg yolk varies between -10 to +30. The reason of this could be the higher water and protein content of the yolk, which results in an increase of the X-ray density values in the egg yolk. Because of the overlapping of the X-ray density values of the yolk and albumen, this evaluation method seems not to be useful for determining the egg yolk ratio in hen's eggs (*Figure 1*).

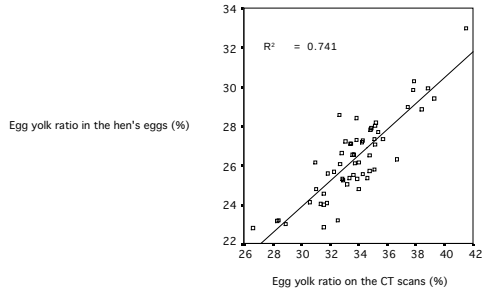
As another method of the evaluation, the surface of the egg yolk was determined on the cross-sectional images for predicting the egg yolk content *in vivo*. As first step of this evaluation only one scan per egg was used for testing the accuracy of prediction. Using the scan taken at the germinal disc resulted in a 69.3% accuracy of prediction (Figure 1). Only a slightly better accuracy was obtained, when the two (Figure 2) or four (Figure 3) neighboring (±1 or ±2) scans were also involved into the evaluation:

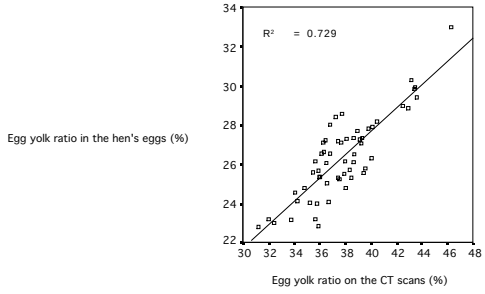
The accuracy of prediction based on the data of the scan taken at the germinal disc was tested on independent samples (n=20) and the following results were obtained: MSE=2.82; r=0.639 (P=0.002).

Based on the results it was concluded, that computer tomography seems to be a useful method for the prediction of egg yolk ratio. The obtained accuracy of prediction seems to be precisely enough for using this techique in further investigations in order to examine the effect of egg composition on the egg's hatchability and hatched chick's development.

Figures 1-3. Correlation between the egg yolk ratio in hen's eggs and egg yolk ratio on the CT scans based on the data of one (Figure 1), three (Figure 2) and five (Figure 3) CT images.







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COMMUNICATION

Effect of adult weight and CT-based selection on the performances of growing rabbits

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ABSTRACT - The aim of the study was to compare the productive performance of different genotypes. Maternal (M; n=32, adult weight /AW/ 4.0-4.5kg, selected for number of kits born alive), Pannon White (P; n=32, AW: 4.3-4.8kg), and Large body line (L; n=32, AW: 4.8-5.4kg) (P and L were selected for carcass traits based on CT /Computer tomography/data) rabbits were analysed. Average daily gain between 5-11wk of age, body weight at 11wk of age and feed intake were significantly (P<0.001) highest for L rabbits. For M, P and L rabbits, the following values were observed: average daily gain=38.6, 43.1 and 47.4g/d; body weight=2458, 2667 and 2949g; feed intake=115, 121 and 138g/d, respectively. Mortality of growing rabbits was unaffected by genotype. It can be concluded that production traits were mainly affected by the adult weight of the genotypes.

Key words: Growing rabbit, Adult weight, CT-based selection, Productive performances.

Introduction – Weight gain, feed consumption and slaughter performance of growing rabbits are affected by several factors; one of the most important is adult weight (Dalle Zotte, 2002). The larger type rabbits show higher growth intensity (Metzger *et al.*, 2006; Ramon *et al.* 1996; Larzul and Rochambeau, 2004) and consume more feed. The objective of the study was to compare the productive performance of three genotypes of different adult weight that were partly selected for carcass traits based on CT data.

Materials and methods - The experiment was carried out at Kaposvár University. Rabbits were weaned at the age of 5 wk (n=96). The genotypes analyzed can be characterized as follows: M=Maternal line: selected for number of kits born alive; AW: 4-4.5kg; P=Pannon White: selected for weight gain and carcass traits by CT measurement since 1993; AW:4.3-4.8kg; L=Large body line: selected for weight gain and carcass traits measured by CT since 2006; AW: 4.8-5.4kg. The rabbits were reared in pairs and fed a commercial pellet *ad libitum*

with or without medication (between the ages of 5-9 and 9-11wk, respectively). Production data were evaluated by means of one-factor ANOVA using the SPSS 11.5 software package. Correlation and partial correlation coefficients were calculated between body weight (BW at the first kindling), body weight gain (BWG at 6-10wk), and BW (6 and 10wk, taking the age effects into account), resp. (n=M:240, P:116, L:154). Mortality rates were compared by chi^2 test.

Results and conclusions – The results are summarized in Table 1.

Table 1. Effect of genotype on productive traits.

Age, wk	Genotype			SE	P
	Maternal	Pannon	Large		
Rabbits, No.	32	32	32		
		Body weight, g			
5	834^A	849^A	951^B	14.0	0.001
7	1461^A	1496^A	1720^B	23.4	<0.001
9	1944^A	2001^A	2305^B	28.8	<0.001
11	2458^A	2667^B	2949^C	31.2	<0.001
		Weight gain, g/d			
5-7	44.6^A	46.2^A	54.5^B	0.91	<0.001
7-9	34.5^A	36.0^A	41.8^B	0.90	0.002
9-11	36.9^A	44.9^B	44.8^B	1.09	0.002
5-11	38.6^A	43.1^B	47.4^C	0.57	<0.001
		Feed, intake, g/d			
5-7	79.7^A	87.2^A	116^B	2.21	<0.001
7-9	123^A	123^A	139^B	2.11	0.001
9-11	142^A	153^A	167^B	2.54	<0.001
5-11	115^A	121^A	138^B	2.21	<0.001
		Feed conversion ratio			
5-7	1.79^A	1.89^{AB}	2.12^B	0.05	0.013
7-9	3.55	3.54	3.34	0.07	0.422
9-11	3.90	3.44	3.87	0.09	0.060
5-11	2.95	2.81	2.93	0.04	0.257
		Mortality, %			
5-7	3.1	0.0	3.1		ns
7-9	0.0	0.0	0.0		ns
9-11	6.7	3.1	3.2		ns
5-11	9.4	3.1	6.3		ns

^{A,B}= *P<0.05.*

BW of the L rabbits significantly exceeded (P=0.001) that of the M and P groups already at weaning. L rabbit does produced more milk (Szendrő and Maertens, 2001; Maertens *et al.*, 2006) and after changing from milk to solid feed, kits also showed higher weight gain. These rabbits also showed greater BWG after weaning (P<0.001): between the ages of 5-11wk they were superior to M and P rabbit by 23% and 10%, respectively. Significant differences (P<0.001) were observed among the 3 genotypes (M<P<L) consistent with the data in the literature (Ramon *et al.*, 1996; Larzul and Rochambeau, 2004) also at 11wk of age. The correlation and partial correlation coefficients between the BW at first kindling and BWG and BW at 6 and 10 wk were M=0.28, 0.27, 0.38; P=0.37, 0.38, 0.53; L=0.35, 0.36 and 0.44, resp. (P<0.001). The effect of ABW was verified among and within the genotypes. L rabbits had the largest feed intake (FI) exceeding that of the M and L group rabbits by 20% and by 14%, resp. This is linked to the higher BWG and BW. Similar results were published by Ramon *et al.* (1996). There was no significant difference between the FI of the M or P rabbits. No significant differences were observed in feed conversion ratio or mortality rate. Most rabbits were lost after the medicated diet was replaced by a non-medicated pellet. The production levels in our experiment were in accordance with literature (Ramon *et al.*, 1996; Dalle Zotte, 2002; Metzger *et al.*, 2006); larger type rabbits had higher BWG and FI. CT-based selection did not modify productive traits. Similar observations were made by Szendrő *et al.* (2008) regarding BWG and BW but the divergent selection modified the FI and feed conversion ratio. It can be concluded that live performances (FI, BWG, BW) were determined by the adult weight of the genotypes.

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COMMUNICATION

Effect of adult weight and CT-based selection on carcass traits of growing rabbits

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ABSTRACT - The aim of this study was to compare the carcass traits of different genotypes. Maternal line (M; n=31; adult weight/AW/4.0-4.5kg) (selected for number of kits born alive), Pannon White (P; n=32; AW: 4.3-4.8kg), and Large type line (L, n=32; AW: 4.8-5.4kg) (P and L were selected for carcass traits based on CT/Computer tomography/data) rabbits were analysed. Rabbits were slaughtered at 11 wk of age. P rabbits showed the highest dressing out percentage (M=60.2, P=61.3 and L=61.1%, with a significant difference between groups M and P, P<0.05), the lowest ratio of fore part (M=26.0, P=25.7 and L=26.9%, differences were significant between groups M-P and L, P<0.05), and the largest ratio of the hind part (M=37.3, P=38.2 and L=37.2%, differences were significant between groups M-L and P, P<0.05) to the reference carcass. It can be concluded that carcass traits were influenced by CT-based selection.

Key words: Growing rabbit, Adult weight, CT-based selection, Carcass traits.

Introduction – According to Dalle Zotte (2002), adult weight can influence rabbit carcass traits. Higher growing intensity but lower dressing out percentage can be observed in larger type rabbits because they have a lower degree of maturity at slaughter (Dalle Zotte and Ouhayoun, 1998). This is why the genotypes with lower adult weight show better dressing out percentage. Muscle volume on the mid part and on the hind legs can be improved by CT-based selection (Szendrő *et al.*, 2004, 2008; Nagy *et al.*, 2006). Selection for increasing the average cross-sectional area of M. *Longissimus dorsi* /MLD/ (L-value) and the muscle volume of hind leg was effective. The objective of the study was to evaluate the carcass traits of three genotypes with different adult weight that were partly targeted by CT-based selection for the carcass traits indicated above.

Materials and methods – The genotypes analysed (Maternal line/M/, Pannon White/P/ and Large body line/L/) were described by Szendrő *et al.* (2009, this issue). Rabbits were

242). Rabbits were weaned at the age of 5wk (n=96) and fed a commercial pellet *ad libitum*. At the age of 11wk all rabbits were slaughtered and dissected according to the WRSA proposal (Blasco and Ouhayoun, 1996). The right hind leg (HL) was also dissected to assess its meat/bone ratio (M/B). Carcass traits were evaluated by means of one-factor ANOVA using the SPSS 11.5 software package.

Results and conclusions – The results are summarized in Table 1.

Table 1. Effect of genotype on carcass traits.

Trait	Genotype			SE	P
	Maternal	Pannon	Large		
Rabbits, No.	24	31	30		
Live weight at slaughter, g	2477^{A}	2659^{B}	2921^{C}	30.1	<0.001
Warm carcass weight, g	1493^{A}	1629^{B}	1789^{C}	20.0	<0.001
Chilled carcass weight (CC), g	1468^{A}	1602^{B}	1757^{C}	20.0	<0.001
Reference carcass weight (RC), g	1214^{A}	1328^{B}	1460^{C}	16.8	<0.001
Dressing out percentage, % (warm carcass)	60.2^{A}	61.3^{B}	61.1^{AB}	0.17	0.031
Hind leg M/B	7.35	7.59	7.24	0.09	0.270
Ratio to chilled carcass, %					
Head	8.66^{B}	8.18^{A}	8.12^{A}	0.06	<0.001
Liver	4.96	5.29	4.78	0.09	0.056
Kidneys	1.32	1.28	1.33	0.02	0.584
Heart + lungs	1.42	1.38	1.46	0.02	0.420
Ratio to reference carcass, %					
Fore part (FP)	26.0^{A}	25.7^{A}	26.9^{B}	0.12	<0.001
Mid part (MP)	34.5	34.2	33.9	0.13	0.111
Hind part (HP)	37.3^{A}	38.2^{B}	37.2^{A}	0.11	<0.001
Perirenal fat (PFaP)	2.16	1.92	1.99	0.08	0.431

A,B=P<0.05.

Weight of carcass and other parts of the body (head, liver, kidneys, heart+lungs, parts of the carcass, HL and its bones /femur, tibia/) were linked with body weight at slaughter. The carcass traits obtained in this study were not in accordance with those reported by Hernández *et al*. (2006), who found that large-type rabbits were less mature when slaughtered at the same age, and therefore showed inferior dressing out percentage (DoP). In this study, the DoP of the P rabbits exceeded that of the M group (P<0.05), but L rabbits also showed favourable results. This can be explained by selecting the P and L rabbits (for 14 and 3 years, resp.) for their L-value (between 1993 and 2004, Nagy *et al.*, 2006; Szendrő *et al.*, 2004) and their thigh muscle volume (since 2004; Szendrő *et al.*, 2008). HP was highest for

P rabbits (P<0.001), which was also a result of CT-based selection but the same for M and L rabbits. FP was highest in the L group (P<0.001). No significant differences were found in MP. The differences between the carcass part ratios for L and P rabbits can be explained by the different duration of the CT-based selection. The differences in MLD/RC ratio among groups were significant only at P<0.10 level but the highest value in the P group could be the result of former selection (surface of MLD; Szendrő *et al.*, 2004). Ratio of head to CC was significantly higher for the M group compared to the P and L rabbits, resp. (P<0.001). No significant differences were detected for the liver, kidney, lungs and heart ratios, respectively. PFaP did not differ significantly among the genotypes, although the same tendencies observed in a previous study were obtained (Szendrő *et al.*, 2008): CT-based selected rabbits showed smaller fat depots. The length of femur and tibia and smallest-diameter of tibia were positively correlated with body weight at slaughter (P<0.001); the highest values were provided in Group L. M/B, percentage of femur and tibia to HL, and tibia length were independent of genotypes.

It can be concluded that contrarily to the data provided in literature, although slaughter performances were unaffected by the adult weight of the genotypes, the effect of CT-based selection was evident in rabbits of different genotypes slaughtered at the same age.

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COMMUNICATION

Effect of adult weight and CT-based selection on rabbit meat quality

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ABSTRACT - This study compared the meat quality of different genotypes. Maternal (M; adult weight/AW/=4.0-4.5kg; selected for the number of kits born alive), Pannon White (P; AW=4.3-4.8kg) and Large type (L; AW=4.8-5.4kg) rabbits were analysed. P and L genotypes were selected for carcass traits based on CT/Computer tomography/data. Rabbits were slaughtered at 11wk of age and hindleg (HL) meat and M. *Longissimus dorsi* (LD) were analysed for proximate composition and fatty acid (FA) profile. Proximate composition was unaffected by the selection programme, even though the meat of P rabbits was leaner and had higher ash content (P<0.10). The LD meat of P rabbits exhibited significantly lower MUFA contents compared to M and L rabbits (25.4 *vs* 28.0 *vs* 27.7%; P<0.01) and higher PUFA content compared to M rabbits (31.9 *vs* 24.9%; P<0.05). This study revealed that long-term CT-based selection is effective in increasing meat leanness and PUFA content.

Key Words: Rabbit, Adult weight, CT-based selection, Meat quality.

Introduction – Recent results have proven that carcass traits can be improved efficiently by Computer Tomography (CT)-based selection (Szendrő *et al*., 2004, 2008). The aim of this study was to assess the effectiveness of CT-based selection on the carcass traits and meat quality of two rabbit genotypes compared to a genotype selected for the number of kits born alive.

Material and methods - A detailed description of the experimental site, feeding, animals, and their management is provided by Szendrö *et al*. (2009). The analyzed genotypes are characterized as follows: M=Maternal line, selected for number of kits born alive, AW: 4-4.5kg; P=Pannon White: selected for weight gain and carcass traits by CT scans since 1993, AW: 4.3-4.8kg; L=Large body line: selected for weight gain and carcass traits by CT scans since 2003, AW: 4.8-5.4kg. At slaughter (11wk of age), the HL and LD were dissected on 15 rabbits per genotype, then pHu and L* a* b* colour measurements were performed on LD and M. *Biceps femoris* (BF). The proximate composition (AOAC, 1984) and FA profile were

Table 1. Effect of genotype on proximate composition of hind leg meat.

	Genotype			P	SE
	Maternal	Pannon	Large		
Rabbits, No.	15	15	15		
Water, %	73.1	73.6	73.2	0.146	0.11
Protein, %	22.3	22.0	21.9	0.082	0.07
Lipids, %	3.43	3.19	3.68	0.350	0.14
Ash, %	1.19	1.20	1.18	0.066	0.004

SE=standard error.

Table 2. Effect of genotype on proximate composition of M. *Longissimus dorsi*.

	Genotype			P	SE
	Maternal	Pannon	Large		
Rabbits, No.	15	15	15		
Water, %	73.4	74.3	73.7	0.117	0.17
Protein, %	23.3	23.5	23.3	0.619	0.08
Lipids, %	2.00	0.99	1.78	0.124	0.21
Ash, %	1.23	1.25	1.23	0.050	0.003

SE=standard error.

Table 3. Effect of genotype on the fatty acids (FA) composition of M. *Longissimus dorsi* (% total FA).

	Genotype			P	SE
	Maternal	Pannon	Large		
Rabbits, No.	15	14	14		
C10:0	0.31	0.29	0.30	0.275	0.007
C12:0	0.27^{b}	0.20^{a}	0.25^{b}	0.003	0.008
C14:0	2.20	1.95	2.08	0.115	0.05
C15:0	1.60	1.77	1.61	0.488	0.06
C16:0	26.8	25.0	26.5	0.174	0.42
C17:0	0.75	0.57	0.69	0.054	0.03
C18:0	7.33	6.96	7.35	0.352	0.12
C20:0	0.14	0.12	0.13	0.066	0.003
Saturated Fatty Acids (SFA)	42.1	39.2	40.3	0.101	0.57
C14:1	0.05	0.05	0.07	0.543	0.008
C16:1	2.12	2.00	2.15	0.759	0.08
C17:1	0.25	0.23	0.24	0.063	0.003
C18:1 n-7	1.98^{b}	1.74^{a}	1.90^{ab}	0.004	0.03
C18:1 n-9	21.4^{b}	18.7^{a}	20.7^{b}	0.002	0.34
C20:1 n-9	0.28	0.24	0.26	0.252	0.008
Monounsaturated Fatty Acids (MUFA)	28.0^{b}	25.4^{a}	27.7^{b}	0.003	0.36
C18:2 n-6	19.2^{a}	24.7^{b}	20.4^{a}	0.008	0.78
C18:3 n-3	1.37	1.67	1.56	0.152	0.06
C18:3 n-6	0.08	0.09	0.09	0.239	0.002
C20:2 n-6	0.28	0.30	029	0.406	0.005
C20:3 n-6	0.26^{a}	0.37^{b}	0.30^{ab}	0.014	0.02
C20:4 n-6	2.46^{a}	3.72^{b}	2.95^{ab}	0.006	0.17
C20:5 n-3	0.15	0.14	0.15	0.788	0.004
C22:5 n-3	0.44^{a}	0.59^{b}	0.48^{ab}	0.016	0.02
C22:6 n-3	0.11	0.12	0.11	0.155	0.002
Polyunsaturated Fatty Acids (PUFA)	24.9^{a}	31.9^{b}	27.8^{ab}	0.022	1.08
n-6	22.5^{a}	29.3^{b}	25.8^{ab}	0.016	0.99
n-3	2.00	2.54	2.23	0.092	0.10
n-6/n-3	11.2	10.9	11.5	0.411	0.18

$^{a, b}$: P<0.05; SE=standard error.

determined on HL and LD meat. FA results were expressed as a percentage (w/w) of total FA methyl esters. Meat quality traits were evaluated by means of one-factor ANOVA using the SPSS 11.5 software package.

Results and conclusions – The pHu and L*, a* colour values were similar among genotypes, whereas b* value (yellowness) was higher in P than M rabbits (-3.47 *vs* -4.89; P<0.01). Although the proximate composition of HL and LD meats was not significantly affected by CT-based selection (Tables 1 and 2), the LD meat of P-genotype rabbits (having been selected for carcass traits for a longer period of time) contained more water, protein, ash, and lower lipids than M and L genotypes.

The LD meat of P rabbits exhibited significantly lower MUFA contents compared to L and M rabbits (25.4 *vs* 27.7 *vs* 28.0%; P<0.01) due to lower C18:1 incidence (P<0.01), and higher PUFA content compared to M rabbits (31.9 *vs* 24.9%; P<0.05), due to higher values of C18:2n-6 and C20:4n-6 (P<0.01) (Table 3). Although the n-6/n-3 ratio did not differ among genotypes, a trend towards its lowering was observed in P compared to M and L genotypes (10.9 *vs* 11.2 *vs* 11.5, respectively). Hernàndez *et al*. (1998) did not observe differences in meat quality between lines or liveweight groups whenever a certain constancy was observed. Our study revealed that long-term CT-based selection is effective in increasing meat leanness and PUFA content. Certain other meat quality variables appear to be affected to lesser extent.

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COMMUNICATION

Minimum slicing interval and frequency for CT-based prediction of pig's body composition

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ABSTRACT - The aims of our study were to test the effect of CT scanning protocol on the fattening performance of pigs, and the necessary scanning interval to accurately estimate tissue volumes in the body of pigs. A total of 16 Large White type pigs were used in this study. Pigs were kept individually and in concrete floor pen and fed at the level of 3.0 times of the maintenance energy requirements. Eight pigs were scanned at 30, 40, 50, 60, 75, 90 and 105kg live weight, while another eight pigs were not scanned during the fattening period. The scanning was performed with Siemens Somatom Plus spiral computer tomograph from head to tail with 10mm slice thickness and 10mm distances between the images. In conclusion restrictedly fed pigs can be examined with CT several times without negative effect on growing performance, but in the fattening phase some reduction in feed conversion can be expected. For the accurate determination of tissue volumes scanning of every 5^{th} cm is sufficient in the 30-105 kg live weight range.

Key words: Computer tomography, Body composition, Pig.

Introduction - During the past decades researchers became more interested in using non invasive techniques, such as real time ultrasound, computer tomography and magnetic resonance imaging to estimate and follow the body composition of pigs (McEvoy *et al*., 2006, Mitchell *et al*., 2001). These techniques offer the possibility to investigate the animals several times during a certain period (Szabo *et al*., 1999). However, the examination of pigs needs transportation, anesthesia and prior fasting. This protocol, especially when applied several times may affect the performance of the animals. To estimate the body composition a series of images (scans) are taken along the body. Depending on the size of the body and scanning interval, this could result in a huge amount of data. To reduce the examination cost and time needed for image processing a reduction of scanning interval would be necessary. However, it is unclear that how many scan would result the sufficient accuracy in volumetric estimation. Therefore our aims were to test the effect of scanning protocol on the fattening performance of pigs, and the necessary scanning interval to accurately estimate tissue volumes in the body of pigs.

Material and methods - A total of 16 Large White type pigs (30.8±2.58kg) (8 barrows and 8 gilts) were used in this trial. The pigs were housed individually in a concrete floor

pen with free access to nipple waterer. Animals were fed with a barley, wheat, tapioca and soybean meal based experimental diet. The diet had 14.6MJ/kg DE, 0.43g ileal digestible Lys/DE ratio for the first phase (30-60kg) and 14.6MJ/kg DE, and 0.36g ileal digestible Lys/DE ratio for the second phase (60-105kg). Daily feed allowance was 3.0 times of maintenance energy requirements (0.42MJ ME/kg0.75). The animals were weighed weekly and the feed amount to be offered was calculated for the next week. The pigs were fed twice a daily at 8.00 and 15.30. Randomly selected four gilts and four barrows out of the 16 pigs were CT scanned at 30, 40, 50, 60, 75, 90 and 105kg live weight. The other eight pigs were not scanned. The scanning was performed with Siemens Somatom Plus spiral computer tomograph from head to tail with 10mm slice thickness and 10mm distances between the images. The total fatty tissue and muscle area were calculated for each cross sectional image. Tissue volumes were calculated by summing up the tissue areas and the distance between the images and expressed in cm^3. Data were analyzed by SAS (SAS Inst. Inc., Cary, NC) GLM procedure. Due to health problems (not related to the trial) two animal from the scanned group, and one animal from the other group had to be excluded from the trial.

Results and conclusions - The daily gains were similar for both scanned and not scanned groups of animals over the fattening period (Table 1). However in case of feed conversion ratio we found lower value for the scanned group in the fattening period. Our data demonstrate that scanning pigs several times may affect the performance. It should also be noted that restricted feeding was applied in the present trial, as a part of a larger nutritional study (Szabo *et al.*, 2001). Animals with *ad libitum* feeding may develop larger difference in performance.

Table 1. The effect of CT scanning on fattening performance between 30-60kg.

	Average daily gain, g			Feed conversion ratio, kg/kg		
	30-60kg	60-105kg	30-105kg	30-60kg	60-105kg	30-105kg
Scanned pigs[a]	530	740	635	2.7	3.6[b]	3.2[b]
Not scanned pigs	545	725	638	2.7	3.2[c]	3.0[c]

[a]pigs were scanned at 30, 40, 50, 60, 75, 90 and 105 kg live weight; b,cmeans in column lacking a common superscript differ significantly (P<0.05).

Thompson and Kinghorn (1992) suggests that 20 to 25 scans of the whole body needed to accurately separate the body fat into carcass and non carcass depots in case of sheep. Our results show that this approach may not give accurate measurement of tissue volumes (Table 2). Regardless of body weight (length) the absolute deviations from the volume determined using all images significantly different when every 6th scan used. The only exception is the deviation of muscle volume at 105kg live weight, where the deviation significantly differs when every 8th scan is used. But the deviation greatly increase between the 4th and 5th scan. Calculating with the average number of scans in each live weight category and assuming to use every 5th scan a total of 24, 31 and 34 scan needed for determining the tissue volume of a 30, 60 and 105kg live weight pigs, respectively. These results suggest that a similar scanning interval exist for various live weights of pigs.

Table 2. Absolute deviations of muscle and fatty tissue volume in pigs body from the volume determined using all the scans.

	Muscle volume deviations (1000 cm^3)										
scans used[a]	all	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
30 kg LW	0	0.03[b]	0.05[b]	0.06[b]	0.11[b]	0.12[c]	0.17[c]	0.16[c]	0.34[c]	0.18[c]	0.31[c]
60 kg LW	0	0.03[b]	0.06[b]	0.10[b]	0.13[b]	0.21[c]	0.25[c]	0.30[c]	0.39[c]	0.28[c]	0.34[c]
105 kg LW	0	0.03[b]	0.08[b]	0.10[b]	0.23[b]	0.19[b]	0.30[b]	0.52[c]	0.75[c]	0.76[c]	0.52[c]
	Fatty tissue volume deviations (1000 cm^3)										
scans used[a]	all	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
30 kg LW	0	0.01[b]	0.02[b]	0.03[b]	0.04[b]	0.06[c]	0.08[c]	0.09[c]	0.05[c]	0.09[c]	0.13[c]
60 kg LW	0	0.02[b]	0.04[b]	0.06[b]	0.06[b]	0.15[c]	0.23[c]	0.18[c]	0.21[c]	0.19[c]	0.14[c]
105 kg LW	0	0.04[b]	0.07[b]	0.11[b]	0.14[b]	0.26[c]	0.32[c]	0.35[c]	0.44[c]	0.52[c]	0.67[c]

[a]the slice thickness of scans was 10mm; [b]deviation not significantly different from zero (P>0.05); [c]deviation significantly different from zero (P<0.05).

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COMMUNICATION

Carcass leanness of pigs in Croatia estimated by EU referent method

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ABSTRACT - The experiment was performed on 146 swine carcasses slaughtered at several Croatian slaughterhouses, selected according to backfat measures obtained by method for lean percentage prediction approved in Croatia (NN 40/2007). One day after slaughter left sides of the carcasses were dissected according to EU reference method (Commission Regulation No 3127/94, Walstra and Merkus, 1996). The dissected lean percentage was assessed using the formulae prescribed in EU Regulation from 1994 (Commission Regulation (EC) No 3127/94) and 2006 (Commission Regulation (EC) No 1197/2006). There were statistically significant differences between the lean shares estimated by Croatian prediction routine and assessed by both previous and current European regulation ($p<0.01$). When pig carcasses were classified by SEUROP system based on the lean percentage established by three mentioned methods, the distribution into quality classes was markedly different. It was concluded that because of substantial difference between the procedures for estimation of dissected lean percentage (51.00 *vs* 56.32%) further investigations on that matter are suggested. Croatian lean meat prediction equation significantly differed from dissected lean expressed by both European assessment methods and needs to be adjusted.

Key words: Pig, Carcass, Lean percentage, Assessment.

Introduction - The knowledge about pig leanness is crucial in the trade of the pig carcasses since it makes the basis for market classification. Due to the differences in slaughtering characteristics between pig populations, the caution should be taken in the estimation of carcass leanness, especially in international trading (Evans and Kempster, 1979; Engel and Walstra, 1993; Daumas and Dhorne, 1997). In order to objectively estimate the leanness of certain pig population, "EU reference method" of dissection was introduced in 1994 (EC No 3127/94). Nissen *et al.* (2005) tested the accuracy of EU referent method on 128 pig carcasses sampled in four countries and showed that EU referent method was fairly accurate. However, the procedure for calculation of estimated total lean percentage on the basis of EU referent method was changed in 2006 (EC No 1197/2006) in the way that scaling factor was altered from 1.3 to 0.89 and the lean meat from four cuts is related to the weight of four cuts with tenderloin, instead to the total weight of the carcass. The change in the procedure of calculation could alter of lean percentage significantly. Hence, the aim of this paper is to determine if there were any changes

in dissectional meatiness calculated by previous and current EU legislation and to compare it with currently valid method of meatiness estimation in Croatia.

Material and methods - Research was performed on 146 swine carcasses selected in accordance with backfat measures obtained by "two points"- method (TP), approved in Croatia (NN 40/2007). Measures for TP-method are: lumbar muscle thickness- M (mm); measured as the shortest connection between the cranial end of the lumbar muscle and dorsal edge of the vertebral canal, and fat thickness - F (mm), measured as the minimum thickness of subcutaneous fat (with skin) at the split of the carcass, above M. *Gluteus medius.* One day after slaughter left sides of the carcasses were dissected using an EU referent method. Ham, shoulder, loin and ribs were dissected into muscles, bones, intramuscular and subcutaneous fat with skin. The tenderloin was taken into calculation as a separate part. The reference lean meat percentage was calculated by two equations: the first one (EU_1) was prescribed by EC No 3127/1994 and the second one (EU_2) is currently valid as prescribed by No 1197/2006. Lean percentage in pig carcasses was also predicted by equation for "two points" (TP) - method currently prescribed in Croatia. Results of carcass lean determination by EU-referent methods from 1994 and 2006 and predicted by TP equation were compared by GLM procedure of Statistica (7.1) for Windows Software (StatSoft Inc., 1984-2006).

Results and conclusions - Measures relevant for the estimation of lean percentage in pig carcasses collected at the slaughter line are presented in Table 1.

On the basis of backfat and muscle thickness measured for the TP method, using the equation prescribed in Croatia, lean meat percentage was predicted. Table 2 shows lean percentage predicted by TP method together with results of dissection by EU-reference method expressed by EU_1 and EU_2 formula. It can be observed that statistically significant differences ($P<0.01$) between them exist. This suggests that equation for meat yield estimation from Croatian regulation needs to be corrected. Comparison of the dissected meat share determined by previous (EU_1) and current (EU_2) European regulation showed surprisingly large differences (51.00 *vs* 56.32%), hence further investigations on that matter are suggested.

Table 1. Measures taken at the slaughter line for the purpose of lean percentage estimation.

Measure	Mean	Min.	Max.	Std.dev.
Cold carcass weight, kg	39.70	25.49	56.46	57.59
Backfat thickness (TP), mm	16.30	4.00	45.00	7.35
Muscle thickness (TP), mm	68.35	50.00	81.00	6.53

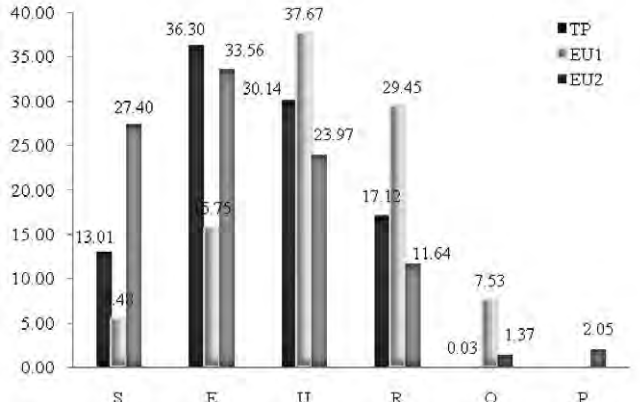
Table 2. Lean meat percentage of pig carcasses calculated by three investigated formulae (N=146).

	EU_1	EU_2	TP
Mean	51.00[c]	56.32[a]	54.35[b]
Std. dev.	6.39	6.41	5.34
Std Err.	0.53	0.53	

[a,b,c]: Row means with common superscripts do not differ (P>0.05).

On the figure 1, distribution of pig carcasses into market classes according to SEUROP system is shown. It can be observed that EU_2 formula for lean meat percentage has classified 27.40% of pig carcasses into the "S" group, whilst the

Figure 1. Relative distribution (%) of the pig carcasses into SEUROP quality classes (N=146).



EU_2 and prediction formulae have classified only 5.48 and 13.01% of pig carcasses into the same market class. It can also be observed that EU_1 and TP formulae have not classified any of the pig carcasses into market groups with lowest lean share (group "O" and "P"), while the EU_2 formula for referent meatiness have classified into the same groups 1.37% and 2.05% of pig carcasses, respectively.

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COMMUNICATION

Carcass quality of crossbred pigs with Pietrain as a terminal sire

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ABSTRACT - The aim of this paper was to investigate the effect of the crossbreed and halothane genotype on carcass quality traits of fatteners from commercial pig farm. Study was carried out on 68 crossbred pigs divided into two groups according to sow genotype: Large White♂x Swedish Landrace♀ (LWxSL) and Large White♂ x German Landrace♀ x (LWxGL). Both sow genotypes were mated with Pietrain (P) as a terminal sire. Influence of crossbreeding and halothane genotype on cold carcass weight, carcass length, dressing percentage and lean percentage, slaughter line measurements as well as fat and M. *Longissimus dorsi* areas were not significant (P>0.05). The value of pH_{45} measured in M. *Longissimus dorsi* was higher in Px(LWxGL) crossbreeds and dominant homozygote genotype (P<0.05). Measurements of pH_{24} were not significantly different (P>0.05) between crossbreeds and halothane genotypes. Except for pH_{45} value, most of other measured carcass quality traits were not affected by crossbreeding combination and halothane genotype (P<0.05).

Key words: Pigs, Carcass quality, Crossbreeds, Halothane genotype.

Introduction – To produce a superior and economically efficient slaughter generation of pigs, it is important to meet the requirements of commercial pig producers, pork processors and consumers. The Pietrain breed is known for its high percentage of lean meat, and therefore it is most commonly found in crossbreeds as a terminal sire line in Croatian large scale farms (Kušec *et al*., 2004). Some studies indicate that carriers of halothane gene in its heterozygous form do have certain advantages in terms of carcass quality, such as greater carcass yield and lean meat content, compared to halothane free pigs (Leach *et al*., 1996). On the other hand, there is a problem of porcine stress syndrome and poor quality of pork (Kallweit *et al*., 2007). The aim of this study was to investigate the effect of the crossbreed and halothane genotype on carcass quality traits of fattening pigs from commercial pig farm.

Material and methods - This study was performed on 68 crossbred pigs divided into two groups according to sow genotype: Large White♂ x Swedish Landrace♀ (LWxSL) and Large White♂ x German Landrace♀ (LWxGL). Both sow genotypes were mated with Pietrain (P) as a terminal sire. Pigs were housed individually from 30 to 100±2kg of live

weight in test station in two seasons. The first season lasted from January to May, and the second one from August to December. Both genotypes were balanced by gender (gilts and castrates). At the end of testing, the fatteners were slaughtered in slaughterhouse near the test station using standard procedure (fasting, two hours resting, electrically stunned). The blood samples were taken on the slaughter line and used for DNA test (Fujii *et al*., 1991). At the slaughter line the measurements of backfat thickness (S) and depth of M. *Longissimus dorsi* (M) were taken, and lean meat percentage was calculated according to Croatian official procedure (NN 2/09). After slaughter (45 minutes *post mortem*) pH_{45} in M. *Longissimus dorsi* (MLD) between the 13th and the 14th rib was measured. One day after slaughter cold carcass weight and the pH_{24} were measured. The length of the carcass was measured from *os pubis* to the 1st rib (A) and from *os pubis* to *atlas* (B). Dressing percentage was calculated as the percentage of cold carcass weight related to live weight. Backfat and MLD areas (cm^2) taken at cross section between the 13th and the 14th rib were measured by planimeter and expressed as the fat/MLD area ratio. Effects of crossbreed and halothane genotype were analyzed using the GLM procedure (SAS, 2004). Statistical model included following fixed effects: crossbreeds, halothane genotype, gender, and season of the testing. Differences between levels were estimated as significant if $P<0.05$.

Results and conclusions - Preliminary analysis showed no significant interaction ($P>0.05$) between crossbreeds and halothane genotype for all variables observed, and therefore it was eliminated from statistical model. Cold carcass weight, dressing percentage and lean percentage were not different between crossbreeds (Table 1). Carcass lengths (A and B) were not affected by genotype, although our values for (Px(LWxSL)) genotype at the similar final weight where considerable shorter than in study of Kušec *et al*. (2004). Slaughter line measurements (S and M), as well as MLD and fat areas were not differed between crossbreeds. The measurements of MLD and fat area in our study were similar as in study from Kušec *et al*. (2004) for (Px(LWxSL)) pigs. The value of pH_{45} measured in MLD was significantly higher in (Px(LWxGL)) pigs than in (Px(LWxSL)) pigs, but value of pH_{24} was not differed between crossbreeds. According to halothane genotype, for all traits there was no significant difference between dominant homozygote pigs (NN) and heterozygote genotypes (Nn), except for pH_{45} measured in MLD ($P<0.05$). Contrary to results of Fisher *et al*. (2000) there was no difference between observed halothane genotypes regarding to dressing percentage. Heterozygote genotype had lower value for pH_{45} in relation to NN genotype. The value of pH_{45} close to threshold value for PSE meat ($pH<5.8$) suggested that heterozygote tend to produce poorer meat quality. Our results were in line with study from Garcia-Macis *et al.* (1996) which confirmed that heterozygote pigs produced more PSE meat than the NN pigs. On the other hand later authors did not find significant effect of crossbreed on meat quality measurements determining PSE meat as in our case. Although there were no significant difference beetwen the halothane genotype in fat/MLD area, fat area found in Nn pigs in relation to NN genotype was slightly smaller ($P=0.12$). Generally, most of the carcass quality traits were not affected by crossbreed and halothane genotype, except for pH_{45} measured in MLD ($P<0.05$).

Table 1. Effect of crossbreed and halothane genotype on carcass quality in pigs (LSMEAN ±SE).

Trait	Crossbreed (C)[1]		Halothane genotype (H)		P-value	
	Px(LWxSL)	Px(LWxGL)	NN	Nn	C	H
Number of pigs	33	35	29	39		
Cold carcass weight, kg	78.72±0.61	80.10±0.65	78.97±0.69	78.96±0.56	0.13	0.32
Dressing percentage,%	77.84±0.55	79.28±0.59	78.07±0.62	79.04±0.51	0.08	0.23
Lean percentage, %	54.17±0.65	53.15±0.69	53.26±0.72	54.06±0.59	0.28	0.39
Carcass length (A), cm	80.39±0.41	81.05±0.44	81.04±0.46	80.40±0.38	0.28	0.29
Carcass length (B), cm	96.02±0.52	96.29±0.55	96.60±0.58	95.71±0.47	0.72	0.23
Fat thickness (S), mm	15.83±0.78	16.83±0.83	16.83±0.87	15.83±0.72	0.38	0.37
Muscle depth (M), mm	66.94±0.71	66.31±0.75	66.35±0.79	66.91±0.65	0.54	0.58
Fat area, cm^2	18.66±0.76	18.45±0.81	19.41±0.85	17.70±0.70	0.84	0.12
MLD area, cm^2	45.26±0.94	46.06±1.00	45.17±1.05	46.14±0.86	0.56	0.47
Fat/MLD area ratio	0.41±0.02	0.40±0.02	0.43±0.02	0.39±0.02	0.66	0.23
pH_{45}MLD	5.93±0.04	6.08±0.04	6.13±0.04	5.88±0.03	0.02	0.01
pH_{24}MLD	5.46±0.03	5.44±0.03	5.45±0.03	5.44±0.03	0.67	0.92

[1]*SL=Swedish Landrace, GL=German Landrace, LW=Large White, P=Pietrain.*

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COMMUNICATION

Effect of breed and rearing system on intramuscular fatty acid profile of M. *Semimembranosus* in raw Slavonian ham

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ABSTRACT - The effects of breed and rearing system on fatty acid (FA) profile of M. *Semimembranosus* in raw Slavonian ham were evaluated. Forty pigs were grouped by breed (Black Slavonian (BS) vs. Black Slavonian x Duroc (BSxD)) and by rearing system (outdoor vs. indoor), 10 pigs per group. All of the saturated FA (SFA) and monounsaturated FA (MUFA) significantly affected by genotype showed smaller values in the intramuscular fat of BS than of BSxD pigs. The percentage of polyunsaturated FA (PUFA) was higher in BS pigs than BSxD pigs. The PUFA/SFA and n-6/n-3 ratios were more favourable in BS pigs. Within SFA and MUFA, only C16:1 and C18:0 were affected by rearing system. On the other hand, rearing system influenced most of the PUFA, but without clear effect on PUFA/SFA and n-6/n-3 ratios.

Key words: Pigs, Fatty acid profile, Breed, Rearing system.

Introduction - Black Slavonian (BS) pig is an autochthonous Croatian breed kept in the past in the outdoors and fed on pastures and oak woodlands (Karolyi *et al*., 2008). At the end of the 20th century breed was critically endangered, but after the recent state protection the population of BS pigs increased. In the last few years there have been around 600 sows. Today's, pigs are kept in different ways, from fully outdoor to completely intensive system. Due to lower growth rates, the BS breed has been also crossed with modern breeds (Luković *et al*., 2007). The BS pigs and their crossbreeds are used for production of local meat products, such as Slavonian ham and kulen. Fatty acid (FA) profile of muscle tissues, as one of the most important attribute of meat quality, is influenced by many effects, such as genotype (Nürnberg *et al*., 1998; Wood *et al*., 2008) and rearing system (Hansen *et al*., 2006). The aim of the paper was to analyze the effects of breed and rearing system on FA profile of intramuscular fat from M. *Semimembranosus* in raw Slavonian ham.

Material and methods - Forty BS and BS x Duroc (BSxD) pigs were fattened under two different rearing systems: indoor and outdoor. There were 10 pigs per breed x rearing system

group, balanced by sex. In the indoor system pigs were fed with conventional diets; from 30 to 100kg (13MJ ME/kg, 16% of crude protein), and from 100 to 135kg (13 MJ ME/kg, 14% of crude protein). Outdoor pigs were fed on wood pasture and alfalfa with addition of approx. 1kg corn per animal/d. Indoor pigs were housed in group of the 10pigs/pen, on straw bedded concrete floor. Outdoor pigs were fattened from March to November 2006 in an area of approx. 20ha. All pigs were transported and slaughtered using standard procedure (electrically stunned, 1.5A, 220V). One day after slaughter, samples of M. *Semimembranosus* (approx. 150g) were taken from raw hams, and stored frozen until the analysis. Fatty acid profile of intramuscular fat was determined by gas chromatography using Chrompack CP 9000 (Csapo *et al*., 1986). The percentage of FA was expressed as a percentage of total FA methyl esters. The results were obtained with two-way analysis of variance by the ANOVA procedure (SAS, 2004) using a model including the fixed effects of genotype, rearing system and their interaction.

Results and conclusions - Breed influenced the FA composition of the intramuscular fat in M. *Semimembranosus* (Table 1).

Table 1. Effect of the breed (B) and rearing system (R) on fatty acid composition of intramuscular fat (M. Semimembranosus) in raw Slavonian ham (mean ±SD).

Fatty acid	Outdoor		Indoor		P value		
	BS	BSxD	BS	BSxD	B	R	BxR
C12:0	0.06±0.01	0.08±0.01	0.06±0.01	0.07±0.01	**	ns	0.15
C14:0	1.22±0.10	1.54±0.19	1.27±0.09	1.41±0.13	**	ns	0.13
C15:0	0.04±0.01	0.04±0.01	0.04±0.01	0.05±0.03	ns	ns	0.39
C16:0	23.41±0.82	26.33±1.16	23.88±0.39	24.98±1.14	***	ns	0.04
C16:1	2.73±0.46	3.51±0.54	1.92±0.27	2.31±0.26	**	***	0.28
C17:0	0.37±0.12	0.33±0.08	0.36±0.04	0.45±0.19	ns	ns	0.24
C17:1	0.30±0.08	0.31±0.08	0.30±0.04	0.40±0.17	ns	ns	0.31
C18:0	12.19±0.97	13.21±0.32	13.68±1.17	13.31±0.57	ns	*	0.08
C18:1	48.01±0.75	46.55±1.72	46.55±1.19	46.6±2.78	ns	ns	0.34
C18:2n-6	8.29±1.33	5.51±0.37	9.17±1.02	7.84±1.80	**	*	0.21
C18:3n-3	0.49±0.21	0.17±0.02	0.38±0.03	0.27±0.06	***	ns	0.05
CLA	0.14±0.02	0.09±0.02	0.17±0.05	0.22±0.13	ns	*	0.11
C20:1	1.03±0.12	0.83±0.15	1.09±0.13	1.05±0.27	ns	ns	0.30
C20:2	0.41±0.09	0.22±0.02	0.53±0.05	0.44±0.06	***	***	0.09
C20:3n-6	0.15±0.03	0.13±0.02	0.08±0.01	0.07±0.01	ns	***	0.31
C20:4n-6	0.43±0.06	0.46±0.15	0.17±0.03	0.16±0.05	ns	***	0.59
C22:5n-3	0.07±0.03	0.04±0.01	0.03±0.02	0.02±0.02	*	**	0.37
C23:0	0.10±0.03	0.03±0.01	0.09±0.01	0.06±0.02	***	ns	0.07
SFA	37.47±1.18	41.67±1.38	39.44±1.00	40.41±1.73	***	ns	0.01
MUFA	52.09±0.97	51.21±1.27	49.88±1.38	50.40±2.74	ns	ns	0.37
PUFA	9.86±1.63	6.55±0.54	10.37±1.14	8.81±1.93	**	*	0.18
PUFA/SFA	0.26±0.05	0.15±0.02	0.26±0.03	0.21±0.05	***	ns	0.09
n-6/n-3	16.77±3.67	28.26±2.82	22.81±1.46	27.83±4.59	***	ns	0.05

**P<0.05; **P<0.01, ***P<0.001, ns=not significant, BS=Black Slavonian, D=Duroc.*

All of the saturated FA (SFA) and monounsaturated FA (MUFA) affected by breed (C12:0, C14:0, C16:0, and C16:1) showed smaller values in the intramuscular fat of BS than of BSxD pigs. Intramuscular fat of BS pigs had a higher percentage of polyunsaturated FA (PUFA) than those of BSxD pigs. Furthermore, PUFA/SFA and n-6/n-3 ratios were more favourable for BS pigs. In the group of SFA and MUFA, only C16:1 and C18:0 were affected by rearing system. On the other hand, rearing system influenced most of the PUFA, but without clear effect on PUFA/SFA and n-6/n-3 ratios. The results obtained indicate higher importance of breed than rearing system effect, especially regarding to total PUFA amount and n-6/n-3 ratio.

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COMMUNICATION

Effect of genotype, sex and slaughter weight on veal *Longissimus* muscle area measured by ultrasound and planimeter

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ABSTRACT - The aim of this research was to determine effect of genotype (Holstein, Simmental and their crossbreeds), sex and slaughter weight groups (SW1=150-160kg and SW2=190-200kg) on veal *Longissimus* muscle area (LMA). Between the12th and the13th rib, two ultrasound LMA (ULMA) images were taken from each animal and carcass LMA (CLMA) traced on transparent foil was measured by planimeter. For both measures, Simmental calves had larger LMA than Holstein ($P<0.001$) and crossbreeds ($P<0.05$). Male and female calves did not differ significantly in ULMA and CLMA. Calves of SW2 group had larger LMA ($P<0.0001$) than SW1 group. High correlation coefficient between ULMA and CLMA was determined in this research. Veal LMA was significantly affected by genotype and slaughter weight. According to high correlation coefficients, ultrasound can be useful in estimating carcass traits of cattle at early age.

Key words: Veal, *Longissimus* muscle area, Ultrasound.

Introduction – As an objective non-invasive method for estimation of beef carcass composition, growth, fat and muscle accretion (Williams, 2002), ultrasound can be used for same purpose in veal calves. Moser *et al.* (1997) concluded that yearling ultrasound measurements of breeding cattle could be useful in predicting breeding values for carcass traits. The most common estimator of total carcass muscle is *Longissimus* muscle area (LMA) measured at a point between the 12th and 13th rib (Williams, 2002). Correlation estimates between ultrasound LMA (ULMA) and actual carcass LMA (CLMA) are variable, ranging from 0.43 (Smith *et al*., 1992) to 0.85 - 0.95 (Waldner *et al.*, 1992; Perkins *et al.*, 1997). For veal production in Croatia are reared Simmental, Holstein calves and their crossbreeds. Although consumers prefer Simmental veal, increasing number of Holstein cows resulted in higher number of Holstein calves for veal production. Producers favour male calves fattened to higher slaughter weights better then female one slaughtered at lower weight. The aim of this study was to determine effect of genotype, sex and different slaughter weight

on veal LMA and correlations between ULMA, CLMA, carcass length (CL) and hot carcass weight (HCW).

Material and methods – Research included 80 calves of three genotypes (30 Holstein, 24 Simmental, 26 crossbreeds Simmental x Holstein). Both sexes were equally represented for all three genotypes. Calves were reared under identical feeding and handling conditions on the one farm. Calves of each investigated genotype were equally divided into two slaughter weight groups (150-160kg=SW1 and 190-200kg=SW2). Day before slaughter, LMA was measured using Aquila Vet (Pie Med.) meat probe placed between 12th and 13th rib on the right side of the body. The ultrasound probe was placed parallel to the 12th and 13th rib bone and toward the midline and moved laterally from the back bone until the complete *Longissimus* muscle came into full view on the screen. This site was chosen because it is easily determined by physical palpation and was used in previous researches on this topic in older cattle category. Two ultrasound images were taken for each animal. Hot carcass weight was measured immediately after slaughter. Carcass length measured by meter on the right half from the anterior edge of symphysis pubis to the anterior edge of the first rib. After cooling for 24 hours at 4°C, CLMA was traced on transparent foil at a point between 12th and 13th rib and measured later with planimeter Robotron (Reiss Precision). Data were analyzed by the GLM and CORR procedure of SAS (2001). Statistical model used for the overall data was as follows:

$y_{ijkl}=\mu+G_i+S_j+SW_k+e_{ijkl}$

where:

y_{ijkl}=predicted LMA

μ=overall mean

G_i=fixed effect of the genotype (i=1,2,3)

S_j=fixed effect of the sex (k=1,2)

SW_k=fixed effect of the slaughter weight (j=1,2)

e_{ijkl}=residual error

Results and conclusions – *Longissimus* muscle area of Simmental calves differed from Holstein and crossbreeds at a level P<0.05 for ULMA and CLMA (Table 1). In the previous work Beauchemin *et al.* (1990) reported similar results for Holstein CLMA area.

Table 1. Effect of genotype on veal LMA (LSM±SE)

LMA (cm^2)	Genotype		
	Holstein	Simmental	Crossbreeds
ULMA	32,50±0,82[a]	36,74±0,95[b]	33,55±0,90[a]
CLMA	35,58±0,86[a]	41,25±1,18[b]	36,99±1,01[a]

[a, b]: values marked with a different superscript within a row differ significantly at P<0.05.

Ultrasound and carcass LMA were not differed between male and female calves. As expected, SW1 group had lower ULMA and CLMA (P<0.0001) than SW2 group (Table 2). Cerdano *et al.* (2006) reported enlargement of calves LMA area at higher slaughter weights.

Correlation estimates between ULMA and CLMA were 0.93, which is similar to results reported by Waldner *et al.* (1992) and Perkins *et al.* (1997) in steers.

Table 2. Effect of sex and slaughter weight on veal LMA (LSM±SE).

LMA	Sex		Slaughter weight (kg)	
(cm^2)	Male	Female	SW1	SW2
ULMA	37.56±0.91	37.20±0.88	31.64±0.71[a]	34.02±0.88[b]
CLMA	34.12±0.74	33.99±0.81	36.14±0.66[a]	39.44±0.69[b]

[a, b]values marked with a different superscript within a row differ significantly at P<0.0001.

Lower but still significant correlation coefficient was found between ULMA and two other carcass measurements (HCW and CL) (Table 3).

Table 3. Correlation coefficients among ultrasound and carcass measurements.

Variable	CLMA	HCW	CL
ULMA	0.93***	0.55***	0.26*
CLMA	-	0.59***	0.29*
HCW	0.59***	-	0.65***

****P<0.0001, *P<0.05.*

Ultrasound and carcass LMA correlation coefficient for Simmental calves were 0.95, Holstein 0.92 and crossbreeds 0.88. Male calves had higher correlation coefficient then female (0.95; 0.92). Calves of SW2 group had higher correlation coefficient (0.93) then SW1 group (0.90). The results of this study showed significant effect of genotype and slaughter weight on veal LMA. High correlation coefficients between ULMA and CLMA are good indicator for future use of ultrasound in predicting breeding values for LMA and some other carcass traits on calves.

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COMMUNICATION

Veal fatty acid composition of different breeds

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ABSTRACT - Veal fatty acid composition in M. *Longissimus thoracis* was investigated in different calf breeds (Simmental, Holstein, Simmental x Holstein). Calves were reared on the same farm under identical feeding and handling conditions. Simmental calves had higher polyunsaturated fatty acid (PUFA) but lower saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) values than Holstein and crossbreed calves (P<0,05). The PUFA/SFA ratio was the highest in Simmental calves and the lowest in Holstein calves. Simmental calves also had the highest n-6/n-3 ratio while the crossbreed calves had the lowest n-6/n-3 ratio.

Key words: Genotype, Veal, Fatty acid.

Introduction – In many industrialized countries, meat is the main source of saturated fats in human diet. However, saturated fatty acids (SFA) are main cause of coronary heart diseases, higher blood cholesterol and various types of cancers (Wood *et al.*, 2003). On other hand, meat is also source of "good" polyunsaturated fatty acids (PUFA) that do not have negative implications on human health. Moreover, some of PUFA (conjugated linoleic and arachidonic acid) have property to promote and benefit human health (Williams, 2000). Ruminant meats contain high levels of PUFA that are metabolic by-products of rumen bio-hydrogenation (Wood *et al.*, 2003; Williams, 2000). Veal regarding other ruminant meats (beef and lamb) has higher level of PUFA and lower level of SFA, respectively (Leth *et al.*, 1998). Majority of veal in Croatia is produced from Simmental calves fed with milk. During the last few decades, as result of increased number of Holstein cows in milk production, significant number of Holstein calves was introduced for veal production. The aim of this research was to investigate effect of the most common calf breeds on veal fatty acid composition.

Material and methods – In commercial veal farm twenty-four (3*8) Holstein, Simmental and Simmental x Holstein calves were housed in individual boxes (0.81 x 1.29m) during adaptation period (50±7 days). After adaptation period calves were housed in group pens 3 x 3m (5 calves per pen). Average diet during fattening period consisted of milk replacer (1850g), grower concentrate (1500g) and ground wheat straw (250g). Average slaughter age of calves was 140±7 days. *L. thoracis* samples (ca. 100g) were taken between 12th and 13th

Table 1. Veal fatty acid composition (% of fatty acids) in M. *L. thoracis* from different cattle breeds (Mean ±SD) (n=24).

fatty acids	Holstein	Simmental	Simmental x Holstein	Significance level
10:0	0.05±0.0^{a}	0.03±0.0^{b}	0.04±0.0^{a}	*
12:0	0.73±0.3	0.51±0.2	0.53±0.2	ns
14:0	4.79±0.9^{a}	3.75±0.6^{b}	3.83±0.6^{b}	*
14:1	0.60±0.2^{a}	0.42±0.1^{b}	0.60±0.1^{a}	*
15:0	0.23±0.0	0.27±0.2	0.27±0.0	ns
16:0	25.35±1.0^{a}	23.71±0.9^{b}	25.11±0.5^{a}	**
16:1	2.45±0.5	2.15±0.5	2.34±0.3	ns
17:0	0.47±0.1	0.53±0.2	0.65±0.3	ns
18:0	11.17±0.8	11.79±1.8	11.75±2.0	ns
18:1 n-9t	1.99±0.8^{ab}	1.70±0.6^{a}	3.68±2.6^{b}	*
18:1 n-9c	34.34±2.8^{a}	31.39±2.1^{ab}	29.37±3.0b	*
18:2 n-6	11.06±1.7^{a}	14.45±2.0^{b}	13.08±3.0^{ab}	*
18:2 c9. t11	0.12±0.0	0.15±0.0	0.129±0.0	ns
18:3 n-3	0.21±0.0^{a}	0.22±0.0^{a}	0.26±0.0^{b}	**
18:3 n-6	0.09±0.0	0.10±0.0	0.10±0.0	ns
20:1	0.23±0.0	0.21±0.0	0.23±0.0	ns
20:2	0.11±0.0^{a}	0.13±0.0^{b}	0.15±0.0^{b}	*
20:3 n-3	0.10±0.0	0.11±0.0	0.12±0.0	ns
20:3 n-6	0.78±0.2^{a}	1.12±0.2^{b}	0.94±0.2^{ab}	*
20:4 n-6	3.02±1.2^{a}	4.21±0.7^{b}	3.76±1.0^{ab}	*
20:5 n-3	0.12±0.1^{a}	0.16±0.0^{ab}	0.19±0.0^{b}	*
22:0	0.11±0.0^{a}	0.16±0.0^{b}	0.16±0.0^{b}	***
22:5 n-3	0.34±0.2	0.45±0.1	0.49±0.2	ns
22:6 n-3	0.10±0.0	0.11±0.0	0.13±0.1	ns
24:0	0.12±0.0^{a}	0.18±0.0^{b}	0.17±0.0^{b}	*
24:1	0.139±0.0^{a}	0.20±0.0^{b}	0.18±0.0^{ab}	*
SFA	43.01±1.7^{a}	40.92±1,1^{b}	42.51±2.0^{ab}	*
MUFA	39.74±3.5^{a}	36.07±2.4^{b}	36.38±2.7^{ab}	*
PUFA	16.02±.3.3^{a}	21.2±2.8^{b}	19.34±4.0^{ab}	*
UIFA	1.24±0.2^{a}	1.80±0.4^{b}	1.79±0.2^{b}	**
PUFA/SFA	0.37±0.1^{a}	0.52±0.0^{b}	0.46±0.1^{ab}	**
n-6/n-3	18.71±2.9^{ab}	19.37±2.0^{a}	15.62±3.4^{b}	*

*SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; UIFA: unidentified fatty acids; a, b: Means within a row with different superscripts differ significantly for marked significance level; n.s.=non significant; P>0.05; *P<0.05; **P<0.01; ***P<0.001.*

rib, 24h *post mortem*. Fatty acids composition was determined by gas chromatography using Chrompack CP 9000 equipped with a flame ionization detector. Percentage of fatty acids was calculated according to Csapó *et al.* (1986) and expressed as percentage of total fatty acid methyl esters. Data were analysed using PROC GLM (SAS V9.1 2001).

Results and conclusions – Fatty acid profile (% of fatty acid methyl esters) in veal M. *L. thoracis* is presented in Table 1.

The predominant fatty acids in veal M. *L. thoracis* were 16:0 (23.71-25.35% of fatty acids methyl esters) and 18:0 (11.17-11.79 %) as SFA, 18:1 c9 (29.36-34%) as MUFA and 18:2n-6 (11.06-14.45%) as PUFA. Breed variations ($P<0.05$) in veal fatty acid composition were observed for the predominant fatty acids, except for 18:0. Similar results have been found in other authors (Alfaia *et al.*, 2007). Holstein calves had SFA, MUFA and PUFA values different ($P<0.05$) then Simmental calves. Simmental calves had higher ($P<0.01$) PUFA/SFA ratio than Holstein, but not different than crossbreeds. Due to the very high percentage of 18:2 n-6, n-6/n-3 ratio had unexpectedly high values. It was suggested that the combination of high level concentrate in diet and early slaughter age (4.7 month) resulted in minor biohydrogenation of dietary fatty acids. This study showed significant influence of breed on the composition of majority of the fatty acids as well on PUFA/SFA and n-6/n-3 ratios.

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COMMUNICATION

Fatty acid composition of muscle and adipose tissue of beef cattle

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ABSTRACT - The fatty acid (FA) composition of muscle and adipose tissue was investigated in intensively fed beef cattle. Heifers had more intramuscular fat with higher proportion of monounsaturated FA, while bulls had higher proportion of polyunsaturated FA (PUFA). The same was found in adipose tissue accompanied by higher proportion of saturated FA (SFA) in bulls. The PUFA/SFA ratio was close to recommendation for human diet only in bulls' muscle, while n-6/n-3 PUFA ratios were generally higher than recommended. The observed FA variability between sexes was due to the differences in fatness. To improve the nutritional value, the n-3 PUFA in beef should be increased.

Key words: Beef cattle, Muscle, Fat, Fatty acids.

Introduction – In addition to the eating quality, the wholesomeness is becoming an increasingly important aspect of meat quality for consumers. Meat wholesomeness is also related to its fat content and fatty acid (FA) composition. Particularly beef has been sometimes criticized for being too high in saturated FA (SFA) and low in polyunsaturated FA (PUFA). Moreover, in grain-fed beef the contents of PUFA and beneficial n-3 PUFA tend to be lower than in grass-fed beef (Kraft *et al*., 2008). In intensive production the beef cattle are feeding with high concentrate rations which could be less favourable for FA composition. The FA profile is also influenced by other factors, like sex and fatness (Nürnberg *et al*., 1998). In this study, the FA composition of muscle and adipose tissue of intensively fed beef bulls and heifers with regards to its nutritional value was studied.

Material and methods – The trial was conducted on Simmental cattle (13♂ and 13♀) raised under similar conditions of housing and diet (maize grain silage *ad libitum*, complemented with 1kg of concentrate and hay per animal daily). At slaughter, cattle were about 1 year of age and weighted averagely 510kg for ♂ and 455kg for ♀. Samples of M. *Longissimus thoracis* and intermuscular fat were taken at the level of the 8th rib on cooled right halves. Total muscle lipids were determined according to AOAC (1996). Fatty acid methyl esters (FAME) were detected using a gas chromatograph Agilent Technologies 6890N (USA), equipped with a capillary column Supelco Omegawax® 320. Individual FAMEs were determined through the retention times of FAMEs in a standard mixture (Nu-Check Prep,

Inc, Elysian, USA). The same standard was used to determine the response factor (Rf) for each FA. The FA weight percentage (%) was determined using the Rf and the conversion factor. Data were tested by Student's t-test.

Results and conclusions – Results (means ±SD) are shown in Table 1.

Table 1. Fatty acids (%) and ratios in muscle and adipose tissue of bulls (n=13) and heifers (n=13).

	Muscle		P value	Adipose tissue		P value
	Bulls	Heifers		Bulls	Heifers	
Total lipids (g/kg)	11.7 ± 4.8	26.2 ± 12.9	**			
C14:0	2.5 ± 0.35	2.4 ± 0.18	ns	3.5 ± 0.30	3.1 ± 0.60	*
C16:0	23.5 ± 1.3	23.4 ± 1.4	ns	24.0 ± 1.3	23.6 ± 2.1	ns
C16:1	2.7 ± 0.45	3.2 ± 0.67	*	2.6 ± 0.55	3.2 ± 10.97	ns
C17:0	1.5 ± 0.22	1.5 ± 0.23	ns	2.2 ± 0.33	1.8 ± 0.27	**
C18:0	15.3 ± 1.3	14.3 ± 1.3	ns	21.2 ± 3.1	17.1 ± 3.7	**
C18:1	35.2 ± 3.2	43.4 ± 3.6	***	40.6 ± 2.3	46.4 ± 3.3	***
C18:2n-6	10.8 ± 3.0	5.7 ± 1.7	***	3.5 ± 0.53	2.4 ± 0.25	***
C18:3n-3	0.34 ± 0.07	0.21 ± 0.04	***	0.24 ± 0.03	0.18 ± 0.02	***
C20:3n-6	0.66 ± 0.17	0.48 ± 0.14	**	0.04 ± 0.01	0.08 ± 0.02	***
C20:4n-6	3.5 ± 1.0	2.1 ± 0.86	***	0.04 ± 0.01	0.06 ± 0.01	***
C20:5n-3	0.19 ± 0.06	0.12 ± 0.06	**	ND	ND	
C22:4n-6	0.47 ± 0.11	0.26 ± 0.09	***	0.01 ± 0.01	0.04 ± 0.02	***
C22:5n-3	0.60 ± 0.18	0.40 ± 0.16	**	0.01 ± 0.01	0.03 ± 0.01	***
SFA	43.6 ± 2.0	42.4 ± 1.9	ns	52.0 ± 3.0	46.3 ± 3.7	***
MUFA	38.7 ± 3.5	47.5 ± 3.7	***	43.9 ± 3.0	50.6 ± 3.8	***
PUFA	16.7 ± 4.4	9.5 ± 3.0	***	3.9 ± 0.56	2.9 ± 0.26	***
n-6	15.6 ± 4.2	8.8 ± 2.8	***	3.6 ± 0.54	2.7 ± 0.25	***
n-3	1.1 ± 0.27	0.72 ± 0.24	***	0.26 ± 0.03	0.21 ± 0.02	***
n-6/n-3	13.8 ± 2.0	12.3 ± 2.3	ns	14.1 ± 1.2	13.1 ± 1.2	*
PUFA/SFA	0.39 ± 0.12	0.22 ± 0.07	***	0.08 ± 0.01	0.06 ± 0.01	**

*ns=not significant, *P<0.05, **P<0.01, ***P<0.001, ND=not detected, SFA=saturated, MUFA=monounsaturated, PUFA=polyunsaturated fatty acids.*

Heifers had more intramuscular fat than bulls which is in line with higher carcass fatness of heifers found previously (Karolyi *et al*., 2006). In muscle, heifers had higher proportion of monounsaturated FA (MUFA), while bulls had higher PUFA proportion. Similar results were found in adipose tissue accompanied by higher SFA proportion in bulls. These findings can be related to fatness. In muscle, the triacylglycerol/phosholipid ratio increases

with fatness with an associated increase in C18:1 and decrease in C18:2n-6 (Wood *et al*., 2008). Also, the activity of Δ9-desaturase, which converts SFA into MUFA, increases significantly with an increase in adipose tissue mass (Smith *et al*., 2006), leading to a general increase in unsaturation mainly due to conversion of C18:0 into C18:1. Concerning to the nutritional value, the PUFA:SFA ratio (P/S) was generally higher in bulls than in heifers, while the n-6/n-3 ratios were comparable due to constant difference in n-6 and n-3 proportions within the sex. The P/S ratio in beef is generally low due to ruminal biohydrogenation of unsaturated FA and it decreases with fatness (De Smet *et al*., 2004). In this study, the P/S ratio in bulls' muscle was close to recommendation for human diet (≥0.4, Higgs, 2002) and more favourable than in concentrate-fed Simmental bulls of higher carcass weight and/or intramuscular fat (Nuernberg *et al*., 2005; Kraft *et al*., 2008). The n-6/n-3 ratios were higher than recommended (<4, Higgs, 2002). In conclusion, the FA variability between sexes was mainly due to the difference in fatness. The indicators of nutritional value of FA imply a need for feeding strategy that will increase the n-3 PUFA content in beef.

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COMMUNICATION

Growth and carcass traits of young bulls sired by Charolais and Limousin

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ABSTRACT - A brown cattle is dual purpose cattle in Slovenia mainly used for milk production. This study included 90 crossbred young bulls of two genotypes, 70 Brown x Limousin (BRxLIM) and 20 Brown x Charolais (BRxCHA). The aim of this study was to determine some growth and carcass characteristics of crossbred young bulls. Data were analysed by GLM procedure considering sire breed and year nested within sire breed as fixed effects and slaughter age as linear regression. Sire breed statistically significantly affected slaughter weight, hot carcass weight, net daily gain, dressing percentage and index of conformation. All three included effects statistically significantly affected only slaughter weight, hot carcass weight and net daily gain.

Key words: Crossbred bulls, Growth traits, Carcass traits.

Introduction – Brown cattle is dual purpose cattle in Slovenia mainly used for market milk production and, also in some farms, for processing milk into cheese and other products. A lot of farmers with small sized herds of Brown cattle have abandoned market milk production in the last few years. They have decided for beef production and they changed to cow - calf rearing system on pastures. Brown cows have good maternal characteristic and enough milk for their calves. Weaned calves are suitable for intensive fattening or pasture rearing. Beef breeds such as Limousin, Belgian Blue, and Charolais are mainly used as sire breeds in Slovenia for industrial crossbreeding. Since the year 2002 Brown x Charolais and Brown x Limousin young bulls have been included in the progeny test station where their growth trait parameters have been measured. After the slaughter the carcass characteristic were also recorded. The aim of this study was to determine some growth and carcass characteristics of these crossbreeds.

Material and methods – This study included 90 crossbred young bulls of two genotypes, 70 Brown x Limousin (BRxLIM) and 20 Brown x Charolais (BRxCHA). BRxLIM were progeny of eight, and BRxCHA of five sires. Young bulls were moved to the test station at the Educational and Research Animal Husbandry Centre Logatec (Slovenia) from the years 2002 to 2007 at the average age of 55.1 days (BRxCHA – 54.5 days, BRxLIM – 55.2 days) and the average body weight of 115.0kg. Bulls were fed with grass ensilage, hay and concentrates. Slaughter age was 540 days in average (BRxCHA – 508 days, BRxLIM – 550

days). Bulls at the test station were weighted every two months, but only the starting and slaughter weights were considered. Weight at 200 days was computed with interpolation. Daily gain was calculated from the body weights and age. After the slaughter, hot carcass weight, carcass length and chest depth were recorded. Carcass conformation and fatness were scored according to the EUROP system. Net daily gain was calculated from hot carcass weight and age at slaughter. Dressing percentage was calculated from hot carcass weight and slaughter weight, while index of conformation (IC) was calculated from hot carcass weight (CW), carcass length (CL) and chest depth (CD) as IC=CW/(CL*CD). Data were analysed by GLM procedure of statistical package SAS/STAT (SAS Institute Inc., 2001) considering sire breed and year nested within sire breed as fixed effects and slaughter age as linear regression.

Results and conclusions – Several studies have been reported to characterize growth and carcass traits of young bulls belonging to the European beef and dual purpose breeds (Albertí *et al*., 2008; Piedrafita *et al*., 2003), as well as for crossbreeds sired by beef breeds (Keane and Allen, 1998; Steen, 1995). Sire breed statistically significantly affected slaughter weight, hot carcass weight, net daily gain, dressing percentage and index of conformation in this study (Table 1).

Table 1. LSMeans and p-values of studied variables.

	LS means ±SE		p-values		
Genotype	BRxCHA (n=20)	BRxLIM (n=70)	Sire breed	Year (Sire breed)	Slaughter age
Slaughter weight (kg)	615 ± 9.8	592 ± 5.2	0.044	0.001	0.002
Daily gain 1 (g/day)	1032 ± 21.0	995 ± 11.3	ns	0.001	<0.001
Daily gain 2 (g/day)	1101 ± 23.4	1113 ± 12.6	ns	<0.001	<0.001
Hot carcass weight (kg)	359 ± 6.7	339 ± 3.6	0.012	0.002	0.001
Net daily gain (g/day)	671 ± 12.3	632 ± 6.6	0.007	0.002	<0.001
Dressing percentage (%)	58.33 ± 0.46	57.26 ± 0.25	0.045	ns	0.006
Index of conformation	61.27 ± 1.01	58.90 ± 0.54	0.043	0.002	ns
Conformation score (1 – 15)	8.97 ± 0.43	8.85 ± 0.23	ns	0.018	ns
Fatness score (1 – 15)	7.81 ± 0.24	7.84 ± 0.13	ns	ns	ns
Carcass length (cm)	136.8 ± 0.99	135.3 ± 0.53	ns	0.021	0.011
Chest depth (cm)	42.8 ± 0.43	42.6 ± 0.23	ns	ns	0.001

n=number of animals, BRxCHA=Brown x Charolais, BR x LIM=Brown x Limousin, Daily gain 1=daily gain on the test station, Daily gain 2=daily gain from 200 days age to slaughter, ns=not significant.

Daily gain on the test station was better of Charolais sired bulls (1032.36g/day) compared to Limousine sired bulls (994.71g/day). On the other hand, BRxLIM bulls had better daily gain from 200 days age to slaughter for 11.82g compared to BRxCHA young bulls.

Very similar daily gains in fattening period in BRxCHA (1193g/day) and BRxLIM (1128g/day) were reported by Ferčej and Osterc (1980) at the same test station. Lower daily gain (951g/day) and dressing percentage (55.56%) found Sagsoz *et al*. (2005) in Brown Swiss x Charolais bulls. Better dressing percentage (61.3%) found Kögel *et al.* (1989) in young bulls of German Brown dams sired by Limousin. Year nested within sire breed was statistically significant for all variables except for dressing percentage, fatness score and chest depth. We have to consider that this effect included also the effect of sire, because each sire did not have progeny each year included in the study. Slaughter age was statistically significant for all variables except for index of conformation and conformation and fatness score. In this trial Charolais sired young bulls had some growth and carcass characteristic better than Limousine sired bulls of Brown dams. BRxCHA young bulls had larger estimated slaughter weight than BRxLIM bulls for 22.95kg as well as larger estimated hot carcass weight for 19.72kg, considered the correction on slaughter age. Those differences are also seen in better dressing percentage of Charolais sired bulls. Both, Charolais and Limousin sired bulls had similar carcass length and chest dept, but index of conformation was better on BRxCHA, because of larger hot carcass weight. However, Charolais sired bulls had "thicker" carcasses. We should consider the almost equal fatness scores of BRxCHA and BRxLIM crossbreds, which means that all variables were estimated at the same level of fatness.

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COMMUNICATION

Carcass traits of Charolais, Limousin, Black and White and crossbreeds of Charolais, Limousin and Belgian Blue x Black and White young bulls in Slovenia

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ABSTRACT - The effect of crossing of Black and White (BW) cows with Charolais (CHA), Limousin (LIM) and Belgian Blue (BB) sires on carcass traits of their crossbred male offspring was evaluated. The crossbred bulls were compared with pure breed BW, CHA and LIM bulls. Bulls younger than 24 months and slaughtered in Slovenian slaughterhouses from 2005 to 2008 were included in the comparison. All crossbred genotypes had heavier carcass weight and better net daily gain than pure breed BW bulls. Within crossbred groups the CHAxBW bulls had the heaviest carcasses and the greatest net daily gain. Among all genotypes the best carcass conformation had CHA and the worst BW bulls. In the comparison to pure breeds the BBxBW bulls had for 1.1 of the class better conformation than BW and for 0.5 worse than CHA bulls. Within crossbreeds the BBxBW bulls had for 0.12 and 0.30 of the class better conformation than CHAxBW and LIMxBW bulls. Carcass fatness varied from 2.3 to 2.6 among genotypes, where the BBxBW buls had the lowest fatness score.

Key words: Crossbreeding, Black and White, Beef breeds, Carcass traits.

Introduction – An improvement of growth and carcass traits of dairy progeny designed for beef production through crossing of dairy dams with beef sires is known and confirmed through several experiments, however the effect on the traits differ between breeds (Gerhardy, 1994; Frelich *et al*., 1998; Hoving-Bolink *et al.*, 1999; Čepin *at al.*, 2001; Keane and Allen, 2002; Grodzki *et al.*, 2006; Keane and Drennan, 2008). In Slovenia, the most used beef breeds for improvement of carcass traits of dairy breeds are Belgian Blue (BB), Charolais (CHA) and Limousin (LIM). Above mentioned positive effects are known mostly from experimental data. The aim of our study was to find out if the positive effects of crossing are expressed also at the animals in field rearing systems in Slovenian conditions and further, which beef breed would be the most suitable one for crossing with Slovenian Black and White (BW) breed.

Material and methods – Data from slaughtered young bulls under 24 month of age from January 2005 to December 2008 were collected from commercial slaughterhouses in

Slovenia. Altogether 17,814 bulls of CHA, LIM, BW, BBxBW, CHAxBW and LIMxBW genotypes were taken into this study. Net daily gain was calculated from hot carcass weight and age at slaughter. Conformation and fatness were estimated by independent controllers according to EUROP system. The data were analysed by SAS, GLM procedure (1990). Genotype, year of slaughter and their interaction were included as fixed effects in the model. The differences among different genotypes were tested with CONTRAST statement.

Results and conclusions – All observed traits are shown in Table 1. BBxBW bulls were about two weeks older than pure breed bulls, which had similar age at slaughter. Carcass weight of all crossbreeds was significantly greater than that of BW bulls, which had the lightest carcass weight. Among the crossbreeds the CHAxBW bulls had the heaviest carcasses and did not differ from that of purebred CHA bulls, which had the heaviest carcasses. Similar results were found for net daily gain. In comparison to the BW bulls, net daily gain of BBxBW, CHAxBW and LIMxBW bulls was increased for 8.1%, 11.6% and 10.7%, respectively. Similar increase of daily gain between BW and LIM- and BB-crossbreeds was observed by Gerhardy (1994).

Table 1. Slaughter ages, live weights, net weight gains, carcass conformation and carcass fatness for CHA, LIM, BW, BBxBW, CHAxBW and LIMxBW young bulls (ls mean ±SD).

Genotype*	No. of observations**		Traits				
	n^1	n^2	Slaughter age (days)	Carcass weight (kg)	Net daily gain (g/day)	Carcass conformation**	Carcass fatness***
CHA	364	269	610.5 ± 5.4^{ac}	359.6 ± 3.5^{a}	595 ± 5^{c}	3.47 ± 0.03^{a}	2.48 ± 0.04^{ac}
LIM	498	321	619.5 ± 4.6^{cd}	345.4 ± 3.0^{c}	563 ± 4^{a}	3.21 ± 0.03^{b}	2.53 ± 0.04^{c}
BW	14473	13021	616.5 ± 0.9^{ac}	301.6 ± 0.5^{d}	493 ± 1^{d}	1.92 ± 0.01^{c}	2.42 ± 0.01^{a}
BBxBW	1202	989	635.7 ± 3.0^{b}	336.7 ± 1.9^{b}	533 ± 3^{b}	3.01 ± 0.02^{d}	2.33 ± 0.02^{b}
CHAxBW	258	191	626.9 ± 6.4^{abcd}	355.4 ± 4.1^{a}	571 ± 6^{a}	2.89 ± 0.04^{e}	2.58 ± 0.05^{c}
LIMxBW	1019	832	630.5 ± 3.3^{bd}	331.4 ± 2.1^{b}	529 ± 3^{b}	2.71 ± 0.02^{f}	2.52 ± 0.02^{dc}

CHA=Charolais, LIM= Limousin, BW=Black and White, BB=Belgian Blue;
***n^1= no. of observations for slaughter age, carcass weight and net daily gain; n^2= no. of observations for carcass conformation and fatness;*
****EUROP classification scoring: conformation: 5 (E=best) to 1 (P=poorest); fatness: 1= leanest to 5=fattest.*
^{a,b}values with different superscript among genotypes differ significantly ($p<0.05$).

Carcass conformation score differed among all genotypes, being the best for CHA and the poorest for BW. The CHAxBW bulls, which were classified in 1.0 conformation class higher than BW bulls, had for 0.2 of the class better carcass estimation in comparison to the average of the bulls from dam (BW) and sire (CHA) breed. Among the crossbreeds the BBxBW had the best conformation followed by CHAxBW and LIMxBW. Carcass fat score varied between 2.3 and 2.6 among genotypes, being lowest for BBxBW and highest for CHAxBW.

Similar effect of crossing BW dams with BB and LIM sires on carcass conformation and fatness of their crossbred bulls found Gerhardy (1994), while the effects of crossing BW dams with CHA and LIM sires in the study from Grodzki *et al.* (2006) were lower as in our study. Better slaughter traits and carcass measurements were also confirmed for BBxFriesian crossbred steers in comparison to pure breed Friesian steers (Keane and Drennan, 2008) and for crossbred CHAxHolstein-Friesian steers (McGee *et al.*, 2008) and did not differ much from our results with bulls.

From the presented results we can conclude, that crossbreeding of BW dams with beef breeds sires greatly improved growth and carcass traits of their male offspring slaughtered younger than 24 months of age. The results were comparable to that from designed experiments of crossbreeding. For maximal improvement of growth traits the CHA breed and of carcass traits the BB breed could be recommended for crossbreeding BW breed in Slovenia.

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COMMUNICATION

Effect of breed on mineral composition of meat from light lambs

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ABSTRACT - The proximate composition and mineral content of light lambs muscle (derived from Istrian and Dalmatian Pramenka breeds) were studied. The M. *Longissimus dorsi* (MLD) samples of 30 carcasses were analysed and the effects of breed and sex were studied. Although lambs of investigated breeds were similar for slaughter age (2.5 months), Dalmatian Pramenka had significantly higher carcass weights (CW; $P<0.05$). Breed had a significant influence on moisture and fat contents, whilst mineral composition (with the exception of selenium) was scarcely affected by breed and sex. Fat and moisture contents were significantly correlated with cold CW. The magnesium, calcium, manganese and selenium contents were significantly correlated (r=0.50, -0.46, 0.44, 0.54; $P<0.05$ respectively) with CW. This study contributes to characterization of lamb carcasses from Istrian Sheep and Dalmatian Pramenka breeds and provides new data on the composition of the MLD of light lambs.

Key words: Mineral composition, Light lambs, Istrian Sheep, Dalmatian Pramenka.

Introduction – As occurs in most of the Mediterranean countries, the Croatian lamb market demands light carcasses. For this reason the present trend in Croatia being to slaughter unweaned lambs (20 to 25kg live weight at 2.5 to 3 months of age). The relevance and high edible quality of lamb meat from autochthonous breeds, such as Istrian Sheep and Dalmatian Pramenka produced in the Adriatic Croatian regions, has been widely recognised by tourists and local consumers. However few information about quality traits of light lamb's meat derived from autochthonous Croatian sheep breeds are available. It is recognised that some quality traits of meat, i.e. colour, tenderness and oxidation can be influenced by mineral content (Osorio *et al*., 2007). The mineral content of ovine meat can vary considerably, and its concentration seems to be affected by genetic, physiological and environmental factors. The aims of this study were to determine the mineral content of Croatian light lamb muscle and the differences in the concentration of minerals in this tissue between two local breeds.

Material and methods – A total of 30 carcasses, 15 from each of the two breeds (Istrian Sheep and Dalmatian Pramenka), and from lambs of both sexes (16 males and 14 females) were used for this experiment. Lambs were raised traditionally, suckling milk from their dams, not being weaned until slaughter at 2.5 months of age, normally at the end of spring. The lambs were electrically stunned after an overnight fast and slaughtered by exsanguination at a local slaughterhouse. After slaughter, carcasses were cooled at 4°C for 24h, weighed and M. *Longissimus dors*i (MLD) samples were collected from the left side of each carcass. The meat samples were then minced, homogenized, packed in plastic bags and frozen at –20°C until the analysis were performed. Procedures described by AOAC (1999) were used to determine moisture, fat, protein and ash contents in MLD samples. Mineral content of the MLD were determined as described by Holló *et al*. (2007). Variance analysis was performed using the GLM procedure of the SAS program (SAS, 1999) by using the model which considered the effects of sex and breed. Effect of sex was not significant. A comparison of each variable (carcass weight (CW), moisture, protein, fat and mineral elements) between breeds was performed by Student's *t*-test and correlation coefficients between variables and CW were determined by PROC CORR procedure (SAS, 1999).

Results and conclusions – MLD composition of the experimental carcasses and correlation coefficients with CW are shown in Table 1. Because no significant differences were

Table 1. Cold carcass weight (CCW), proximate composition (fresh weight basis) and mineral content of the MLD of Istrian and Dalmatinska Pramenka light lambs.

		Total lambs	Weight effect	Breed (mean ±S.D.)	
		mean ±S.D.	*r*	Istrian sheep	Dalmatian Pramenka
CCW	kg	11.10 ± 1.57	-	10.44 ± 1.63^{A}	11.51 ± 0.58^{B}
Moisture	%	75.86 ± 1.34	-0.50*	76.44 ± 1.23^{A}	75.28 ± 1.22^{B}
Protein	"	20.38 ± 0.40	0.25	20.39 ± 0.48	20.36 ± 0.33
Fat	"	2.45 ± 1.24	0.46*	1.98 ± 0.97^{A}	2.91 ± 1.24^{B}
Ash	"	1.18 ± 0.07	0.14	1.17 ± 0.07	1.19 ± 0.07
K	mg/100g	340 ± 9	-0.27	342 ± 6	337 ± 11
P	"	191 ± 8	-0.12	194 ± 8	191 ± 9
Na	"	54 ± 5	0.04	53 ± 5^{A}	57 ± 5^{B}
Mg	"	22 ± 1	0.50*	22 ± 1	23 ± 1
Ca	"	2.5 ± 0.4	-0.46*	2.8 ± 0.4^{A}	2.2 ± 0.1^{B}
Zn	"	1.8 ± 0.2	0.27	1.8 ± 0.2	1.9 ± 0.1
Fe	"	1.6 ± 0.2	0.45*	1.5 ± 0.2^{A}	1.7 ± 0.1^{B}
Cu	µg/100g	130 ± 19	-0.15	134 ± 22	126 ± 17
Mn	"	9.5 ± 1.5	0.44*	8.9 ± 1.5^{A}	10.1 ± 1.2^{B}
Se	"	4.2 ± 1.7	0.54*	2.7 ± 0.8^{A}	5.6 ± 0.7^{B}

r: correlation coefficient between carcass weight and the respective variables;

$^{A, B}$: Means for breeds in the same row followed by different letters are significantly different (P<0.05) by Student's t-test;

**: Statistically significant at P<0.05.*

found between sexes, data classified according to this factor were not included. CW (ranging from 8.5 to 12.5kg) was significantly (P<0.05) correlated with both fat and moisture contents (r=0.46 and -0.50, respectively). These correlation coefficients are similar to those obtained by Miguélez *et al*. (2008) for suckling lambs. There were significant differences (P<0.05) in fat and moisture contents between Istrian and Dalmatian Pramenka breeds, which could be attributable to a carcass weight effect and/or genetic variation among breeds on carcass composition (Miguélez *et al*., 2008). The mineral composition of the MLD of Istrian and Dalmatinska Pramenka light lambs is also shown in Table 1. CW was correlated with Mg, Ca, Fe, Mn and Se content and significant differences (P<0.05) for Na, Ca, Fe, Mn and Se contents were detected between breeds. Na, Ca, Zn, Mn and Se contents were considerably lower than values reported for edible portion of loin chop of Australian lambs (Hoke *et al.*, 1999). This could be explained by different ages at slaughtering and different carcass weight of the compared lambs. Finally, effects of breed on fat and moisture contents of MLD from Istrian and Dalmatian Pramenka lambs were observed. The mineral composition of MLD from lambs in this study was scarcely affected by breed and sex. However, CW appeared to be significantly positively correlated (P<0.05) with Mg, Mn, Fe and Se contents, but it was negatively correlated (P<0.05) with Ca content.

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COMMUNICATION

Effect of sex on slaughter performance and meat quality of Ermellinata di Rovigo chickens

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ABSTRACT - In this trial male and female chickens belonging to a dual-purpose Italian breed, Ermellinata di Rovigo (ER), were reared under a free-range production system (June-October) from 47 days of life until slaughter age, at 138 (I age) and 168 (II age) days of age. At both ages, the final body weight, the dressing-out percentage and the ready-to-cook carcass weight were higher (P<0.01) in males. At II age the female carcass showed higher (P<0.01) proportion of breast and lower (P<0.01) proportion of leg. At both ages, the redness index (a*) of breast and thigh were lower (P<0.01) in females, whereas the yellowness index (b*) showed the opposite trend; the females showed higher lipids in breast meat (P<0.05), thigh meat (P<0.01) and skin (P<0.01). The breast tenderness did not change. The results indicate that the ER birds have a different live body weight, slaughter performance and meat quality according to sex, both at I and II age. At 168 days, under the studied environmental conditions, the chickens were in prepubertal period and the sex affected the dressing-out percentage, meat colour and skin lipids in particular.

Key words: Chicken, Sex, Slaughter performance, Meat quality.

Introduction – There is an increasing demand for organic and free-range meat, as an unconventional production and respecting the well-being of the animals (Castellini *et al*., 2008). In Italy, in addition to hybrid chickens intensively reared under indoor conditions, some Italian local breeds still exist, mainly in the Veneto region, which has an important poultry tradition. The knowledge of genetic variability, productive performance and slaughter performance of these Italian breeds (De Marchi *et al.* 2006; Rizzi *et al*., 2007; Rizzi *et al*., 2008) that could be reared under extensive production systems is limited.

Material and methods – The trial was carried out on 42 females and 42 males belonging to Ermellinata di Rovigo (ER) breed. This breed was created during the 1950s in the Veneto region. ER has ermellinate plumage and comes from Sussex and Rhode Island breeds. The experimental period started in June when the animals were 47 days old and lasted until October. The animals were provided both outdoor and indoor spaces; the outdoor space contained perches and shaded space. The outdoor temperature varied from 23 to 15°C and the relative humidity ranged from

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70 to 75%, from summer to autumn, respectively. A pellet feed was fed to the birds *ad libitum*. At 138 (I age) and 168 (II age) days of age, 22 females and 22 males were slaughtered (Rizzi *et al.,* 2007). Ultimate pH (pHu) and colour measurements (CIElab colour space, CIE, 1976) were performed on *Pectoralis major* and *Semitendinosus* muscles at 24 hours after slaughter. Chemical analyses (AOAC, 2000) were performed on breast (*Pectoralis major)* and thigh (all muscles) meat and breast skin. Meat cholesterol was analysed by HPLC. Shear force (WBSF) was measured by means of an Instron texture analyzer provided with a Warner-Bratzler apparatus on cooked breast muscle.

The data were submitted to one-way ANOVA with sex as main effect (SAS, 2001). Differences between means were tested using Duncan's multiple range test (SAS, 2001).

Results and conclusions – In Table 1 the live body weight and the slaughter performance of the chickens are presented. Body weight significantly differed (P<0.01) between males and females at both ages. The dressing-out percentage was higher (P<0.01) in males since the females showed a developing reproductive apparatus. Ready- to-cook carcass weight was lower (P<0.01) in females. Sex affected the carcass conformation (% of ready-to-cook carcass) since breast % was higher (P<0.01) in females at both ages, whereas leg % was lower (P<0.01). The drumstick meat/bone (M/B) ratio was higher (P<0.05) in females at I age, whereas at II age no difference was observed.

Pectoralis major and *Semitendinosus* pHu (Table 2) did not differ at both ages. L* value was

Table 1. Live body weight, slaughter performance and carcass conformation.

		I age			II age		
		male	female	SEM[1]	male	female	SEM[1]
Live body weight	g	2532^{Aa}	1840Bb	185	2735 Aa	2054 Bb	149
Dressing-out percentage	%	82.3^{Aa}	77.6 Bb	4.64	78.9 Aa	71.3 Bb	2.06
Ready-to cook-carcass	g	1680^{Aa}	1207 Bb	144	1776 Aa	1246 Bb	104
Breast	%	19.8^{Bb}	22.9 Aa	0.95	20.2 Bb	23.4 Aa	1.10
Leg	%	40.8^{Aa}	35.6 Bb	1.36	41.4 Aa	36.0 Bb	1.52
Drumstick M/B ratio		2.62^{b}	2.85a	0.234	2.99	3.05	0.266

a, b: P<0.05; A, B: P<0.01.; 1observations (n) of each group (I-II age): 20-21.

not affected by sex; a* value was higher (P<0.01) in males at both ages and in both muscles. The opposite was observed for b* value, which was higher (P<0.01) in females.

The chemical composition of breast, thigh and skin is summarized in Table 2. Breast protein did not differ between sexes at both ages; lipids were higher (P<0.05) in females at I and II age. Cholesterol was similar between groups at both ages. Thigh protein did not change, whereas lipids were higher (P<0.01) in the females, at both ages. Breast skin showed lower (P<0.01) protein and higher lipids at I and II age. Thigh and skin cholesterol was not affected by sex. The cholesterol value differs between breast and leg (Azcona *et al*., 2008) and according to the age of the birds. The WBSF did not change between sexes.

The ER breed shows a relevant body dimorphism according to sex both at 138 and 168 days of age. Under the studied environmental conditions, similar differences were observed between sexes at both ages; in particular, some parameters such as dressing-out percentage and skin lipid content were notably affected by sex at II age, as a consequence of a prepubertal condition.

Table 2. Chemical and physical characteristics of breast, thigh and skin.

		I age			II age		
		male	female	SEM[1]	male	female	SEM[1]
Pectoralis major							
pHu		5.71	5.69	0.098	5.67	5.68	0.116
L*		56.5	56.6	3.58	57.5	57.6	3.38
a*		2.13^{Aa}	0.574^{Bb}	0.874	2.81^{Aa}	-0.344^{Bb}	0.731
b*		0.412^{Bb}	2.88^{Aa}	1.078	-1.25^{Bb}	2.49^{Aa}	1.517
Semitendinosus							
pHu		5.86	5.85	0.179	5.80	5.85	0.113
L*		51.4	51.82	3.19	49.2	50.9	3.21
a*		6.86^{Aa}	4.19^{Bb}	1.43	8.10^{Aa}	4.49^{Bb}	1.21
b*		0.101	1.47	1.48	-2.49^{Bb}	0.653^{Aa}	1.06
Breast[2]							
- protein	%	20.9	21.2	0.807	22.5	22.7	0.778
- lipids	%	0.366^{b}	0.501^{a}	0.112	0.158^{b}	0.263^{a}	0.065
- cholesterol	mg/100 g	41.9	37.8	4.02	41.0	41.4	6.31
Thigh[2]							
- protein	%	19.6	19.9	1.15	19.4	17.7	3.07
- lipids	%	3.14^{Bb}	5.88^{Aa}	1.09	2.97^{Bb}	5.57^{Aa}	1.31
- cholesterol		70.4	75.8	11.3	59.7	56.3	13.9
Skin[2]							
- protein	%	17.5^{Aa}	13.6^{Bb}	1.32	20.6^{Aa}	11.9^{Bb}	1.84
- lipids	%	21.3^{Bb}	44.2^{Aa}	4.95	19.3^{Bb}	50.5^{Aa}	3.53
- cholesterol	mg/100 g	226	250	30.6	198	177	31.0
Breast WBSF	kg/cm^2	2.13	1.75	0.596	1.61	1.73	0.398

^{a,b}: P<0.05; ^{A,B}: P<0.01; [1]observations (n) of each group: 10 (pH and colour), 7 (meat composition and tenderness); [2]: on as is basis.

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COMMUNICATION

Meat traits of rabbits housed outdoors: effect of stocking density

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ABSTRACT - The extensive outdoor rearing system is considered capable of satisfying high standards of animal welfare: the effects of outdoor rearing system stocking density on meat quality traits of slow growing rabbits were studied. Sixty rabbits reared in outdoor cages were randomly assigned to three stocking densities: 0.06m^2/rabbit, 0.2m^2/rabbit and 0.4m^2/rabbit. At 102±1 days of age, twelve animals per group were slaughtered and pHu, L* a* b* colour and cooking loss were measured on *B. femoris* and *Lumborum* muscles. The animals reared at 0.2 and 0.4m^2/rabbit density showed a lower lightness of *B. femoris* muscle and a higher a* value than the other group. The higher disposable space induced greater physical activity, probably increasing muscle oxidative metabolism and consequently inducing less pale meat. Outdoor rearing at low rabbit density seems to satisfy the animals' spatial and social needs, improve sanitary conditions, and furnish good meat quality.

Key words: Rabbit, Open air, Stocking density, Meat characteristics.

Introduction – Interest in obtaining rabbit meat from less intensive rearing systems has increased in the last decade, and many investigations have been performed to verify the effect of alternative rearing systems on welfare, productive performance and meat quality. The extensive outdoor rearing system was studied because it is considered capable of satisfying high animal welfare standards; contrasting results are often obtained, however, due to the high number of variables involved, such as stocking density, group size, type of floor, and strain (Dal Bosco *et al*., 2002; Dalle Zotte *et al*., 2009; Lambertini *et al*., 2001; Paci *et al*., 2005; Pla, 2008; Trocino *et al*., 2004). The aim of the study was to investigate the effects of different stocking densities on meat quality traits of slow growing rabbits reared outdoors.

Material and Methods – Sixty weaned rabbits (both sexes), aged 35 days, of a local rabbit population, characterized by high rusticity and adaptability to unfavourable environmental conditions, were used. At 49 days of age, the rabbits were divided into three groups of 20 animals each and housed in wire net floor colony cages (cm 100x150x76h) in an outdoor pen; the same group size was used (4 animals/cage) and the following stocking densities were applied: 0.06m^2/rabbit (D 0.06 group,); 0.2m^2/rabbit (D 0.2 group); 0.4m^2/rabbit (D 0.4 group). At 102±1 days of age, twelve rabbits per group were weighed, electri-

cally stunned and slaughtered (Blasco and Ouhayoun, 1996). After 24h chilling, the following meat characteristics were assessed: ultimate pH (pH_u) was determined *in situ* on the *Longissimus lumborum* (LL) muscle at the level of the 5th lumbar vertebra and on the *Biceps femoris* (BF) muscle with a portable pH-meter (Hanna). Instrumental meat colour, expressed as L* (lightness), a* (redness), b* (yellowness) according to CIELAB colour space (CIE, 1976) was measured with a Minolta CR300 chromameter (Minolta, Osaka, Japan) on a transversal section of LL muscle and on the BF muscle surface. Cooking loss was determined on LL. Data were analysed by ANOVA, considering the rearing system as the main categorical factor (SAS, 2002).

Results and conclusions - Meat quality traits are shown in Table 1. The pH_u measured on BF and LL muscles was not affected by the stocking density tested; this result is in disagreement with part of the findings reported in literature, where significant meat pHu differences are ascribed to locomotory activity and stocking density (Dal Bosco *et al*., 2002).

Table 1. Effect of stocking density on meat quality traits.

	Stocking density				
	D0.06	D0.2	D0.4	P value	SEM1
Rabbits, No.	12	12	12		
M. *B. femoris*					
- pH_u	6.02	6.04	5.90	ns	0.05
- L*	55.0^{A}	51.4^{B}	52.3^{AB}	0.01	5.12
- a*	3.27	3.98	3.93	ns	1.31
- b*	3.44	3.09	3.19	ns	0.94
M. *L. lumborum*					
- pH_u	5.70	5.74	5.72	ns	0.03
- L*	58.3	56.4	57.2	ns	8.52
- a*	1.60^{b}	2.18^{ab}	2.90^{a}	0.05	1.03
- b*	1.73	1.54	2.14	ns	0.62
- Cooking loss, %	13.4	15.0	15.1	ns	8.64

[1]SEM: Standard Error of the Mean; [A, B, a, b]: means with unlike superscripts within row differ (P<0.01; P<0.05, resp.).

As regards L* a* b* colour values, BF muscles of D 0.2 and D 0.4 groups showed lower L* than the D 0.06 groups (51.35 and 52.33 *vs* 55.01, respectively P<0.01), as reported by other authors (Maertens and Oeckel, 2001). In the same muscle, the redness value (a*) tended to be higher and similar in the groups at lower stocking densities compared with the group reared at higher density (3.98 and 3.93 *vs* 3.27; P=0.26). LL of rabbits reared at lower density (0.4m^2/rabbit) showed higher a* value than the D 0.06 group (2,90 *vs* 1,60; P<0.05). The higher disposable space might have induced greater physical activity, increasing muscle oxidative metabolism and consequently inducing more coloured meat (Paci *et al.*, 2005;

Pla, 2008). The cooking loss of LL muscle tended to be lower (P=0.30) in higher stocking density rabbits, which also showed more fatness of carcass. Stocking density affects mainly meat colour: rabbits reared at low density produced less pale meat, and consumers often associate this trait with a more natural rearing system that is more capable of satisfying the animals' spatial and social needs, improving sanitary conditions, and furnishing good meat quality.

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COMMUNICATION

Evolution of European sea bass (*Dicentrarchus labrax*) freshness during storage

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ABSTRACT - The study aimed to assess freshness evolution in 90 European sea bass (*Dicentrarchus labrax*) analyzed 2h after catch (day 0) and after 1, 2, 4, 6, and 8 days of storage at 2°C. Sea bass weighted 308±37g with average carcass yield of 89.8% and fillet yield of 48.8% slaughter weight. During storage skin colour indexes linearly changed (L<0.01) showing higher L* and lower a* and b* values. The eye liquor pH increased with storage, with both significant linear and quadratic components of variance. Fillet hardness increased from day 0 to day 4 and then decreased on day 8 (quadratic component of variance <0.01). Sensory freshness assessed by Quality Index Method showed a quadratic evolution and high correlation (R^2=0.95) with days of storage.

Key words: European sea bass, Freshness, Quality Index Method.

Introduction – Freshness is the most important trait that contributes to raw fish quality. *Post-mortem* processes modify progressively the initial fish quality to a rate which depends on *ante-mortem* factors (species, fish physiological condition, slaughter procedure) as well as on handling and storage procedures after death. Several types of measurements (sensorial, physical, chemical and microbiological) may assess fish freshness. Among sensorial analyses, the EC freshness grades scheme (EU council decision no. 103/76, January 1976) is currently used to evaluate fish freshness, but research and industry are more and more focusing on the use of the Quality Index Method (QIM), which is species-specific and may also be used to predict storage life (Alasalvar *et al*., 2002; Álvarez *et al*., 2008). The present paper measured quality evolution in raw sea bass *(Dicentrarchus labrax)* during 8 days of storage by means of physical and sensory traits.

Material and methods – Ninety European sea bass (308±37g) were caught in a commercial farm, slaughtered by immersion in ice-slurry and immediately transported to the laboratory in thermally insulated boxes. The fish were divided into six groups (each of 15 specimens, homogeneous in terms of weight and variability) to be analyzed immediately

(day 0, within 2h after catch), and after 1, 2, 4, 6, and 8 days of storage. The fish were closed into polystyrene boxes and stored without ice in a refrigerated room at 2°C. At each storage time, sensory analysis was performed on intact fish by five trained panelists according to the Quality Index Method (QIM) scheme (Alasalvar *et al*., 2002). The panelists scored 15 traits (fish appearance for brightness, skin, slime, stiffness; eye for clarity, shape, iris, blood presence; gills for colour, mucus and odour; belly for discolouration and firmness; vent for condition and smell) on a continuous scale of 0 to 2 or 3 demerit points. The sum of the scores given for each of the 15 parameter was the final Quality Index increasing from 0 (fresh fish) to higher values (maximum 40) as the fish deteriorate. The pH of eye liquor and right fillets was measured. Colour was recorded on skin of raw fish and right fillets (dorsal side) according to CIELAB color space (CIE, 1976). Texture profile analysis was performed on the dorsal fillet by TA.HDI dynamometer (Stabel Micro System Ldt., UK) using two consecutive cycles of 25% compression and a 20mm-diameter cylindrical probe moving at a constant speed of 2mm/sec. Data were submitted to analysis of variance using the GLM procedure of SAS and the storage time as the variability factor and estimating linear (L) and quadratic (Q) component of variance.

Results and conclusions – Sea bass carcass yield averaged 89.8% and fillet yield 48.8% slaughter weight (Table 1). During storage skin colour indexes linearly changed (L<0.01) showing higher L* and lower a* and b* values, going towards blue and green colours. Similar colour evolution was observed on the fillet. Moreover, colour indexes were higher during days 1 to 4 of storage than at day 0 and days 6-8 (Q<0.05). The pH of eye liquor increased with storage life (L and Q<0.001), while fillet pH did not change (Table 1). Fillet texture significantly varied: hardness increased from slaughter (4.86N on day 0) to the day 4 of

Table 1. Effect of storage on physical traits and QIM score of sea bass.

	Days after slaughter						Prob.[1]		RSD
	0	1	2	4	6	8	L	Q	
Carcass yield, % SW[2]	88.8	89.5	91.1	89.8	89.8	89.9	0.10	<0.01	1.49
Fillet yield, % SW[2]	48.5	49.6	47.9	48.1	49.2	49.8	0.27	0.11	2.31
Skin L*	44.8	49.5	54.4	50.7	51.7	52.3	<0.001	<0.001	3.31
Skin a*	0.28	0.50	0.37	-0.73	-0.48	-1.22	<0.001	0.01	0.52
Skin b*	5.63	5.83	6.34	3.68	4.82	2.42	<0.001	0.02	1.81
Fillet L*	37.8	34.6	36.8	37.7	39.2	39.4	<0.001	<0.01	2.01
Fillet a*	-2.46	-2.92	-2.68	-2.95	-2.75	-2.71	0.24	0.01	0.40
FIllet b*	-0.17	-0.98	-1.88	-2.48	-2.73	-3.01	<0.001	0.03	1.02
Eye pH	7.25	7.05	7.14	7.05	7.30	7.48	<0.001	<0.001	0.16
Fillet pH	6.44	6.42	6.41	6.47	6.45	6.39	0.58	0.22	0.09
Fillet hardness, N	4.86	5.98	6.38	7.20	6.77	6.89	<0.001	0.02	1.43
QIM score	0.0	5.1	8.6	13.8	17.0	18.4	<0.001	<0.001	1.53

[1]L: linear component of variance; Q: quadratic component of variance. [2]SW, slaughter weight.

storage (7.20N) following *rigor mortis* onset and then started to decrease with *rigor* resolution at days 6 and 8) (L<0.001; Q=0.02). Previous studies in red skinned fish also reported increasing skin lightness and decreasing red and yellow colour components with increasing storage (Pavlidis *et al*., 2006). In sea bass and sea bream, decreasing L* and discolouration were measured on longer storage periods (until 21d) (Cakli *et al*., 2006; Álvarez *et al*., 2008). In a recent review, Abbas *et al*. (2008) confirmed muscle pH to be clearly correlated with fish freshness and to increase after 10-12d of storage. Flesh softening with storage time was instrumentally measured on sea bream and sea bass also by other authors (Alasalvar *et al*., 2002; Álvarez *et al*., 2008). Sensory analysis of specific traits (data not reported) and QIM score (Table 1) were always significantly affected by storage time. Eight days after slaughter sea bass still showed an acceptable degree of freshness (QIM=18.4), even if some traits (appearance for brightness, slime, stiffness; gill odour and mucus) degraded more rapidly than others. QIM scores showed high correlation (R^2=0.95) and both linear and quadratic evolution from 0 to 8 days of storage. This confirms previous findings that recommend the use of QIM to predict storage life of sea bass and other species (Alasalvar *et al*., 2002; Álvarez *et al*., 2008).

In conclusion, physical and chemical traits of sea bass significantly changed during a 8-day storage period. Sensory evaluation of fish freshness using QIM resulted to be highly correlated with storage time and appeared a promising technique to assess sea bass freshness and predict shelf life.

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COMMUNICATION

Application of bioelectrical impedance vector analysis (BIVA) in dogs: a preliminary study on gender-related differences

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ABSTRACT - In this preliminary study, BIVA has been performed on 17 healthy Italian Hound dogs, 10 males (M) and 7 females (F), in order to verify if gender-related differences can be detected. Only in F higher reactance (Xc) values (F: 46.4 vs M: 37.7, P<0.05) and a significant negative correlation (-0.80, P<0.05) between BCS and resistance (R) values were detected. 50%, 75% and 95% tolerance ellipses were calculated both in M and F using average Xc and R values standardized for withers height. Probably due to the low number of subjects used in the present study, the variability of the individual vector distribution (F: 79.6 vs M: 53.0Ohm/m), as well as the mean impedance vector lengtht (F: 548.2 vs M: 498.9Ohm/m), were similar in F and M. The gender-related difference in phase angle values was not significant (F: 0.168 vs M: 0.157, P=ns). In conclusion, the use of BIVA in dogs indicated differences between males and females which should be confirmed by a larger number of subjects.

Key words: Dog, BIVA, Gender-related differences.

Introduction – Bioelectrical impedance vector analysis (BIVA) is a stand-alone procedure that permits the evaluation of the body composition in humans from direct measurement of impedance (Z) vector. The Z vector is graphically represented as the combination of two vectors: resistance (R) and reactance Xc, standardized for height and plotted as point vectors in the RXc plane (Piccoli, 2003). In humans, 50%, 75% and 95% tolerance ellipses have been calculated from sex- and race–specific reference healthy populations since they are the main variables influencing body composition and the Z vector distribution pattern consequently (Piccoli *et al.,* 2002). To our knowledge, such method was never used in dogs. The aim of this preliminary investigation was to detect gender-related differences in Z vector distribution and length in a small population of Italian hound dogs.

Material and methods – For the present study 17 healthy young Italian hound dogs (7 females and 10 males) were recruited. Withers height (H), body length (L) measurements

and Body Condition Score (BCS) (Laflamme, 1997) were performed. Measurements of R and Xc were obtained using a BIA 101 single frequency bioelectrical impedance analyzer (Akern s.r.l., Firenze, Italy). Electrodes were placed on the right limbs, after shaving and cleaning with alcohol two 3×3cm skin areas on each. On the forelimb, the proximal detector electrode (DE) was placed 4cm cranially to the olecranon and the transmitter electrode (TE) 4cm distally from this site. On the hindlimb, the proximal DE was placed 2 cm caudally from the patella and the TE 4 cm distally from this site. Electrodes used for this purpose were EEG cup electrodes (EL TPC, Micromed S.p.A., Treviso, Italy) filled with a conductive adhesive cream (Microten 60, Micromed S.p.A., Treviso, Italy). An operator which wears rubber gloves kept dogs in the upright position, taking care of keeping the animal's limbs perpendicularly to the ground. In the meanwhile, two more operators which wear rubber gloves placed electrodes on the reference points. The alternating current (800µA, 50kHz) was transmitted by the distal electrode to each limb and the voltage drop was detected by the proximal electrodes. The phase angle (ϕ) was calculated by the formula arctangent (arctan) of Xc/R (Piccoli, 2003) in males and females. Differences between mean values have been tested by Student's t test, whereas differences between variances have been tested by F-test. R and Xc data were analyzed by ANOVA model using PROC GLM (SAS, 2003) considering the effect of BCS. Both in males and females, Pearson correlations were carried out between BCS and values of R and Xc, and between R and Xc values, both standardized for H and L. Differences were considered significant at $P<0.05$. Moreover, 50%, 75% and 90% tolerance ellipses for the individual Z vectors have been calculated both for males and females (SAS, 2003).

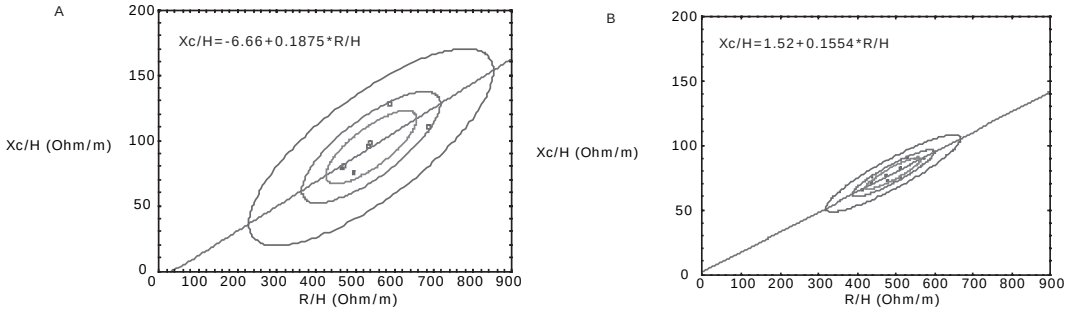
Results and conclusions – Average measurements performed in males and females are reported in Table 1. Gender significantly affected Xc values, females showing higher values than males ($P<0.05$). Due to the low number of cases included in the study, the ANOVA analysis did not permit to achieve reliable conclusions on the influence of BCS on R and Xc values, neither in males nor in females. However, BCS was significantly negatively correlated only with R in females (-0.80, $P<0.05$) whereas no significant correlations were detected in males.

Table 1. Average and standard deviation of R and Xc values, body length (L) and withers height (H) measured in males and females.

Gender	R (Ohm)	Xc (Ohm)	L (cm)	H (cm)	BCS
Males	237.6±22.5	37.7±4.5[b]	54.4±6.5	48.4±3.8	4.8±0.8
Females	266.0±39.9	46.4±8.1[a]	54.6±3.3	49.3±2.4	5.4±0.8

Average Xc and R values standardized for H or L, were highly positively correlated in males (r=0.91 for R/H and Xc/H, $P<0.001$ and r=0.97 for R/L and Xc/L $P<0.001$), whereas in females correlations were not as strong as for males (r=0.78 for R/H and Xc/H, $P<0.05$ and r=0.75 for R/L and Xc/L $P=0.052$). Therefore, the standardization for H or L can be used in males indifferently whereas in this group of females the L standardization is not reliable. Based on these results, H standardization has been chosen to calculate 50%, 75% and 95% tolerance ellipses for the individual Z vectors in males and females (Figure 1).

Figure 1. Linear regression of Xc/H and R/H and 50% (dotted line), 75% (interrupted line) and 95% tolerance ellipses (continuous line) in female (A) and male (B) dogs



A sex-specific property Z vector distribution and length have been reported in human populations and can be due to a greater variability of soft tissue structure and hydration in females (Piccoli *et al.,* 2002). In the present study, the differences observed between males and females in the variability of the individual vector distribution (F: 79.63 *vs* M: 53.01Ohm/m, *P*=ns) and in the mean Z vector length (F: 548.25 *vs* M: 498.87Ohm/m, *P*=ns) did not reach the statistical significance, probably due to the low number of subjects included. In principle, a greater ϕ is related with soft tissues containing a greater amount of cells (myocytes and adipocytes) with a comparable volume of ionic solution (Piccoli *et al.,* 2002). Phase angle (ϕ) of the females' Z vector resulted not statistically different from that registered in males (0.168 *vs* 0.157, *P*=ns): also in humans, a gender-related difference in ϕ is reached only when a large population is considered (Piccoli, 2003). These are the first results concerning the use of BIVA in dogs and indicate gender-related differences which should be confirmed by a larger number of subjects.

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