EFFECT OF OUTDOOR REARING SYSTEM ON FAT DEPOSITION AND EATING QUALITY IN ORGANIC HEAVY PIGS

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Background

Over the last years, the interest in organic production has increased considerably in Italy. However, only a small percentage of pigs today are organically produced (about 0,2 % of total slaughtered pigs in 2003). Nevertheless, the organic sector, both fresh meat (loin) and traditional processed products (dry cured ham, salami, etc.), is growing. The possibility of fattening pigs through outdoor system using pasturage field, seems to meet the organic regulation requirements for animal welfare and farmer demand for low cost investments (housing and manure utilisation). Over the last ten years, several studies were published on the effects of outdoor rearing system on growth performance, carcass composition and meat quality traits of fattened pigs. However, almost all research has considered the slaughter animal live weight approximately between 80 to 110 kg. Effects of grazing, physical activity (exploring, rooting, etc), fattening season (cold or hot weather, raining days), soil conditions (type of cover crops, watery mud), on fresh meat quality traits are still not well known. Investigations on eating quality, mainly performed on loins (*M. Longissimus dorsi*), have produced contradictory results, as far as pigs from different rearing (outdoor *vs* indoor) or finishing systems (conventional *vs* organic) have been compared.

Objectives

In the Italian production, more than 80 % of pigs are slaughtered at an average live weight of 165-170 kg (heavy pig, with minimum age of 9 months) for traditional dry cured ham production. The quality traits of fresh ham intended for curing have obviously been considered more important than those of other cuts. However, eating quality profile of fresh loin is also a concern for organic driven consumers.

This study investigates the main eating quality traits of pork loin (*M. Longissimus dorsi*) from outdoor and indoor organically produced heavy pigs.

Materials and methods

Investigation was carried out using a total of 96 samples of pork loin from heavy pigs –castrated male only-, produced in 3 different organic farms, and slaughtered at the same abattoir during 4 trials.

Animals

The pigs were from three-way cross-bred slaughter pigs, where the terminal sire was pure-bred traditional Italian Large White and the dams were crosses between Landrance and Duroc. All piglets came from one herd, organic farm with reproductive outdoor system; after 45 days of farrowing and 55 days of post-weaning, pigs were delivered to the three finishing farms (average live weight 37.7 ± 3.8 kg). Some pigs was stalled in a conventional piggery according to organic specification (indoor rest area with deep straw and outdoor concrete paddock) in groups of 8. The pigs reared outdoors were kept in grass fields (2/3 grass 1/3 wood bush, about 3000 m^2 each group of 8 animals). All pigs were fed restrictedly twice a day with the same commercial organic feed (15.5% crude protein, 0.65% lysine, 1.8% linoleic acid, 12.2 MJ of ME/kg of dry matter) receiving 2.0-2.5-3.0 and 3.5 kg/d of feed approximately at 40-80-110-140 kg of live weight (the study started in May and ended in November 2003). After 3 h of transport and 2h of rest in the lairage, pigs were electrically stunned and slaughtered.

Meat

At the end of slaughter line, the estimation of carcass meat percentage was performed using FOM (Fat o Meter equipment) by measuring subcutaneous fat (twice) and LD muscle depth. Subcutaneous fat thickness of fresh ham was also manually measured in the lateral side at level of *M. Biceps Femoris*. Carcasses were immediately hot boned (approximately 40-45 minutes after slaughter), and the primal cuts were cooled

separately (loins-rib in, shoulders, hams, bellies, back fat, and neck cuts) at 0-2 °C for 24 h (air speed 0.5 m/s), as usual in Italian pig slaughterhouses. pH was measured at 45 min and 24 h by inserting the electrode in the *M. Longissimus dorsi* at the last rib. A 10-12 cm section of LD sample was dissected from each loin (right side), after 24 h cooling (above the last rib), vacuum packed and transported to the lab for analysis. From each sample a slice of 2.5 cm thick was used for cooking loss and shear force measurement, using a Instron equipment with Warner Bratzler device on boiled meat (cooking was complete when central temperature reached 75 °C). Two chops of 2.5 cm thickness were assigned to panel test (8 trained panellists) for sensory analysis on roosted meat, cooked in oven (cooking was complete when central temperature reached 75 °C). The panellists used an 8-point category scale to score the tenderness, juiciness, pork flavour and overall palatability. Both shear force and sensory analysis were performed on fresh meat after 3 days of ageing. A slice of fresh meat was used for chemical determination of intramuscular fat (IMF) and fatty acid composition (Riley et al., 2000).

Statistical analysis

Lean meat percentage, fat thickness, ph, IMF, fatty acid composition and sensory data were analysed by general linear model procedures (SAS procedure GLM). Rearing system, batch and finishing farm were considered as fixed effects. The two-way interaction between rearing system and farm were also tested. Differences between pair-wise combinations of the least square means were tested for significance ($P<0.05$).

Results and discussion

Main results of carcass quality traits are shown in Table 1. Organic pigs finished outdoors had lighter carcass weights, leaner carcasses and less subcutaneous fat deposits (P <0.005). Difference in daily gain and carcass weight between indoor and outdoor rearing system in finishing pigs may be explained with the different amount of energy needed for physical activities (exploring, rooting, etc.) of free ranging pigs, as reported in similar studies (Enfalt et al., 1997; Sather et al. 1997). However, other studies (Beattie et al., 2000; Gentry et al., 2002) found a positive or no effect of rearing system on average daily gain and carcass weight, in outdoor finished pigs. It is clear that the level of physical activity depends on e.g., soil characteristics, presence of mud, raining days and climate conditions (temperature, day light etc).

Table 1. Least square means for carcass and main LD quality traits

	rearing system (RS)			significance	
Trait	indoor	outdoor	SE	farm	farm x (RS)
Carcass traits					
Cold carcass weight (kg)	133.4[a]	127.2[b]	5.65	<0.05	<0.05
Lean meat (%)	50.6[b]	52.2[a]	1.85	n.s.	n.s.
P2 fat thickness (mm)	32.3[a]	30.1[b]	2.12	<0.05	n.s.
Ham fat thickness (mm)	27.7[a]	25.5[b]	1.15	n.s.	n.s.
LD quality traits					
Ph 1	6.37	6.42	0.12	n.s.	n.s.
Ph 24	5.57	5.52	0.08	n.s.	n.s.
Intramuscular fat (%)	3.8[b]	4.1[a]	0.22	n.s.	<0.05
Shear force (kg)	2.8	2.9	0.27	n.s.	n.s.
Cooking loss (%)	28.6	27.4	2.04	n.s.	n.s.
LD sensory analysis					
Tenderness	4.36	4.17	0.16	n.s.	n.s.
Juiciness	4.65[b]	4.88[a]	0.21	n.s.	n.s.
Pork flavour	3.31	3.48	0.13	n.s.	n.s.
Overall liking	3.84[b]	4.12[a]	0.11	n.s.	n.s.

LSM estimates with different superscript, within a row (rearing system) differ, $P < 0.05$; n.s. not significant

All these environmental, management and climate variables may play a critical role in increasing or decreasing of the activities of free range pigs, making the comparison between different studies difficult. During this experiment (from May to November, 2003) high summer-autumn temperatures and a long rainless period, may have reduced the environmental effect on energy consumption.

Significant reduction of backfat in carcasses from outdoor finished pigs was observed, with consequent increasing of estimated lean meat percentage. Lean meat percentage values found in this experiment are not comparable with other findings from similar studies, because of the great difference on carcass weight and specific estimating equation used.

An unexpected significant reduction of subcutaneous fat was found in the ham of the outdoor finished pigs. This may be considered a negative aspect, since the required level (Regulation for typical Italian cured ham, EC origin protected product) is fixed at 20 mm minimum of thickness. However, more data should be recorded to clarify if the intense physical activity of free range could affect the development of thighs (bone length and ham thickness etc.).

Intramuscular fat of outdoor finished pigs was significantly higher than that of the indoor finished. The result is in agreement with Gentry et al. (2002), but conflicts with the findings of Enfalt et al., (1997) and Danielsen et al. (2000). Nevertheless, the high carcass weight and the age of pigs in this experiment, call for great attention on comparative findings from different studies. It is possible that in long fattening period with restricted feed, the age (9-10 months), physical activity and muscles maturity, may play an important role on shifting fat deposition from subcutaneous to intramuscular depots. No significant differences were found concerning pH1 and pH24, Warner Bratzler shear force on cooked meat, or cooking loss between the two rearing system.

Table 2. Fatty acid composition (% least square mean and standard error) in intramuscular fat from LD

	rearing system		
Fatty acid	indoor	outdoor	SE
14:0	1.36	1.43	0.08
16:0	26.18	25.48	0.32
16:1 n-7	2.93	2.72	0.12
17:0	0.15	0.16	0.01
18:0	13.12	12.94	0.27
18:1 n-9	43.86	43.66	0.21
18:1 n-7	3.36	3.47	0.05
18:2 n-6	6.12[b]	7.03[a]	0.23
18:3 n-3	0.74[b]	0.81[a]	0.02
20:0	0.46	0.35	0.09
20:2 n-6	0.54	0.61	0.02
20:4 n-6	0.27[b]	0.36[a]	0.03
SAFA	41.27[a]	40.36[b]	0.27
MUFA	50.69	50.46	0.38
PUFA	7.13b	8.20a	0.31

LSM estimates with different superscript, within a row (rearing system) differ, $P < 0.05$; Identified fatty acids below 0.15% -trace- are not shown

Eating quality can usually be well described by a sensory panel. Juiciness and pork flavour are probably the most important meat quality traits for consumers eating pork. In this experiment, no differences were found for tenderness and pork flavour. However, the panellists found the meat of outdoor finished pigs juicier and more acceptable (overall liking). Several researchers have found no differences in the eating quality of pork when comparing pork from indoor and outdoor rearing (Van der Wall et al., 1993; Jonsall et al., 2000), nor a negative effect on tenderness or juiciness (Enfalt et al., 1997). Jensen and Jakobsen (1996) did, however, report a clear difference in meat quality and sensory quality between loins from organic pigs reared indoors and outdoors. Also Gentry et al. (2002), reported that meat from outdoor finished pigs has higher flavour intensity. In this experiment, better juiciness scores of loins from outdoor finished pigs compared to indoor finished, may be linked with the higher level of intramuscular fat found. No easy comparison is possible from the sensory quality results of this experiment and other similar studies, since slaughter procedure applied in Italy (hot boning and loin dissection from bones, with high risk of cold shortening before rigor mortis) may play a critical role on influencing tenderness and juiciness.

Fatty acid composition in the intramuscular fat of the loins (*M. Longissimus dorsi*) are show in Table 2.

Only small differences in fatty acid composition (%) between the loins of outdoor and indoor finished pigs were found. A slight increase in unsaturated fatty acids was observed for 18:2 n-6, 18:3 n-3 and 20:4 n-6, from outdoor finished pigs, and consequently, SAFA and PUFA were significantly affected. The fatty acid composition of the pork intramuscular fat has been reported to be affected by feed composition (Kouba et al., 2003), breed or genotype, sex as well as carcass fatness (Wood et al., 2003). Furthermore, it has been suggested that the rearing system may affect the lipid composition of pig muscles (Hogberg et al., 2001) when interacting with sex and genotype.

The differences found in this experiment in polyunsaturated fatty acid (18:2 n-6, 18:3 n-3 and 20:4 n-6) composition may due to the intense physical activity of outdoor finishing pigs compared to the indoor groups, with consequent change on lipid classes (neutral and polar lipid) with their respective roles in living animal (Clarke, 2000). However, because outdoor pigs were reared in a large grazing area, the amount and quality of grass daily ingested may have affected the total amount of unsaturated fatty acids in the feed. No significant effect of the type of organic finishing farm was found on the fatty acid composition of IMF.

Conclusions

Overall, results comparing indoor and outdoor pig finishing systems have been variable. Some reasons for this variation include differences in seasonal effects, ground type, grazing area, genotype and final slaughter weight. Organic production system with its specific managing and feeding requirements, may also affect the performance and meat quality of outdoor finished pigs. Changes in carcass composition (leaner of fatter) and fat distribution, in outdoor finished pigs compared to the indoor-finished, may represent a positive or negative aspect depending on final product destination (fresh meat or traditional cured salami).

Manipulation of fatty acid composition, by changing feed composition and feeding regime in outdoor organic pig finishing system, using grass or silages, will have to be carefully tested on large scale experiments. For processed products with long curing, such as dry cured ham (14-16 months of seasoning), increasing of PUFA should be carefully monitored, for increasing risk of fatty acids oxidation and off-flavour development.

References

Beattie, V. E., N. E. O'Connell, and B. W. Moss, 2000. Influence of environmental enrichment on the behavior, performance and meat quality of domestic pigs. Livest. Prod. Sci. 65:71–79.

Clarke, S. D., 2000. Polyunsaturated fatty acid regulation of gene transcription: a mechanism to improve energy balance and insulin resistance. British J. Nutr., 83, 59-66.

Danielsen, V., Hansen, L.L., Moller, F., Bejerholm, C., and Nilsen, S., 2000. Production results and sensory meat quality of pigs fed different amount of concentrate and ad lib clover grass or clover silage. In Ecological Animal Husbandry in the Nordic Countries. Proc.NJF Seminar DARCOF, report (2): 79-86.

Enfalt, A.-C., Lundstro¨m, K., Hansson, I., Lundeheim, N., Nystrom, P.-E., 1997. Effects of outdoor rearing and sire breed (Duroc or Yorkshire) on carcass composition and sensory and technological meat quality. Meat Sci. 45, 1-15.

Gentry, J. G., J. J. McGlone, M. F. Miller, and J. R. Blanton, Jr., 2002. Diverse birth and rearing environment effects on pig growth and meat quality. J. Anim. Sci. 80:1707–1715.

Hogberg, A., Pickova, J., Dutta, P. C., Babol, J., and Bylund, A. C., 2001. Effect of rearing system on muscle lipids of gilts and castrated male pigs. Meat Sci, 58, 223-229.

Jensen, B., and Jakobsen, K., 1996. Kvalitet og ernearingmaessig vaerdi agokologiske svin. HusdyrForskning, 4(1), 11-15.

Jonsall, A., Johansson, L., and Lundstrom, K., 2000.. Sensory quality and cooking loss of ham muscle (M. Biceps femoris) from pigs reared indoors and outdoors. Meat Sci., 57, 245–250.

Kouba, M., Enser, M., Whittington, F. M., Nute, G. R., & Wood, J. D., 2003. Effect of a high linolenic acid diet on lipogentic enzyme activities, fatty acid composition and meat quality in the growing pig. J. Anim. Sci., 81, 1967–1979.

Riley, P. A., Enser, M., Nute, G. R., & Wood, J. D., 2000. Effects of dietary linseed on nutritional value and other quality aspects of pig muscle and adipose tissue. Anim. Sci., 71, 483–500.

SAS Institute, 1995. SAS users guide system for Windows, release 6.11. Cary, NC: SAS Institute INC.

Sather, A. P., S. D. M. Jones, A. L. Schaefer, J. Colyn, and W. M. Robertson., 1997. Feedlot performance, carcass composition and meat quality of free range reared pigs. Can. J. Anim. Sci. 77 (2): 225-232.

Van der Wal, P. G., Mateman, G., de Vries, A. W., Vonder, G. M. A., Smulders, F. J. M., & Geesink, G. H., 1993. 'Scharrel' (free range) pigs: carcass composition, meat quality and taste-panel studies. Meat Science, 34, 27–37.

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