Slov Vet Res 2011; 48 (1): 15-26
UDC 636.4.083:631.147:637.51

Original Scientific Article

GROWTH, CARCASS AND MEAT QUALITY TRAITS OF PIGS RAISED UNDER ORGANIC OR CONVENTIONAL REARING SYSTEMS USING COMMERCIALLY AVAILABLE FEED MIXTURES

Maja Prevolnik[1, 2], Marko Ocepek[1], Marjeta Čandek-Potokar[1, 2], Martina Bavec[1], Dejan Škorjanc[1]*

[1]Faculty of Agriculture and Life Sciences, University of Maribor, Pivola 10, 2311 Hoče, Slovenia; [2]Agricultural Institute of Slovenia, Hacquetova 17, 1000 Ljubljana, Slovenia

*Corresponding author, E-mail: dejan.skorjanc@uni-mb.si

Summary: The objective of the study was to evaluate performance from birth until slaughter, as well as final carcass and meat quality, of pigs raised either conventionally (n=32) or respecting organic standards (n=35) using commercially available organic feed mixtures. Lower (22%) feed intake from weaning until week 11 was noted for organic pigs. As a consequence, organic pigs had lower growth rate persisting until week 22. In the last phase (weeks 22 to 26) when food intake was limited, growth rate declined in conventional, and increased in organic, pigs. All pigs were slaughtered at the usual commercial age (26 weeks). Due to the slower growth, organic pigs had lower carcass weight, dressing %, smaller *longissimus dorsi* (LD) muscle, and lighter hams, while no differences were observed in fat tissue measurements and carcass leanness (the exception being the area of fat over LD). Analysis for the same slaughter weight indicated that organic pigs would have fatter carcasses as conventional pigs if slaughtered at the same weight. With regard to meat quality, a higher ultimate pH and intramuscular fat content were observed for organic pigs. The results of the present study indicate possible problems (lower feed intake, growth retardation) associated with the use of commercially available organic diets for piglets. On the other hand such diets can increase intramuscular fat content, which is interesting in terms of improved meat quality.

Key words: organic farming; growth; carcass quality; meat quality; stress markers; pig

Introduction

In most European countries, organic pig production has so far played a minor role and the proportion of organically produced pigs is very low (less than 1% (1,2). However, there is a general interest in the European Union (EU) in organic production systems. Consumers often perceive organic food to be healthier, safer, and more palatable and nutritious, owing to the recognition that organic food is wholesome, environmental friendly, traditional and sustainable (3).

Received: 9 November 2010
Accepted for publication: 31 January 2011

Owing to the specific standards and requirements, the costs of organic production could be up to 30% higher than those of conventional rearing (4). The legislation associated with organic pig production is aimed at animal welfare, including the provision of environmental conditions that allow livestock to perform their normal behaviour patterns. The animals must be free from hunger and thirst, thermal and physical discomfort, and they must be protected from injuries, diseases, fear and stress. The legislation (5) provides requirements that include specifications for housing conditions, animal nutrition, and animal breeding, as well as animal care, disease prevention and veterinary treatment.

Many studies have been carried out to determine if the consumer perceptions, that quality of organic food is better, are supported scientifically. Growth performance and the carcass and meat quality of pigs from organic and conventional production systems have been compared, and the published results show inconsistencies (1,2,6-11). Discrepancies in the published results can be related to housing, feed, breed or genotype, and their interactions, which are reflected in the health, welfare and productivity of pigs.

In view of the inconsistency of the research reports and to test local conditions, an experiment was conducted with the objective to evaluate growth performance and carcass and meat quality traits of pigs reared conventionally or respecting organic standards, but using commercially available organic feedstuffs. Contrary to the majority of the studies, where pigs were put to the test at 20–30 kg live weight, the objective of our experiment was to follow the growth performance of pigs from birth until slaughter and to evaluate the consequences for carcass and meat quality.

Materials and methods

Animals, housing and feed

The study was conducted at the Pig Research Centre of Faculty of Agriculture and Life Sciences, University of Maribor, Slovenia, and national legislation on animal protection (12) was respected. The experimental pigs were the progeny of LANDRACE×LARGE WHITE dams and LANDRACE×PIETRAIN sires (free of the *RYR1* gene). The pigs originated from eight sequential litters born within two months period. The piglets in the first four litters formed a group that was reared according to conventional practices of housing and feeding (n=35; 13 females and 19 castrates). Pigs from the other four litters formed a group of pigs (n=40; 15 females and 20 castrates) that were reared respecting the constraints of EU legislation on organic production (5). Surgical castration of the male pigs was performed at the age of three or four days. Owing to mortality, the final analysis comprised 67 pigs (n=32 conventional, and n=35 organic pigs).

Table 1: Available space in conventional and organic pigs according to rearing phase

	Available space	
Rearing phase	Conventional	Organic
Lactation (4 or 6 weeks for conventional or organic group, respectively)	Pen size 1.8×2.5m^2	Pen size 1.8×2.5m^2
Growing (weeks 4-11 or 6-11 for conventional or organic group, respectively)	Pen size 1.8×2.0m^2 0.26-0.36 m^2/piglet	Pen size 3.8×2.3m^2 0.62-0.67 m^2/piglet Straw bedding Outdoor area 2.9×2.3m^2
Finishing (weeks 11-26 for both groups)	Pen size 3.8×2.1m^2 0.66-0.72 m^2/piglet	Pen size 3.8×2.1m^2 1.33 -1.59 m^2/piglet Straw bedding Outdoor area 2.9×2.1m^2

The differences between organic and conventional rearing system are detailed below and in Table 1 and Table 2. Organic pigs had a larger rearing space, access to an outdoor area, straw bedding, longer lactation, and received a commercially available organic feed mixture. Pigs were weaned after 28 days (conventional) or 42 days (organic) of lactation. After weaning, pigs from the conventional group were allotted to three pens for the whole fattening period. Pigs from the organic group were housed in three pens until week 11 when they were further divided into seven pens in order to fulfil space requirements. The available space (Table 1) was in agreement with relevant legislation (5,12).

Pigs were fed with a commercially available feed mixture in pellets (Table 2). The same feeding strategy was used for all pigs, except that the organic pigs received feed mixture of organic origin. From the second week of lactation, in addition to their intake of milk, all the piglets were provided with additional feed mixture (in pellets). During the last four weeks of fattening, only 2.2 kg of feed mixture per pig was provided daily in order to limit fat deposition.

Table 2: Composition of experimental diets[A]

	Conventional			Organic	
Feed mixture	Prestarter[1]	Bek-1 farm[1]	Bek-2 farm[1]	Alpenkorn Ferkel[2]	Alpenkorn Schweine[2]
Rearing phase	Lactation & post-weaning 2-8 weeks	Growing 8-16 weeks	Finishing 16-26 weeks	Lactation & post-weaning 2-9 weeks	Growing & Finishing 9-26 weeks
Diet ingredients	maize 38%, barley 12%, soya meal 17%,milk powder 8%, wheat 8%, fish flour 5%, soya concentrate 2%, minerals, oils & fats, vitamins, Lys, aromatic substances, enzymes, organic acids	maize 35%, barley 22%, soya meal 18%, wheat 15%, sunflower meal 3%, fish meal 1%, lucerne 1%, minerals, oils and fats, vitamins, Lys, aromatic substances, enzymes	maize 34%, barley 23%, soya meal 15%, wheat 11%, sunflower meal 4%, lucerne 2%, minerals, oils and fats, vitamins, Lys, aromatic substances, enzymes	wheat 50%, wheat bran 11%, faba bean 10%, soybean 7%, triticale 6%, barley 5%, rape cake 3%, potato proteins 3%, molasses 2%	triticale 25%, wheat 15%, wheat bran 12%, barley 9%, maize 7%, sunflower cake 9%, rape cake 7%, soybean 5%, faba bean 3%, potato proteins 2.5%, molasses 2%
CP, g/kg	206	169	158	170	170
ME, MJ/kg	12.3	12.0	12.0	12.8	12.5
Lys, g/kg	12.5	10.0	7.0	8.0	8.0

[A]Conventional and organic feed mixtures were commercially available; CP - crude proteins; ME - metabolizable energy; Lys – lysine; [1]supplier Perutnina Ptuj d.d., PC Krmila, DE Proizvodnja krmil, Draženci, SI-2250 Ptuj; [2]supplier UNSER LAGERHAUS Warenhandels Ges.m.b.h., Mischfutterwerk, Südring 240, A-9020 Klagenfurt

The pigs were weighed individually one day after birth and at 4, 6, 11, 22 and 26 weeks of age. Daily gains were calculated using the data on body weight and age at weighing for the whole experimental period (0 to 26 weeks; life daily gain) and for the periods between sequential weight measurements. Feed intake was recorded per pen and divided by the number of pigs to give the daily intake per pig. Feed conversion efficiency was calculated per pen as the ratio between feed intake and live weight gain for each period from weaning until slaughter (week 4 or 6 to 26).

Transport and slaughter procedures

All pigs were slaughtered at the same age (26 weeks) in a commercial abattoir. Pigs from one pen were slaughtered together on the same day. The experimental design required that pigs from the two rearing systems could not be slaughtered on the same day. To avoid confounding of slaughter day and the effect of rearing system, we organised slaughter in six groups (three for conventional and three for organic pigs) with the purpose of randomizing the effect of slaughter day. Pigs were fasted for 12 hours prior to transport to the abattoir. On the day of slaughter, they were loaded between 6 and 8 a.m. and transported for 20 minutes to the local abattoir. The lairage lasted 2-3 hours. During the transport and slaughter procedures there was no mixing of the pigs. Pigs were slaughtered between 8 and 11 a.m. according to the routine abattoir procedure which consisted of CO_2 stunning (86 vol. % in air), vertical exsanguination, vapour scalding, dehairing and evisceration, followed by the veterinary inspection and SEUROP carcass classification (13).

Plasma stress markers

Stress markers were assessed in plasma taken at slaughter in order to monitor for differences in the level of stress between slaughter series. At slaughter, blood samples (approximately 4 ml) were taken into plastic tubes containing EDTA (to prevent blood coagulation). Immediately after blood collection the tubes were placed on ice and taken to the laboratory where the blood was centrifuged at 1800 rpm for 15 minutes. The supernatants (plasma) were collected and stored at −20°C until analysis of the levels of plasma markers of stress using commercial kits. The tests were based on enzyme immunoassays for the *in vitro* diagnostic quantitative determination of cortisol, neopterin and Hsp70 according to the manufacturer's instructions (14-16). The intensity of the colour was read at 450 nm using a spectrophotometer (Varioscan Flash) and SkanIt Software Version 2.4.3. RE (Thermo Fisher Scientific Inc. Waltham, MA, USA). The concentrations of cortisol, neopterin and Hsp70 in plasma samples were expressed in μg/dL, nmol/L and ng/mL, respectively.

Carcass quality traits

At the end of the slaughter line, the pigs were classified according to SEUROP by the approved classification body (Bureau Veritas), using a method that consists of taking two measurements at the carcass split line: DM fat (minimal fat thickness over the *m. gluteus medius*) and DM muscle/width (shortest distance between the cranial end of *m. gluteus medius* and dorsal edge of the vertebral canal). The carcass lean meat percentage was calculated according to the formula (DM meat = 60.81879 – 0.72992×DM fat + 0.12157×DM muscle) approved for Slovenia (17). One day after the slaughter, additional carcass traits were measured. The hind leg (without shank) was cut off the carcass between 6th and 7th lumbar vertebra. It was weighed prior to and after the removal of subcutaneous fat, and the ratio between the weights was calculated. A digital image of the carcass cross section (last rib) was taken with a digital photo camera (Canon PowerShot G3, Canon Inc., Tokyo, Japan). The loin eye area (*longissimus dorsi* (LD**)** area), corresponding fat area (fat over LD) and their ratio (LD meat:fat ratio) were determined from the images with LUCIA.NET 1.16.5 software (Laboratory Imaging s.r.o, Prague, Czech Republic). Belly leanness was assessed using a 1–4–7 scale (1 represents only fat, 4 half meat and half fat, and 7 only meat).

Meat quality traits

The pH was measured with a MP120 Mettler Toledo pH meter fitted with a combined glass electrode InLab427 (Mettler-Toledo, GmbH; 8603 Schwarzenbach, Switzerland) at one hour (pH_1) and 24 hours *post mortem* (pH_U). Duplicate measurements were taken in the LD muscle at the level of the last rib and in the *semimembranosus* (SM) muscle approximately 4 cm lateral to the *os pubis*. Measurements of colour CIE L* a* and b* (18) were taken one day after slaughter from a freshly cut surface of LD (at the level of the last rib) using a Minolta Chroma Meter CR-300 (Minolta Co. Ltd, Osaka, Japan) with an 11 mm diameter aperture and D_{65} illuminant, calibrated against a white tile. At the same time, the colour intensity of LD was also assessed using a 1-6 Japanese colour scale (1 and 2 represent pale, 3 and 4 normal, and 5 and 6 dark meat colour; (19)). A 2.5 cm slice of LD was taken from the loin at the level of the last rib for determination of drip loss (EZ drip loss) according to the method of Christensen (20). Drip loss was determined in duplicate, after 24 and 48 hours of storage at 4°C, and expressed as a percentage of the initial sample weight. Intramuscular fat of the LD was determined with NIR spectroscopy (NIR Systems model 6500, Silver Springs, MD, USA) according to Prevolnik *et al.* (21).

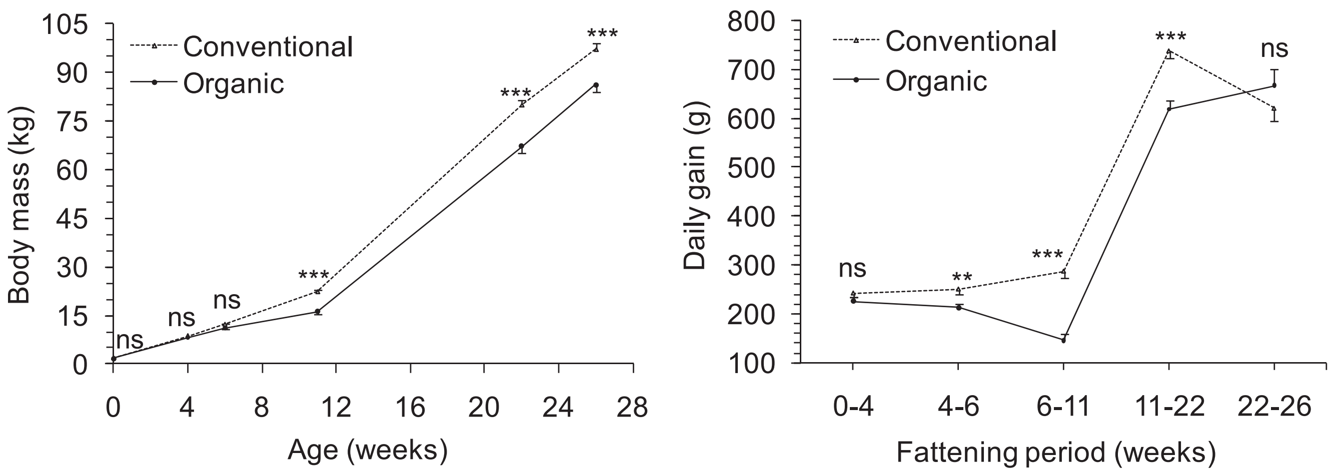
Statistical analysis

Analysis of variance (GLM procedure of SAS 9.1, SAS Inc., Cary, NC, USA) was performed in order to evaluate the effect of rearing system. For growth and carcass traits, the model comprised fixed effects of rearing system and sex, random effect of litter nested within rearing system, and interaction between rearing system and sex (which was always non-significant). For meat quality traits and plasma stress markers, an effect of slaughter day within rearing system was added to the model as a random effect. An additional analysis was performed for carcass traits, with warm carcass weight added as a covariate (in the case of meat quality traits it was non-significant). When significant effect of treatment (P<0.05) was detected, least squares means (*LS means*) were compared (PDIFF option, Tukey adjustment).

Results

Growth performance

Growth performance (body weight and daily gain) differed between conventional and organic pigs (Fig. 1). In Slovenia, the usual slaughter weight of pig fatteners is about 100 to 110 kg at 6 months of age and growth rate observed for pigs of conventional group can be considered as an average result in Slovenian situation. In the first six weeks there was no difference in body weight between organic and conventional pigs. At all subsequent stages organic pigs had lower body weight than the conventional pigs. At the end of the experiment the difference in body weight between the organic and conventional pigs was 11 kg (86 vs. 97 kg, respectively), demonstrating lower growth rate of organic pigs when compared with the conventional pigs (462 vs. 523 g/day, respectively). Initially (at four weeks of age), when piglets were fed mother's milk, no difference in growth rate was observed (243 vs. 226 g/day, for conventional and organic piglets, respectively). It is only when the feed and feeding regime change that the differences are seen. Lower but non-significant growth rate of organic pigs started in weeks 4–6 when these pigs were still fed milk (the conventional pigs had been already weaned), despite being offered additional concentrate feed. Growth rate decline continued after



ns: not significant; ***P<0.001, **P<0.01.

Figure 1: Changes in body mass and daily gain (LS means ± s.e.) for pigs raised under conventional and organic rearing system

Table 3: Feed intake and feed conversion efficiency[A] of pigs raised under conventional and organic rearing system

Period	Conventional	Organic
Number of animals	32	35
4^{th} to 6^{th} week		
Feed intake (kg/day)	0.32	-
Feed conversion efficiency	0.781	-
6^{th} to 11^{th} week		
Feed intake (kg/day)	0.76	0.48
Feed conversion efficiency	0.377	0.274
Weaning to 11^{th} week		
Feed intake (kg/day)	0.63	0.48
Feed conversion efficiency	0.439	0.274
11^{th} to 22^{nd} week		
Feed intake (kg/day)	1.85	1.87
Feed conversion efficiency	0.400	0.330
22^{nd} to 26^{th} week		
Feed intake (kg/day)	2.20	2.20
Feed conversion efficiency	0.306	0.307
Weaning to 26^{th} week		
Feed intake (kg/day)	1.53	1.59
Feed conversion efficiency	0.383	0.336

[A]Measured per pen and calculated per pig.

the weaning (in weeks 6–11). Lower daily gain was recorded for organic pigs until week 22. In the last fattening period (weeks 22–26) organic and conventional pigs had similar daily gain (667 vs. 620 g/day, respectively). During the final period, when feed was rationed to 2.2 kg, a decrease of growth rate compared to previous phase was observed for conventional pigs, whereas this quantity was sufficient to cover the needs for increased growth rate observed in organic pigs, owing to their lower weight.

Growth performance of the pigs can be related to feed composition and feed intake (Tables 2, 3). The organic feed used in the period post-weaning had lower protein level and organic pigs exhibited lower feed intake. In other periods (weeks 11–26), feed intake and the diet were comparable between groups. Because of lower feed intake and growth rate, the organic pigs exhibited lower feed conversion efficiency.

Carcass traits

Lower growth rate of the organic pigs was reflected in most of the carcass traits (Table 4). In comparison with conventional pigs, organic pigs had lower carcass weight, lower dressing %, smaller LD muscle (DM muscle and LD area), larger fat area over LD, and lighter hams, with no significant difference in subcutaneous fat thickness (DM fat) or carcass leanness. If the influence of organic rearing is estimated for the same carcass weight, an effect is shown for fat thickness (higher than conventional), LD muscle (lower), carcass and belly leanness (lower) and LD meat:fat ratio (lower). Thus it can be speculated that organic pigs would present fatter carcasses than conventional pigs if slaughtered at the same weight.

Table 4: Carcass quality traits of pigs raised under conventional and organic rearing system[A]

	At the same age			At the same carcass weight		
	Conventional	Organic	*Sig.*	Conventional	Organic	*Sig.*
Number of animals	32	35		32	35	
Carcass weight, kg	75.8 ± 1.5	65.6 ± 2.0	***	-	-	-
Dressing, %	78.1 ± 0.5	76.2 ± 0.7	*	77.6 ± 0.5	77.2 ± 0.7	ns
DM fat, mm	14.9 ± 0.7	15.3 ± 0.9	ns	14.1 ± 0.6	16.9 ± 0.8	*
DM muscle, mm	66.7 ± 0.9	61.1 ± 1.2	***	65.5 ± 0.8	63.5 ± 1.1	ns
DM meat, %	58.1 ± 0.5	57.1 ± 0.6	ns	58.5 ± 0.4	56.2 ± 0.6	**
LD area, cm^2	44.9 ± 0.9	35.1 ± 1.2	***	43.5 ± 0.7	37.8 ± 1.0	***
Fat over LD, cm^2	13.1 ± 0.4	11.7 ± 0.5	*	12.6 ± 0.3	12.5 ± 0.4	ns
LD meat : fat ratio	3.5 ± 0.1	3.1 ± 0.1	*	3.5 ± 0.1	3.1 ± 0.1	*
Belly leanness (1-7)	5.0 ± 0.1	4.8 ± 0.2	ns	5.1 ± 0.1	4.6 ± 0.2	*
Ham, kg	9.6 ± 0.2	8.3 ± 0.3	***	9.1 ± 0.1	9.1 ± 0.1	ns
Ham in carcass, %	25.2 ± 0.2	25.4 ± 0.2	ns	25.1 ± 0.2	25.5 ± 0.2	ns
Ham meat, %	83.4 ± 0.5	82.2 ± 0.6	ns	83.7 ± 0.5	81.7 ± 0.7	*
Ham fat, %	16.6 ± 0.5	17.8 ± 0.6	ns	16.3 ± 0.5	18.3 ± 0.7	*
Ham meat : fat ratio	5.2 ± 0.2	4.7 ± 0.2	†	5.3 ± 0.2	4.5 ± 0.2	*

[A]Values in the table are LS means ± s.e.; LD - muscle *longissimus dorsi*; DM fat - minimal fat thickness over the *m. gluteus medius*; DM muscle - shortest distance between cranial end of *m. gluteus medius* and dorsal edge of vertebral canal; ns: not significant; ***P<0.001, **P<0.01, *P<0.05; †<0.10

Plasma stress markers and meat quality traits

Rearing system was not associated with any significant differences in the plasma levels of cortisol, neopterin or Hsp70 between conventional and organic pigs. However, it is worth noting that the level of Hsp70 was 2-fold higher in organic pigs.

With regard to meat quality, the rearing system had a significant effect only on pH_U and the intramuscular fat content of the LD muscle (Table 5). Although significantly higher, the difference in pH_U was small from the practical point of view and was not accompanied by any differences in colour or water holding capacity (drip loss) between organic and conventional pigs. Intramuscular fat content of the LD muscle was low in both groups of pigs, and despite lower carcass weight, the organic pigs exhibited higher intramuscular fat content than conventional pigs (1.8 vs. 1.4 %, respectively).

Table 5: Level of plasma stress markers at slaughter and meat quality traits for pigs raised under conventional and organic rearing system[A]

Item	Conventional	Organic	*Sig.*
Number of animals	32	35	
Plasma stress markers			
Cortisol, µg/dL	10.3 ± 1.1	10.7 ± 1.3	ns
Neopterin, nmol/L	3.0 ± 0.5	2.8 ± 0.6	ns
Hsp70, ng/mL	3.6 ± 1.4	7.4 ± 1.6	†
Meat quality traits			
SM pH_1	6.30 ± 0.06	6.44 ± 0.10	ns
SM pH_U	5.64 ± 0.03	5.66 ± 0.04	ns
LD pH_1	6.03 ± 0.08	6.17 ± 0.12	ns
LD pH_U	5.52 ± 0.01	5.58 ± 0.02	**
LD colour (1-6)	3.6 ± 0.1	3.6 ± 0.1	ns
Minolta L*	54.1 ± 0.5	54.4 ± 0.7	ns
Minolta a*	6.1 ± 0.2	6.2 ± 0.3	ns
Minolta b*	2.7 ± 0.1	2.8 ± 0.2	ns
Drip loss 24h , %	4.3 ± 0.5	4.9 ± 0.7	ns
Drip loss 48h, %	6.4 ± 0.5	7.2 ± 0.7	ns
Intramuscular fat, %	1.40 ± 0.10	1.77 ± 0.13	*

[A]Values in the table are LS means ± s.e.; SM - muscle *semimembranosus*; LD - muscle *longissimus dorsi*; pH_1 - pH measured one hour after slaughter; pH_U - pH measured 24 hours after slaughter; ns - not significant; **P<0.01, *P<0.05; † P<0.10; Frequency of PSE meat (fast pH fall shortly *post-mortem*) was 18% in conventional and 20% in organic pigs

Discussion

Growth performance

The lower growth rate of the organic pigs started during the last stage of lactation and persisted until 22 weeks of age. To explain growth retardation several factors should be considered, which may have interacted, the prolonged lactation, the lower post-weaning feed intake (due to less palatable organic feed or its lower protein level) and larger space provided to organic pigs, which will be discussed below.

The observed growth retardation in weeks 4-6 can be related to the prolonged lactation of organic pigs, which results from the diminished milk yield of the sows at the end of lactation, although all the pigs were supplied with additional concentrate. The most noticeable decrease of growth rate in organic pigs was observed post-weaning and it coincides with lower feed intake of organic pigs. The importance of feed intake for growth traits has previously been demonstrated (22). A possible reason for the lower feed intake, given that we observed no particular problem with diarrhoea in the organic pigs, could be the lower palatability of the organic feed mixture (1). It is also possible that the animals felt satiated earlier on the organic diet. The regulation of the appetite is a complex mechanism which acts via ghrelin, a 28-amino acid peptide. Ghrelin is involved in tryptophan-mediated appetite stimulation in swine (23) and has been shown to be stimulated by protein ingestion in men (24,25). Deficiency of tryptophan has been shown to reduce appetite and feed intake in pigs (26,27).

Moreover, the organic feed concentrate used for organic pigs in the growing phase had lower concentrations of protein and lysine than the conventional diet (Table 2), which is critical in the first stage of fattening. The availability of essential amino acids adequate for growth is known to be the main difficulty in organic feeding of pigs (28). Organic standards, and especially the ban on synthetic amino acids, make it difficult to meet the amino acid requirements of young pigs. Organic sources rich in amino acids and in lysine could be produced, but are expensive and therefore rarely produced and used for economical reasons. In the present study, commercially available diet was used containing 8.0 g/kg of lysine (Table 2), whereas according to Sundrum (29) requirements for suckling piglets and weaners can be covered with diets containing at least 12 g lysine/kg.

Underfeeding or nutrient deprivation during the post-weaning period has a major impact on subsequent growth performance (30). Accelerated growth following a period of slower growth, as a result of restricted feeding or nutrient deprivation, is defined as compensatory growth. The use of feeding strategies for obtaining compensatory growth in organic pigs has been of interest (11,31), especially because of the problems with protein supply in organic pig production.

In the finishing period (weeks 22–26) the growth rate of the organic and conventional pigs was comparable. Requirements for amino acids, especially lysine, decrease as animals get older and heavier (32), and the lysine content of both diets in the later phases of this experiment was sufficient (29). In the finishing period the organic pigs received the same quantity of feed, and of similar composition, as the conventional pigs, which was sufficient to cover the needs for increased growth rate of organic pigs due to lower body weight.

Due to lower feed intake, the organic pigs had lower feed conversion efficiency. However, we cannot exclude the possibility that feed efficiency might have been affected by other parameters such as feed composition, pen space, and outdoor access. The greater physical activity of pigs, which were allocated a larger space and access to an outdoor area, may have resulted in higher energy expenditure.

Comparison of the results of the present study with similar literature reports (studies using feeding of organic concentrates) shows inconsistency. In agreement with our results, Enfält *et al.* (6) observed a delay in reaching slaughter weight for pigs grown under organic conditions with outdoor access, as compared to conventional pigs, although in their study pigs were fed *ad libitum* throughout the experiment and had more outdoor space as in the present study. On the contrary, Millet *et al.* (8) observed a better growth rate for pigs in organic housing that were fed organic feed concentrate *ad libitum*, as compared to conventional pigs. Several other studies have also reported a higher feed intake and growth rate for organic pigs, as compared to conventional pigs (1,2,10). Strudsholm and Hermansen (11) reported that when pigs had been fed *ad libitum* with concentrates, indoor compared with outdoor rearing did not affect growth rate, only feed consumption (which increased). The value of the present study is a demonstration of possible problems with commercially available organic feed mixtures for piglets in early life, which was reflected in growth performance.

Carcass quality

Due to slower growth of organic as compared to conventional pigs, carcass weight and consequently other carcass traits were affected. Differences between the organic and conventional pigs were observed mainly for the traits of muscularity, for which the most influential explanatory factors seem reduced growth rate due to lower feed intake and limited supply of proteins in organic feed concentrate. The comparison between organic and conventional pigs simulated for the same carcass weight indicated that organic pigs would be fatter if slaughtered at the same weight as conventional pigs. This result can be related to the compensatory growth of organic pigs affecting the deposition of adipose rather than muscle tissue.

Published studies dealing with pig carcass traits under organic production regimes (1,2,6,8,10,11) show significant effects of housing and feeding, but the results are difficult to compare and inconsistent since they reflect the variability in the feeding and housing systems applied in different studies. One study (2) however can be highlighted which showed no difference in carcass quality when organic and conventional pigs were reared *ad libitum*, while 70% restriction of concentrates given to organic pigs reduced their growth rate and increased the lean meat percentage.

Plasma stress markers and meat quality

In the present experiment the main purpose of assessing plasma stress markers at slaughter was to monitor for the effect of slaughter day (and preslaughter susceptibility to stress), owing to its importance for meat quality. The biochemical markers used (cortisol, neopterin and Hsp70) reflect different aspects of stress. Cortisol is the main hormone of hypothalamic–pituitary–adrenocortical axis and is released by the adrenal cortex in response to stress. It influences feeding behaviour, pancreatic hormone secretion, energy expenditure, and protein/lipid balance (33). In the present study, plasma cortisol levels at slaughter were similar in pigs from both rearing systems. The comparable level of cortisol indicates a similar stress response to the pre-slaughter procedures for both rearing systems. Studies that deal with the cortisol level in different rearing systems are rare. In accordance with our results, Barton-Gade (7) and Lebret *et al.* (28) reported no effect of rearing system on the plasma cortisol level prior to slaughter. A comparable level of neopterin in organic and conventional pigs is an indicator of similar health status, because studies suggest it is a good marker of cellular immune activation, with increased concentrations detected in infections, autoimmune diseases and animals with tumours (34). Hsp70 is a stress-limiting factor that is involved in the response to stress at a cellular level (35). The results of the present study suggest that rearing system was not associated with plasma Hsp70 level. Despite this, it is interesting to observe that the level of Hsp70 was 2-fold higher in organic pigs. A possible explanation for the lack of significance was the high variation within groups. Nevertheless, we can consider this result indicative of a stronger response of the organic pigs to stress in terms of cell protein protection.

Regarding meat quality an effect of rearing system was observed only for pH_U and LD intramuscular fat content, both being higher in organic pigs. Differences in pH_U were not big enough to be reflected in LD colour or drip loss, which are properties important for the consumer, and highly correlated to pH_U (36). In contrast to our results, higher pH_U values in conventional as compared to organic pigs (6,8), or no differences (2,9), have been reported. Studies show, that intramuscular fat is higher in older and heavier pigs and follows general body adiposity (37,38). Despite a considerably lower carcass weight, higher intramuscular fat was observed in organic pigs in the present study, which can be related to feeding. A strategy of restriction and re-alimentation has been suggested to increase intramuscular fat content (38). Contrary to our result, organic feeding has often been shown to reduce intramuscular fat (1,6,10), or no effect has been observed (2). On the whole, the results of the present study corroborate previous reports which show limited effect of organic production on meat quality.

Conclusions

In comparison to conventional rearing, in the present study, organic pigs exhibited post-weaning growth retardation and as a consequence lower carcass quality. The increased growth rate of organic pigs in the last fattening phase, following the initial growth retardation, explains lower carcass quality and higher intramuscular fat content, the latest being of interest in terms of improved meat quality. The results of the present study indicate possible problems associated with the use of commercially available organic diets for piglets.

Acknowledgements

The authors acknowledge the financial support by Slovenian Research Agency (project J4-9532, project V4-0338, program P4-0072) and partly by the Ministry of Agriculture Forestry and Food.

References

1. Millet S, Hesta M, Seynaeve M, et al. Performance, meat and carcass traits of fattening pigs with organic versus conventional housing and nutrition. Livest Prod Sci 2004; 87: 109–19.

2. Hansen L, Claudi-Magnussen C, Jensen S, Andersen H. Effect of organic pig production systems on performance and meat quality. Meat Sci 2006; 74: 605–15.

3. Chang J, Lusk J. Fairness and food choice. Food Policy 2009; 34: 483–91.

4. Bornett H, Guy J, Cain P. Impact of animal welfare on costs and viability of pig production in the UK. J Agric Environ Ethics 2003; 16: 163–86.

5. Council Regulation (EC) No 889/2008 of 5 Septembre laying down detailed rules for the implementation of Council Regulation (EC) no 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. Off J Eur Union L 2008; 51(250): 1-84.

6. Enfält A, Lundström K, Hansson I, Lundeheim N, Nyström P. Effects of outdoor rearing and sire breed (Duroc or Yorkshire) on carcass composition and sensory and technological meat quality. Meat Sci 1997; 45: 1–15.

7. Barton–Gade P. Effect of rearing system and mixing at loading on transport and lairage behaviour and meat quality: comparison of outdoor and conventionally raised pigs. Animal 2008; 2: 902–11.

8. Millet S, Raes K, Van den Broeck W, De Smet S, Janssens G. Performance and meat quality of organically versus conventionally fed and housed pigs from weaning till slaughtering. Meat Sci 2005; 69: 335–41.

9. Oksbjerg N, Strudsholm K, Lindahl G, Hermansen JE. Meat quality of fully or partly outdoor reared pigs in organic production. Acta Agric Scand 2005; 55: 106–12.

10. Olsson V, Andersson K, Hansson I, Lundström K. Differences in meat quality between organically and conventionally produced pigs. Meat Sci 2003; 64: 287–97.

11. Strudsholm K, Hermansen J. Performance and carcass quality of fully or partly outdoor reared

pigs in organic production. Livest Prod Sci 2005; 96: 261–8.

12. Zakon o zaščiti živali = Law on Animal Protection. Uradni List RS 2007; 17(43): 5943

13. Commission Regulation (EC) No 1249/2008 of 10 December 2008 laying down detailed rules on the implementation of the Community scales for the classification of beef, pig and sheep carcasses and the reporting of prices thereof. Off J Eur Union L 2008; 51(337): 3–30.

14. IBL International. Cortisol ELISA: enzyme immunoassy for the in-vitro-diagnostic quantitative determination of free cortisol in human saliva and total cortisol in dilutet serum. RE52611: instruction for use 2008. Hamburg: IBL International GMBH, 7 str.

15. Assay designs. Hsp70 higs sensitivity EIA kit: enzyme immunoassay kit for quantitative determination of Hsp 70 in human serum and plasma. EKS-715: instruction for use 2008. Hamburg: IBL International GMBH, 16 str.

16. IBL International. Neopterin ELISA: enzyme immunoassay for the in-vitro-diagnostic quantitative determination of neoptherin in human serum, plasma and urine. RE59321: instruction for use 2008. Hamburg: IBL International GMBH, 6 str.

17. Commission decision of 18 February 2008 amending Decision 2005/879/EC authorising methods for pigs carcases in Slovenia. Off J Eur Union L 2008; 51(56): 28–30.

18. CIE. Recommendations on uniform color spaces-color difference equations, psychometric color terms. International Commission on Illumination, CIE Publication No.15, Supplement 2, 1978.

19. Nakai H, Saito F, Ikeda T, Ando S, Komatsu A. Standard models of pork colour. Bull Nat Inst Anim Ind 1975; 29: 69–74.

20. Christensen L. Drip loss sampling in porcine m. longissimus dorsi. Meat Sci 2003; 63: 469–77.

21. Prevolnik M, Čandek-Potokar M, Škorjanc D, et al. Predicting intramuscular fat content in pork and beef by near infrared spectroscopy. JNIRS 2005; 13: 77–85.

22. Arthur P, Giles L, Eamens G, Barchia I, James K. Measures of growth and feed efficiency and their relationships with body composition and carcass traits of growing pigs. Anim Prod Sci 2009; 49: 1105–12.

23. Zhang H, Yin J, Li D, Zhou X, Li X. Tryptophan enhances ghrelin expression and secretion associated with increased food intake and weight gain in weanling pigs. Domest Anim Endocrinol 2007; 33: 47–61.

24. Erdmann J, Lippl F, Schusdziarra V. Differential effect of protein and fat on plasma ghrelin levels in man. Regul Pept 2003; 116: 101-7.

25. Erdmann J, Topsch R, Lippl F, Gussmann P, Schusdziarra V. Postprandial response of plasma ghrelin levels to various test meals in relation to food intake, plasma insulin, and glucose. J Clin Endocrinol Metab 2004; 89: 3048-54.

26. Eder K, Peganova S, Kluge H. Studies on the tryptophan requirement of piglets. Arch Anim Nutr 2001; 55: 281–97.

27. Seve B, Le Floc'h N. Mutual valorisation of crystalline L-tryptophan and L-threonine in starter feed for piglets. Role of the liver threonine dehydrogenase. J Rech Porcine Fr 1998; 30: 209–16.

28. Lebret B, Meunier-Salaun MC, Foury A, Mormede P, Dransfield E, Dourmad JY. Influence of rearing conditions on performance, behavioral, and physiological responses of pigs to preslaughter handling, carcass traits, and meat quality. J Anim Sci 2006; 84: 2436–47.

29. Sundrum A. Managing amino acids in organic pig diets. In: Hovi M, Baars T, eds. Proceedings of 4th NAHWOA Workshop. Wageningen, 2001: 181–91.

30. Le Dividich J, Sève B. Effects of underfeeding during the weaning period on growth, metabolism, and hormonal adjustments in the piglet. Domest Anim Endocrinol 2000; 19: 63–74.

31. Fernández J, Nørgaard J. Compensatory growth in slaughter pigs reared under organic conditions. J Sci Food Agric 2009; 89: 1376–81.

32. van Milgen J, Valancogne A, Dubois S, Dourmad J, Sève B, Noblet J. InraPorc: a model and decision support tool for the nutrition of growing pigs. Anim Feed Sci Technol 2008; 143: 387–405.

33. Dallman MF, Strack AM, Akana SF, et al. Feast and famine: critical role of glucocorticoids with insulin in daily energy flow. Front Neuroendocrinol 1993; 14: 303–47.

34. Breineková K, Svoboda M, Smutná M, Vorlová L. Markers of acute stress in pigs. Physiol Res 2007; 56: 323–29.

35. Liu Y, Steinacker JM. Changes in skeletal muscle heat shock proteins: pathological significance. Front Biosci 2001; 6: 12–25.

36. Prevolnik M, Čandek-Potokar M, Novič M, Škorjanc D. An attempt to predict pork drip loss from pH and colour measurements or near infrared spectra using artificial neural networks. Meat Sci 2009; 83: 405–11.

37. Čandek-Potokar M, Žlender B, Lefaucheur L, Bonneau M. Effects of age and/or weight at slaughter on longissimus dorsi muscle: biochemical traits and sensory quality in pigs. Meat Sci 1998; 48: 287–300.

38. Lebret B. Effects of feeding and rearing systems on growth, carcass composition and meat quality in pigs. Animal 2008; 2: 1548–58.

RASTNOST, KLAVNE LASTNOSTI IN KAKOVOST MESA PRAŠIČEV, VZREJENIH V EKOLOŠKEM ALI KONVENCIONALNEM NAČINU REJE Z UPORABO KOMERCIALNO DOSTOPNIH KRMNIH MEŠANIC

M. Prevolnik, M. Ocepek, M. Čandek-Potokar, M. Bavec, D. Škorjanc

Povzetek: Cilj raziskave je bil oceniti rastnost pujskov od rojstva do zakola, klavne lastnosti in kakovost mesa prašičev, vzrejenih bodisi konvencionalno (n = 32) ali upoštevajoč standarde ekološke reje (n = 35) ob uporabi ekoloških krmnih mešanic, ki so na voljo na trgu. V tej raziskavi je bila poraba krme od odstavitve do 11. tedna za 22 % nižja pri prašičih iz ekološke reje. Posledično so ekološko vzrejeni prašiči imeli nižje priraste vse do 22. tedna starosti. V zadnji fazi pitanja (od 22. do 26. tedna), ko je bila razpoložljiva krma omejena, se je prirast pri konvencionalnih pitancih zmanjšal, pri ekoloških pa povečal. Vsi prašiči so šli v zakol pri običajni komercialni starosti (26 tednov). Zaradi počasnejše rasti so imeli ekološko vzrejeni prašiči manjšo maso trupa, manjši klavni izplen, manjšo mišico *longissimus dorsi* (LD) in lažja stegna, medtem, ko pri debelini podkožne maščobe in mesnatosti trupov (z izjemo površine podkožne maščobe nad LD) ni bilo razlik. Ob korekciji na maso trupov je analiza pokazala, da bi ekološki prašiči imeli bolj zamaščene trupe kot konvencionalni, če bi bili zaklani pri enaki masi. V zvezi s kakovostjo mesa je bila pri ekološko vzrejenih prašičih ugotovljena višja vrednost pH po 24 urah in višja vsebnost mišične maščobe. Rezultati kažejo, da pitanje prašičev z uporabo komercialno dostopnih ekoloških krmnih mešanic za pujske lahko vodi v slabše proizvodne rezultate (manjše zaužitje krme, nižji prirasti), po drugi strani pa lahko takšna dieta poveča vsebnost mišične maščobe, ki je zanimiva zaradi izboljšanja kakovosti mesa.

Ključne besede: ekološka reja; rast; klavna kakovost; kakovost mesa; stres; prašič