

CHARACTERISTICS OF CARCASS AND TISSUES IN PIGS OF TUROPOLJE BREED AND CROSSBREDS TCSL

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ABSTRACT

Some carcass traits and muscle fiber characteristics of *m. Longissimus dorsi* (MLD) in pigs of Turopolje breed (T) and crossbreds TCSL were analyzed. The hogs T (n = 19, 568 ± 20 days) and TCSL (n = 10, 575 ± 27 days) were progenies of the same boar, T3_{HB}, and sows of Turopolje breed and crossbred CSL (♂C Hypor line × ♀SL, Swedish Landrace). All pigs were reared and fattened in the outdoor system, according to traditional Croatian technology of low input. Live (LW) and carcass weight (CW) and some carcass traits and chemical composition of muscle and fat tissues were analyzed. In the carcass, the lean percentage (L%) was calculated on the basis of back fat thickness (BF) and MLD thickness, according to “two point” method (CRO, Regulation, NN 85/05). The samples of MLD from the left side at the 13/14th rib level were taken after slaughtering (5 min.) and frozen in liquid nitrogen until histo-morphological analysis (diameter of slow twitch oxidative, SO; fast twitch glycolytic, FG; and fast twitch oxidative, FOG fiber types). After chilling carcass (24 h, at +4 °C), the samples of MLD and the belonging back fat were taken from the same place for analysis of chemical composition (water W, protein P, lipid L, ash A). According to the estimated results the pigs of Turopolje breed and TCSL significantly differed as follows: LW (95.31 and 117.10 kg), CW (77.11 and 97.50 kg), BF (31.68 and 28.00 mm), MLD dept (50.16 and 60.10 mm), L (45.25 and 47.69%), SO (33.69 and 44.24 μm), and FG (38.48 and 47.60 μm). The chemical content of muscle and fat tissues was not significantly different between investigated pigs.

Key words: pigs / breeds / Turopolje pig / TCSL crossbreds / carcass / *m. longissimus dorsi*

LASTNOSTI KLAVNIH POLOVIC IN TKIV PRI TUROPOLJSKEM PRAŠIČU IN TCSL KRIŽANCIH

IZVLEČEK

Analizirali smo nekatere lastnosti klavnih polovic in lastnosti mišičnih vlaken v *m. longissimus dorsi* (MLD) pri turopoljskih prašičih (T) in TCSL križancih. Merjasci T (n = 19, 568 ± 20 dni) in TCSL (n = 10, 575 ± 27 dni) so bili potomci istega merjasca, T3_{HB} in svinj turopoljske pasme in križancev CSL (♂C Hypor linija × ♀SL, švedska landrace). Prašiči so bili vzrejeni in spitani zunaj v prosti reji v skladu s tradicionalno hrvaško tehnologijo majhnega inputa. Analizirali smo telesno maso in maso klavnih polovic ter nekatere lastnosti klavnih polovic in kemično sestavo mišičnega in maščobnega tkiva. V klavnih polovicah smo delež pustega mesa izračunali na osnovi debeline hrbtna slanina in MLD po dvo-točkovni metodi (CRO, Pravilnik NN 85/05). Vzorce leve MLD med 13. in 14. rebrom smo odvezli po klanju (5 minut), jih zamrznili v tekočem dušiku za čas do histomorfoloških analiz (premer počasi krčljivih oksidativnih, SO; hitro krčljivih glikolitični, FG; in hitro krčljivih oksidativnih FOG tipov mišičnih vlaken). Po ohlajanju polovic (14 ur pri +4 °C) smo vzorce MLD in pripadajoče hrbtna slanina odvezli na istem mestu in določili kemično sestavo (voda, beljakovine, maščobe, pepel). Po ocenjenih rezultatih se turopoljski prašiči in križanci TCSL pomembno razlikujejo v sledečih lastnostih:

telesna masa (95,31 oz. 117, 10 kg), masa klavnih polovic (77, 11 oz. 97,50 kg), debelina hrbtna slanina (31,68 oz. 28,00 mm), debelina MLD (50,16 oz. 60,10 mm), delež mesa (45,25 oz. 47,69 %), premer SO mišičnih vlaken (33,69 oz. 44,24 μm) in premer FG mišičnih vlaken (38,48 oz. 46,60 μm). Kemična sestava mišičnega in maščobnega tkiva se ni pomembno razlikovala med preiskovanima pasmama prašičev.

Ključne besede: prašiči / pasme / turopoljski prašič / križanci TCSL / klavne polovice / *m. longissimus dorsi*

INTRODUCTION

Turopolje pig breed is the autochthonous Croatian breed and one of older Europeans pigs and breeds (Ritzoffy, 1931; Belić *et al.*, 1961; Robić *et al.*, 1996). Turopolje pig/breed was created as and today it still is a breed for the outdoor system of production in ecosystem of flood forests (*Quercus robour*, *Fraxinus excelsior*, *Fagus silvatica*) and marsh meadows (*Deschampsietum caespitosae*), continental climate and technologies of low input in outdoor system. In the past and today (in some area and in cases) an old Croatian pig breeding and production is used in the outdoor system. This technology is characterized with low feed input, with the possibility of utilization of natural resources of the environment (acorn, grass and soil). The numbers of scientific and expert papers were published (Đikić *et al.*, 2002) about origin, historical and economic importance and factors which brought this breed into FAO list of endangered and disappearing breeds (Loftus and Scherf, 1993). This list was formed after signing the Convention on Biological Diversity (CBD) in Rio de Janeiro in June 1992. Republic of Croatia signed CBD (January 5th, 1997). In 1999 Croatia passes the strategy of flora and fauna biological diversity which includes Turopolje pig (Radović, 1999). Table 1 show the size of breeding population registered in herdbook of Turopolje pig breed in years 1996 (the start of program of re-establishment and preservation) and in 2007 by annually reports of Croatian Livestock Center (CLC, 1997 and 2008).

Table 1. Breeding population of Turopolje pig breed in Croatia (Croatian Livestock Center, 1997; 2008)

Year	Sows	Boars	Gilt	Young boar
1996	12	3	--	--
2007	164	29	2	2

Number of sows and boars (Table 1) besides the state subsidies indicate the state of endangerment and disappearing of this breed (FAO standards, Loftus and Scherf, 1993). In the last ten years the renewed was very slow, but and the number of gilts gives no opportunity to change the present state. The breeding population is owned by few family farms and by organization Universitas Communitas Nobilium Campi Turopolia (UCNCT, V. Gorica) which owns the majority of the population. In 1996 UCNCT started first with preservation by opening herd book at Croatian Livestock Center (CLC). Some of the reasons of very slow increase of breeding population could be in breed traits (small litter size and index farrowing /sow /year, low daily gain of piglets and hogs), appearance of some diseases (brucellosis) or lack of land areas – what are needs at preservations *in situ* in outdoor system. Also, there is no economic program for meat production or dry meat products, nor breed is used in crossbreeding with modern genotypes of pigs as it is usual with native breeds in Italy or Spain (Oliver *et al.*, 1997). However, it is important to emphasize that Turopolje pig breed traditional production system of low input in the outdoor ecosystem of flood forests and marsh meadows, is a part of Croatian and World wide biological diversity and cultural heritage, and therefore needs to be preserved. With this reason,

the remainder of Turopolje pig population is under research of many biological traits, both on phenotypic and molecular level (Đikić *et al.*, 2002; Harcet *et al.*, 2006; Margeta *et al.*, 2006).

The objective of this study was to establish some characteristics of carcass traits and chemical composition of muscle and fat tissues as well as muscle fiber diameter at Turopolje pig and their crossbreds TCSL. Results of this research will be used as a base for defining the standards of today Turopolje pig breed, as well as a starting point for breeding and economical program in crossing with some modern genotype of pig.

MATERIAL AND METHODS

Animals and management

Investigation was carried out on hogs of Turopolje breed (T, $n = 19$, 568 ± 20 age days) and crossbred TCSL ($n = 10$, 575 ± 27 age days). The hogs were progeny of same boar of Turopolje breed T3_{HB} and two groups of sows, Turopolje breed and crossbred CL (♂C Hypor line × ♀SL Swedish Landrace). Pigs were reared and fattened in the outdoor production system of flood forest biocenosis (*Quercus robur*, *Fraxinus excelsior* and *Fagus sylvatica*) and marsh meadows (*Deschampsietum caespitosae*) in the Turopolje area (near to Zagreb). Traditional Croatian technology of low feed input (0.5 kg of corn seed/animal/day) in the ecosystem was implemented in the extensive management. Natural resources (acorn, soil and pasture) were utilized, but having a mind the environmental balance as well.

Carcass and tissues characteristics

In the abattoir for each hog were established the live weights, and hot carcass after slaughtering. In the carcass the lean percentage (L%) was calculated on the basis of back fat thickness, (BF, mm) measured on the spot where *m. gluteus medius* gets the deepest in the subcutaneous fat. The MLD (mm) thickness was measured as the shortest distance between the cranial end of *m. gluteus medius* and dorsal spinal edge and the method “two point”, (TP, CRO Regulation/Pravilnik, NN, 85/05) was used.

For the chemical analysis the samples of muscle and fat tissues were taken from the MLD and belonging back fat (between 13/14th ribs) on left side after chilling (24 h at +4 °C). The standard methods were used (ISO 1443/73, NN, 39/99) for chemical analysis. In samples of muscle and fat tissues the percentage of water (W, drying method at temperature of 105 °C to constant mass), protein (P, total proteins per Kjeldahl), lipid (L, extraction with ether per Soxhlet) and ash (A, direct burning at temperature at 550 °C) were determined.

Muscle fiber characteristics were determined in the sample of the MLD taken on dorsal side in the 13/14th rib level 5 min after slaughtering and frozen in liquid nitrogen until analysis. For muscle fiber typing (Salomon, 1981; Pearse, 1972), 10 μm thick transverse serial sections were cut in cryostat (Frigocut 2800, Reichert–Jung, Heidelberg, Germany) and stained for actomyosin ATP-ase after pre-incubation in alkaline (pH 9.4), and acid (pH 4.33 and 4.6) media in order to identify three main fiber types (slow twitch oxidative, SO; fast twitch glycolytic, FG and fast twitch oxidative-glycolytic, FOG). In addition, serial sections were used to demonstrate SDH and NADH reductase activity. The fiber diameter (μm) was calculated from fiber cross section area assuming fiber were circular in shape.

The data were analyzed by software package SAS (vs. 6.10, 1999). The t-test was used in data analyses.

RESULTS AND DISCUSSION

Carcass characteristics

The results in Table 2 show live and carcass weights and some technologies characteristics of carcass of Turopolje pig breed and crossbreds TCSL.

Table 2. Live weight and carcass characteristics of Turopolje (T) and crossbred (TCSL) pigs

Traits	Turopolje (T)	Crossbred (TCSL)
	□ ± SD	
Live weight, kg	95.31 ± 2.45 **	117.1 ± 4.19 **
Carcass (w), kg	77.11 ± 2.22 **	95.60 ± 4.54 **
Back fat, mm	31.68 ± 0.81 **	28.00 ± 1.79 **
MLD, mm	50.16 ± 1.32 **	60.10 ± 1.67 **
Lean, %	45.25 ± 0.22 **	47.69 ± 0.65 **
SEUROP class	R	R

** P < 0.01

The estimated results of T breed and crossbred TCSL (Table 2) pigs of the slaughtering and hot carcass weights, and in the relation of pig's age, indicate on very low life daily gain. But the slaughter weights at TCSL were higher than in T and life daily gain was higher of about twenty percent. The carcass lean percentage was different between groups; however the carcasses of both groups were classified in R class according to SEUROP system. By Croatian Regulation (NN, 85/05) in class R the lean percentage is in range from 45% to 50% and therefore the carcasses of T were in the lowest and TCSL in the middle of R class. The differences between T and TCSL pigs in lean percentage were the consequence of differences in thickness of back fat and MLD what a base in carcasses classification is. The estimated meatiness (Table 2) between pigs of T breed and TCSL were significantly different (P < 0.01), as expected due to their different genetic background. Turopolje pig breed is a late mature fatty/meaty production type of pig and was not under the selection processes as modern meaty type of sows CSL used in crossing at production of crossbred' TCSL. But, differences between and variability (some traits as live/carcass weights) within groups could be consequence in different feed utilization and to acclimatization of animals in the conditions of technology of low feed input and outdoor production system. The results of crossbred TCSL give opportunity to use Turopolje pig breed in crossing with modern pig breeds and setting up a breeding program that would support the increase of population on the economic base.

Tissues composition

The chemical composition of MLD and back fat is shown in Table 3.

Chemical composition of MLD and back fat (Table 3) was not significantly different between groups. In muscle tissue of both groups the content of lipid was low and water was high. The given results for lipid and proteins are different in comparisons with standard values for adult mammals (water 75%, lipid 2%, and protein 19%) by Lawrie (1998).

In the muscle tissue of investigated pigs the content of water was higher and content of lipid was lower than in some native breed like Mangalitsa (fatty), Black Slavonian and Iberian (meaty/fatty) or in some modern selected breeds and crossbreds (Oliver *et al.*, 1997; Kralik *et al.*, 2001; Kallweit *et al.*, 2001). The same values of fat tissue were in opposite than in muscle tissues in comparison to results by according literature. These indicate the specific way of the

metabolism and storage of fat in the body and could be one of the reasons of higher thickness of back fat in Turopolje breed in comparison to other breeds. Also, these results indicate the need of further investigations of other traits and tissue characteristics (iodine number, collagen content etc).

Table 3. Chemical composition of MLD and back fat (%) of Turopolje (T) and crossbred (TCSL) pigs

Content, %	Tissue	Turopolje (T)	Crossbred (TCSL)
		$\bar{x} \pm SD$	
Water	M	75.31 \pm 0.33	75.84 \pm 0.34
	F	8.20 \pm 0.54	8.53 \pm 1.02
Protein	M	21.05 \pm 0.25	20.53 \pm 0.25
	F	1.73 \pm 0.15	1.74 \pm 0.30
Lipid	M	1.01 \pm 0.07	1.30 \pm 0.13
	F	89.43 \pm 0.69	89.53 \pm 1.22
Ash	M	1.05 \pm 0.01	1.05 \pm 0.02
	F	0.09 \pm 0.86 $\times 10^{-3}$	0.08 \pm 0.89 $\times 10^{-3}$
NFE*	M	1.58 \pm 0.17	1.28 \pm 0.16
	F	0.55 \pm 0.2 $\times 10^{-3}$	0.11 \pm 0.1 $\times 10^{-3}$

* Nitrogen-Free Extract; M = muscle *Longissimus dorsi*; F = back fat

Results in the Table 4 show the diameters of SO, FG and FOG fibers types of MLD of T and crossbreds TCSL pigs.

Table 4. Histo-morphological characteristics of muscle fiber types in MLD of Turopolje (T) and crossbred (TCSL) pigs

Breed/ crossbred	SO	FG	FOG
	$\bar{x} \pm SD, \mu\text{m}$		
Turopolje	33.69 \pm 2.22 *	38.48 \pm 2.02 **	36.84 \pm 2.58
TCSL	44.24 \pm 4.34 *	47.60 \pm 2.89 **	38.99 \pm 1.10

** P < 0.01; * P < 0.05

In investigated pigs the fiber diameters of SO, FG and FOG showed, beside some higher variability, that values were in a normal range in comparison to general reports for the swine as species by Lawrie (1998). However, the diameters of fiber types SO, and FG were significantly smaller in T pig breed than in crossbred TCSL pigs. However, comparison with literature results showed that the diameters of all fiber types were smaller than in the selected pigs with high growth potential and lean deposition in the carcass (Maltin *et al.*, 1997; Karlson *et al.*, 1999; Fiedler *et al.*, 2003). These results are some different in consideration with values for adult pigs (wild 58–85 μm and domestic 40–80 μm) cited by Pas *et al.* (2004) of many authors. That indicated that Turopolje pig breed could be genetically different in the relation to other breeds, especially if keep in mind its origin (Ritzoffy, 1931) and absent of intensive selection for muscle growth which in pigs may cause a large changes in fiber type composition (Maltin *et al.*, 1997). Investigation of fiber types proportions should be continued and especially in the relation to the quality traits of meat.

CONCLUSIONS

Turopolje pig breed is in the state of endangerment (by FAO standard) and the present number of gilts suggests that fast changes in the number of animals are not possible. In present population of Turopolje pig breed some characteristics of carcass and tissue are specific and could be a consequence of historical conditions of breeding, selection and production of this breed in the specific environment of the outdoor system.

The characteristics of carcass and tissues of crossbred TCSL pigs give opportunity to use Turopolje pig breed in crossing with modern pig breeds and setting up a breeding program which would support the reestablishment of the population on the economic base.

REFERENCES

- Belić, J./ Ognjanović, A./ Šterk, V. Modern pig production. Beograd, Zadružna knjiga, 1961, 69–73.
- Croatian Livestock Center. Annual report - pig breeding. Zagreb, CRO, 1997, 64 p.
- Croatian Livestock Center. Annual report - pig breeding. Zagreb, CRO, 2008, 58 p.
- Đikić, M./ Jurić, I./ Kos F. Turopolje pig – autochthonous Croatian breed – turopolka. V. Gorica, CRO, Plemenita Općina Turopoljska, 2002, 1–181.
- Fiedler, I./ Nürnberg, K./ Hardge, T./ Nürnberg, G./ Ender, K. Phenotypic variations of muscle fibre and intramuscular fat traits in Longissimus muscle of F2 population DurocxBerlin Miniature Pig and relationships to meat quality. *Meat Sci.*, 63(2003), 131–139.
- Harcet, M./ Đikić, M./ Gamulin, V. Low genetic diversity in the Turopolje pig breed using microsatellites and mitochondrial D-loop sequencing. *Food Technol. Biotechnol.*, 44 (2006)1, 105–109.
- International standard (ISO). Meat and meat products - Determination of total fat content, 1973, 1443-1973 (E), 1–12.
- Kallweit, E./ Kohler, P./ Henning, M. Future aspects of porcine carcass and meat quality. In: 9. International symposium “Animal science days” Meat and milk production in the future, Radenci, 2001-10-03/05, Slovenia. *Zb. Biotech. Fak. Univ. Ljubl. Kmet., Supl.*(2001), 191–198.
- Karlson, A.H./ Klont, R.E./ Fernandez, X. Skeletal muscle fibres as factors for pork quality. *Livest. Product. Sci.*, 60 (1999), 255–269.
- Kralik, G. / Petričević, A. Production traits of Black Slavonian pig. In: Biological diversity in animal production of Republic of Croatia, Zagreb, Croatia, 2001-09-18/19. *Proc. Croatian Academy of Sciences and Arts*, 2001, 115–122.
- Loftus, R./ Scherf, B. World Watch List for Domestic Animal Diversity. 1st ed. Rome, FAO, UNEP, 1993, 376 p.
- Lawrie, R.A. Lawrie’s meat science. Abingdon, England, Woodhead Publ., 1998, 336 p.
- Maltin, C.A./ Warkup, C.C./ Mattgews, K.R./ Grant, C.M./ Potter, A.D./ Delday, M.I. Pig Muscle Fibre Characteristics as a Source of Variation in Eating Quality. *Meat Sci.*, 47(1997)3–4, 237–248.
- Margeta, V./ Frajman, P./ Kralik, G./ Dovč, P. Determination of PPARGC1 Cys430SER polymorphism and MHS genotype in Croatian autochthonous pig breeds. *Acta Agraria Kaposvariensis*, 10(2006)2, 333–339.
- Narodne novine (NN). Pravilnik o kakvoći svinjskih trupova i polovica na liniji klanja, 85(2005), 1663.
- Oliver, M.A./ Serra, X./ Gispert, M./ Perez-Enciso, M., /Noguera, J.L. Meat quality characteristics of Iberian and Landrace breeds under intensive conditions. In: 48th Annual meets of EAAP, Wien, 1997-08-25/28, Austria, 4 p.
- Pas, M.F.W./ Everts, M.E./ Haagsman, H.P. Muscle Development of Livestock Animals, Physiology, Genetics, and Meat Quality. Wallingford, England, CAB International, 2004, 411 p.
- Pearse, A.G.E. Histochemistry - Theoretical and applied. Edinburgh, London, Longman, 1972, 183 p.
- Radović J. Overview of condition of biological and landscape diversity of Croatia with strategy and action plan for protection. Zagreb, CRO, Državna uprava za zaštitu prirode i okoliša, 1999, 151 p.
- Ritzoffy, N. Contribution to knowledge on Turopolje pig. *Veterinarski arhiv*, 1(1931), 83–134.
- Robić, Z./ Đikić, M./ Jurić, I./ Stipić, N./ Rupić, V./ Mužić, S./ Božac R./ Liker, B. The Turopolje pig one of the oldest European races: It is saving and Renewal. In: Proceedings of 4th International Symposium “Animal Science Days”, Kaposvar, 1996-09-15/17. Kaposvar, Nagy J. press, 1999, 90–94.
- Salomon, F.V./ Michel, G. / Salomon, B. / Gruschwitz, F. Zur Fasertypisierung an Skelettmuskeln. *Morph/histol. Vet. Med.*, 36 (1981), 349–353.
- SAS Online Doc® Release 8. SAS Institute Inc. Cary, NC USA, 1999.