Performance of Krškopolje Pigs in Extensive and Intensive Production Systems

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Summary

An observational study of growth performance was performed with Krškopolje pigs reared in extensive (EXT) and intensive (INT) production system. Pigs in INT system (n=6) were housed indoors and received a complete feed mixture, while EXT pigs (n=6) were kept in combined indoor/outdoor system and were fed a traditional meal (cooked root crops) and a mixture of ground grains. Growth performance and meat quality traits of *longissimus dorsi* (LD) muscle of pigs were assessed. Pigs were monitored from 86 to 224 days of age and were weighed 4-times (at 86, 129, 195, 224 days) with 4 growth stages (25-45, 45-75, 75-90 and 90-120 kg) considered. Overall INT pigs achieved 49 % higher daily gain and were heavier at slaughter than EXT pigs (88 vs. 120 kg, P<0.001). Growth rate of INT and EXT pigs was similar (443 vs. 464 g/day) from 25-45 kg, whereas EXT pigs grew slower than INT pigs in the periods 45-75 and 75-90 kg (445 vs. 853 and 505 vs 893 g/day, respectively). In the last period (90-120 kg) only INT pigs were monitored and they exhibited a decline in growth rate (580 g/day) compared to the previous two periods. Due to higher body weight (BW) at slaughter, INT had thicker backfat than EXT pigs (40 vs. 22 mm, P<0.000), however at equal BW (88 kg), no differences were noted. EXT pigs exhibited lower CIE L* (P=0.044) and higher CIE a* (P=0.003) colour parameters of LD (i.e. darker, redder LD colour), indicative of more oxidative muscle metabolism of EXT pigs.

Key words

autochthonous breed, Krškopolje pig; growth, carcass, meat quality

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Introduction

Krškopolje pig is the only Slovenian autochthonous pig breed. The interest for Krškopolje breed is increasing in the last years, esp. on organic farms and on family farms with direct product sales. The public aid for conservation of this breed contributes to its wider use. Many small scale farmers still rear pigs in the traditional extensive systems with self-grown feeding resources, in particular cooked root crops. Some farmers rear Krškopolje pigs also in intensive systems with commercially available complete feed mixtures. We recently demonstrated that growth performance of Krškopolje pigs does not differ between ecological and conventional production system if diets fed are equivalent in supply of energy and protein (Batorek-Lukač et al., 2016). No data is available about productive traits of Krškopolje pigs in traditional (extensive) farming system. Therefore, performance of Krškopolje pigs was evaluated in two production systems at two farms; in one a traditional meal of cooked root crops was supplemented with complete feed mixture or ground cereals (depending on the stage of growth), whereas on the second, the pigs were fed with barley based complete feed mixture.

Materials and methods

Pigs were delivered to both farms at similar age (85.9±2.5 days) and BW (26.3±2.1 kg). On the extensive (EXT) farm, the pigs (n=6) were housed in a pen with solid floor and straw bedding (2.5 m^2/pig) and additional access to outdoor area. On the intensive farm, the pigs (n=6) were housed indoors in a pen with partly slatted floor (1.3 m^2/pig). Pigs were not siblings (came from 12 different litters). The study was conducted for 138 days (feeding diets are provided in Table 1).

For the estimations according to production stage, 4 periods were considered; 1) 25-45 kg, 2) 45-75 kg, 3) 75-90 kg and 4) 90-120 kg. EXT pigs received a basic meal (3.2 kg/pig/day) consisting of cooked potatoes and other root plants (carrots, turnip, fodder beet, swede) and in addition a) a complete feed mixture (1.1 kg/pig/day) in period 1, and b) a mixture of ground cereals (2.8 kg/pig/day) in periods 2 and 3. INT pigs were fed barley based feed mixtures adapted to growth stage (Table 1), provided on *ad libitum* basis until app. 75 kg. Thereafter feed mixture allowance was limited to 3.5 kg/pig/day. Estimates of consumed metabolizable energy (ME), crude protein (CP) and lysine were calculated per period (Table 2) assuming complete consumption of distributed feed.

Pigs were slaughtered at similar age (224±6.0 days). Backfat thickness was measured (BFT) at the level of last rib (8 cm laterally); in INT pigs on live animals (with ultrasonic device), in EXT pigs on the carcass. A day after the slaughter, a sample of *longissimus dorsi* muscle (LD) was taken from cooled carcasses at the level of last rib for measurements of ultimate pH (pH24), colour (CIE L*, a*, b* colour parameters) with Minolta

Table 1. Composition (calculated) of the diets

	Extensive			Intensive	
	Basic meal (period 1,2,3)	Growing diet (period 1)	Grain supplement (period 2,3)	Finishing diet 1 (period 1,2)	Finishing diet 2 (period 3,4)
Dry matter, g/kg	157	880	855	877	874
ME, MJ/kg DM	13.5	15.5	15.3	13.4	13.8
Crude ash, g/kg DM	61	75	23	58	55
Crude protein, g/kg DM	119	205	103	174	160
Crude fat, g/kg DM	3	43	22	23	29
Crude fiber, g/kg DM	61	40	37	74	63
Lysine, g/kg DM	4.8	11.4	4.0	10.4	10.4
Lysine/ Crude protein	0.040	0.056	0.039	0.060	0.065

DM – dry matter; Basic meal: potatoes 40%, fodder beet 30%, carrots 10%, turnip 10%, swede 10%. Grain supplement: barley 50%, maize 25%, triticale 25%. Growing diet: maize, soybean meal, barley, wheat, wheat feed flour, corn gluten meal, corn gluten, sugar beet molasses, yeast, soy oil, $CaCO_3$, monocalcium phosphate, salt. Finishing diet 1: barley, wheat, maize, alfalfa, sunflower meal, soybean meal, wheat feed flour, soybean oil, molasses, $CaCO_3$, salt, monocalcium phosphate, vitamin and trace mineral mixture, L-lysine HCL, DL-methionine, lignosulphonate. Finishing diet 2: barley, soybean cake, sunflower cake, wheat feed flour, molasses, $CaCO_3$, salt, monocalcium phosphate, vitamin and trace mineral mixture, L-lysine HCl, DL-methionine, threonine, tryptophan, lignosulphonate.

Table 2. Estimation of daily intakes of metabolizable energy, crude protein and lysine per pig based on actually distributed feed or theoretical feed intake per growing stage (in parentheses)

Growth stage	DM (kg/day)		ME (MJ/day)		f (×MEm)		CP (g/day)		Lysine (g/day)	
	Ext	Int	Ext	Int	Ext	Int	Ext	Int	Ext	Int
1 (25-45 kg)	1.5 (1.5)	1.5 (1.5)	22.3 (22.3)	20.1 (20.1)	3.4 (3.4)	3.1 (3.1)	264 (264)	261 (261)	13.8 (13.8)	15.6 (15.6)
2 (45-75 kg)	2.9 (2.3)	2.5 (2.3)	43.5 (34.3)	33.5 (30.8)	4.7 (3.6)	3.6 (3.3)	307 (245)	435 (400)	12.0 (9.6)	26.0 (24.0)
3 (75-90 kg)	2.9 (2.9)	3.0 (2.9)	43.5 (43.5)	41.4 (40.0)	3.6 (3.6)	3.4 (3.3)	307 (307)	480 (464)	12.0 (9.6)	31.2 (30.2)
4 (90-120 kg)		3.0 (3.5)		41.4 (48.3)		2.9 (3.3)		480 (560)		31.2 (36.4)

EXT – extensive; INT – intensive; DM – dry matter; ME – metabolizable energy; MEm – metabolizable energy for maintenance; f (×MEm) – multiplied by MEm factor; CP – crude protein.

chromameter and drip loss (24 and 48 hours storage) according to the EZ method (Christensen, 2003). For determination of intramuscular fat content (IMF), the samples were minced and IMF was determined by near-infrared spectral analysis (NIR Systems 6500, Foss NIR System, Silver Spring, MD, USA) using internal calibration (Prevolnik et al., 2005). Data was submitted to analysis of variance using the General Linear Models (GLM) procedure of the SAS/STAT module (SAS 8e, 2000; SAS Inc., Cary, NC, USA). For daily gain the model included the fixed effect of group (farm×period), while for BW, backfat and meat quality traits the model included fixed effect of farm. Differences between groups were considered significant if $P<0.05$.

Results and discussion

Growth performance. Regarding the EXT system, it should be noted, that we didn't interfere with the farmer's usual way of feeding, we merely carried out the weighing of pigs, recorded the feed distribution and conducted the laboratory analyses of diets. Table 2 gives an overview of the estimated intake of ME, CP and lysine based on the quantity of distributed feed (dry matter - DM) according to growth stage. Relating to theoretically expected DM feed intake (106 g/kg $BW^{0.75}$, according to NRC, 1998) we could note that pigs in EXT group received sufficient quantity of DM in all stages of growth, but in the second stage of growth (45-75 kg), the offered feed was well over their theoretical DM intake (not consumed completely), which indicates that the intake of energy and proteins based on actually distributed feed (Table 2) is very likely overestimated for EXT pigs at this stage of growth (for about 20%). Regarding INT pigs, it can be concluded that their intake was in agreement with theoretical expectations and it can be considered that they were fed ad libitum (3-4×MEm). It can also be concluded that the supply of proteins was sufficient in INT pigs, whereas in EXT pigs protein supply was satisfactory only in the first growing stage (until 45 kg) and thereafter the meal was deficient in proteins. With regard to lysine needs (17-19 g/day, according to NRC, 1998; 17.7 g/day according to Nieto et al. 2015 for fatty type Iberico pig) results show that in the first growing stage both EXT and INT pigs were somewhat deficient, whereas in the following stages EXT pigs were largely deficient and INT pigs were highly above their requirements. At the beginning of the study (86 days of age) and until approximate age of 130 days and 45 kg BW, INT and EXT groups did not differ in BW denoting similar growth rate in both groups (Figure 1). Thereafter, due to increased growth rate, INT pigs were heavier at all weighing points.

While EXT pigs exhibited similar growth rate throughout the study, growth rate of INT pigs was doubled in the period until 195 days of age (between 45 and 90 kg) and was almost 2-fold higher than in EXT pigs in that period (Figure 1b) resulting in 31.5 kg more gain of INT than EXT pigs. It is worth noting that growth rate of INT pigs strongly decreased in the last period (after 90 kg) and was then comparable to growth rate of EXT pigs. The achieved growth rate of Krškopolje pigs in the first period is similar to daily gains reported for Iberico breed and lower than in modern breeds (Rivera-Ferre et al., 2005). If we relate growth performance with estimated consumption of ME and CP according to growth stage, then we can observe that until 45 kg, growth rate was similar in INT and EXT pigs, which can be related to comparable consumption of energy and nutrients in both systems. A deficiency in lysine in this period indicates that full growth potential of Krškopolje pigs probably could have been achieved with higher lysine intake. As shown by Rivera-Ferre et al. (2005) 35% lysine deficiency (of recommended supply) reduced daily gain of growing Iberico pig by 60%. Based on our results we can conclude that in this initial growing stage covering the amino acid requirements is essential for pigs to fully exhibit their growth potential. Growth rate of Krškopolje pigs in the subsequent growing periods (until 90 kg) was 455 g/day in EXT and 878 g/day in INT system. It can be assumed that pigs in INT system could fully exhibit their growth potential as they were fed ad libitum and their estimated energy and nutrient intake covered their nutrient requirements. It can also be observed, that their protein and lysine intake was well above requirements, therefore it could be suggested that protein content of the diets for Krškopolje pigs in the BW range 45-90 kg could be lower than in feed mixtures for lean fatteners. It could also be considered that nutritional requirements of Krškopolje pigs are more similar to other breeds with low genetic potential for lean tissue deposition (as Iberico) than to modern breeds. In a study of Nieto et al. (2002) on Iberico,

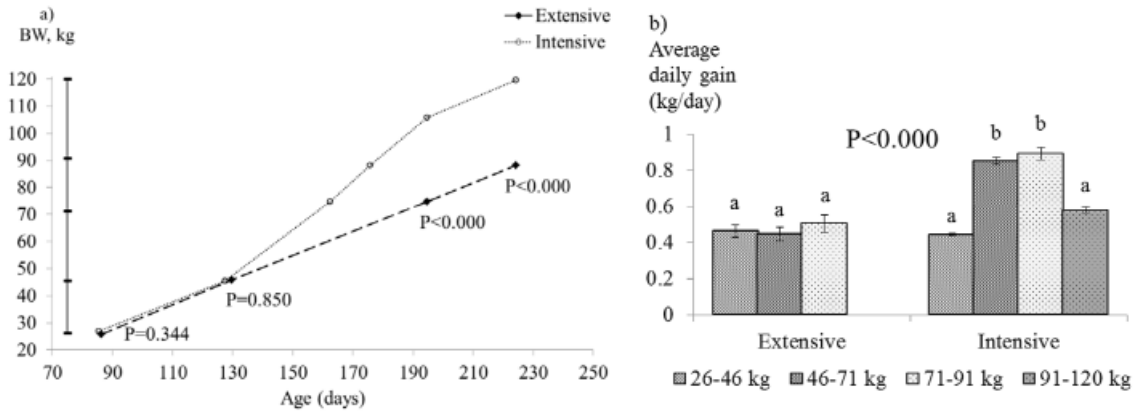

Figure 1. Body weight (a) and daily gain (b) of Krškopolje pigs reared in intensive or extensive system

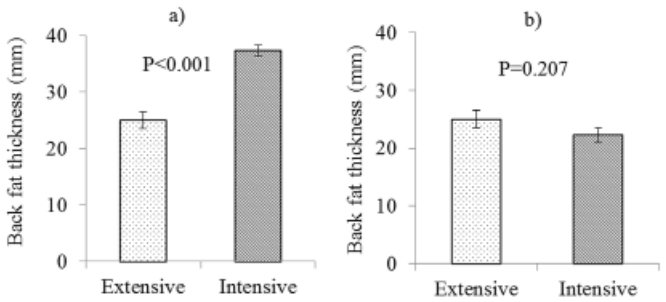

Figure 2. Back fat thickness (mean±SE) of Krškopolje pigs reared in extensive or intensive system at a) slaughter (the same age) and b) at the same body weight (88 kg)

Table 3. Meat quality traits (mean) of Krškopolje pigs reared in extensive or intensive system

	Extensive (n=6)	Intensive (n=6)	RMSE	P value
IMF, %	3.1	2.8	1.2	0.700
pH 24 h	5.43	5.46	0.13	0.671
Drip loss after 24 h, %	3.7	4.2	1.5	0.580
Drip loss after 48 h, %	5.4	5.8	1.7	0.714
Colour parameters				
CIE L*	47.8	50.4	1.9	0.044
CIE a*	8.5	6.6	0.9	0.003
CIE b*	1.0	0.9	0.5	0.740

RMSE – root mean square error; IMF – intramuscular fat.

the maximum deposition of proteins was achieved with a diet having 129 g CP/kg DM (ideal protein concept; 15.4 MJ ME/kg DM) and that increasing the level of proteins did not increase protein accretion. In EXT pigs, the observed growth rate was 1.9-fold lower as in INT despite being fed ad libitum and with energy above their needs. This can only be explained with lysine deficiency. It can be estimated that in EXT system only about 50-60% of the recommended lysine intake was achieved with the offered diet, which corroborates the ratio between observed daily gains for EXT and INT pigs. An interesting point to comment on relates to the last growing stage (90-120 kg) in which only INT pigs were monitored. Their growth rate (580 g/day) was significantly lower in this period compared to the preceding two stages (45-90 kg) despite receiving 2.9×MEm. Two aspects could be responsible; energy losses due to metabolism of excess proteins and changed composition of gain in favour of fat deposition. When the relationship between protein deposition and ME intake is declined, a relative increase in lipid gain with BW is evidenced (Nieto et al., 2012). It also denotes that if we want to limit fat tissue accretion, the pigs should receive, as in the present study, diets with lower nutrient concentration. For example, considering Krškopolje pigs from 100 to 150 kg, and a recommended daily intake of 2.5×MEm (i.e. 41.5 MJ ME), 352 g CP and 21 g lysine to cover nutritional requirements, a diet with 10.4 MJ ME/kg DM, 88 g CP/kg DM and 5.2 g lysine/kg DM would fit this purpose. At slaughter, INT had thicker backfat as EXT pigs (Figure 2a) which can be related to differences in final BW. However, measuring BFT in INT pigs by an ultrasonic device during growth permits rough comparison of BFT with EXT pigs (correlation between *in vivo* and measurement on carcass in INT pigs being 0.70, data not shown) at the same BW (i.e. 88 kg), which showed no considerable difference in back fat thickness between rearing systems at the same stage of growth (Figure 2b).

Meat quality. Meat quality traits are presented in Table 3, however, it should be noted that the comparisons are only indicative (limited) due to the difference in final BW.

Despite lower weight and overall body fatness of EXT pigs, there was no difference in IMF content between EXT and INT pigs (Table 3). Literature shows, that back fat thickness (BFT) or percentage of dissectible fat can be increased by lower CP or lysine content, even though the effect is much lower on carcass than on IMF deposition (Lebret, 2008). Ultimate pH and drip loss were not different between INT and EXT pigs. Drip loss determined in this study for Krškopolje pigs is comparable to the values observed in modern genotypes in the same laboratory (Tomažin et al., 2016). Contrary to our result, the literature usually reports lower drip loss for local than for modern pig breeds e.g. French Basque (Lebret et al., 2015), Portugese Alentejano and Bísaro (Santos e Silva et al., 1999). Higher CIE a* and lower CIE L* values denote redder and darker LD muscle of EXT pigs implying a likely higher oxidative muscle metabolism of pigs with slower growth and possibility to move around. It is however difficult to evaluate to which extent this could be attributed to nutrition (lysine deficiency) or to physical activity. Physical activity has been associated with increased muscle oxidative metabolism (Gondret et al., 2005), similarly Lebret et al. (2015) showed that muscles of extensively reared Basque pigs exhibited lower glycolytic potential and darker colour. Higher oxidative capacity of muscle fibres was also demonstrated in group of pigs restrictively fed (app. 60% restriction) for 3 weeks (Katsumata et al., 2000).

Conclusion

Traditional feeding and rearing system influenced growth performance and lipid deposition in Krškopolje pigs (slower growth due to lysine deficiency) with some indicative benefits in terms of meat quality of extensively reared pigs.

References

Batorek Lukač N., Tomažin U., Prevolnik Povše M., Škrlep M., Čandek-Potokar M. (2016): Effect of production system (organic vs. conventional) and roughage supplementation in diet on performance of growing-finishing Krškopolje pigs. Book of abstracts of "9th International Symposium on Mediterranean Pig", November 3-5, Portalegre, Portugal, p 36

Christensen L.B. (2003): Drip loss sampling in porcine m. *longissimus dorsi*. Meat Sci 63: 469–477

Gondret F., Combes S., Lefaucheur L., Lebret B. (2005): Effects of exercise during growth and alternative rearing systems on muscle fibers and collagen properties. Reprod Nutr Dev 45: 1–10

Katsumata M., Cattaneo D., White P., Burton K. A., Dauncey M. J. (2000): Growth hormone receptor gene expression in porcine skeletal and cardiac muscles is selectively regulated by postnatal undernutrition. J Nutr 130: 2482–2488

Lebret B. (2008): Effects of feeding and rearing systems on growth, carcass composition and meat quality in pigs. Animal 2 (10): 1548–1558

Lebret B., Ecolan P., Bonhomme N., Méteau K., Prunier A. (2015): Influence of production system in local and conventional pig breeds on stress indicators at slaughter, muscle and meat traits and pork eating quality. Animal 9(8): 1404–1413

Nieto R., Lara L., Barea R., García-Valverde R., Aguinaga M. A., Conde-Aguilera. J. A., Aguilera J. F. (2012): Response analysis of the Iberian pig growing from birth to 150 kg body weight to changes in protein and energy supply. J Anim Sci 90: 3809–3820

Nieto R., Martínez-Pérez M., Haro A., Lara L., Aguilera J. F. (2012): Effects of protein intake on rate of growth, protein deposition and carcass traits of heavy Iberian pigs. J Anim Sci 93: 3471–3482

NRC (1998): Nutrient Requirements of Swine: 10th Revised Edition. Natl. Acad. Press, Washington, DC, USA

Prevolnik M., Čandek-Potokar M., Škorjanc D., Velikonja Bolta Š., Škrlep M., Žnidaršič T., Babnik D. (2005): Predicting intramuscular fat content in pork and beef by near infrared spectroscopy. J of Near Infrared Spectrosc, 13: 77–85

Rivera-Ferre M. G., Aguilera J. F., Nieto R. (2005): muscle fractional protein synthesis in higher in Iberian than in Landrace growing pigs fed adequate or lysine-deficient diets. J Nutr 135: 469–478

Santos e Silva J., Ferreira-Cardoso J., Bernardo A., Pires da Costa J. S. (1999): Conservation and development of the Bísaro pig. Characterisation and zootechnical evaluation of the breed for production and genetic management. In: Wenk C (ed) Quality of Meat and fat in pigs as affected by genetics and nutrition, Zurich, Switzerland, pp 85–92

Tomažin U., Čandek-Potokar M., Batorek Lukač N., Škrlep M., Prevolnik Povše M., Škorjanc D., Salobir J., Levart A., Červek M., Rezar V. (2016): Effects of vitamin E, sweet chestnut wood extract and hops supplementation on pig meat quality and oxidative stability. In: Popovič Z (ed) Proceedings of the "International Symposium on Animal Science 2016", Belgrade, Serbia, pp 527–533

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