PIG HOUSING AFFECTS THE FATTY ACID COMPOSITION OF PORK FAT

Trezona, M.[1,2], Pluske, J.[2], Mullan, BP[1] and D'Souza, DN.[1]

[1]Department of Agriculture, Locked bag no. 4, Bentley Delivery Centre, 6983, Western Australia
[2]Division of Veterinary and Biomedical Sciences, Murdoch University, Murdoch, Western Australia 6150

Background

There has been a rapid uptake of low-cost deep litter housing systems for intensive pig production in Australia over the past decade. This housing system provides a low capital investment alternative to intensive pig housing systems, where pigs are raised in insulated buildings, in small groups of 8 to 15 pigs per pen on fully or partially slatted concrete floors. In deep litter systems, pigs are raised in large groups of 100 or more on bedding, such as straw, in canvas covered, naturally ventilated structures. Studies investigating the impact of rearing pigs outdoors in paddocks versus indoors in conventional housing have shown differences in pig growth, carcass quality and pork quality (Nilzen *et al*. 2001; Gentry *et al.* 2002; Gentry *et al.* 2004). Lambooij *et al*. (2004) investigated the effects of housing conditions on pork quality characteristics, and concluded that the differences in pork quality can be substantial when the differences in housing conditions are large. Hence we would expect that the inherent differences between conventional and deep litter housing systems may similarly affect carcass quality and eating quality.

The fatty acid composition in various depots such as subcutaneous, intermuscular and intramuscular fat affects the technological aspects of meat quality. Differing concentrations of fatty acids have been shown to influence the firmness of the fat which has implications for the appearance and cutting of fresh and processed pork (Tume and D'Souza, 1999). Fatty acid composition can also influence fat colour, with fat of a higher melting point appearing whiter than fat with a lower melting point (Wood *et al.* 2003). The consumption of polyunsaturated fatty acids has been found to benefit human health, but increased levels of polyunsaturated fat in meat have detrimental effects on product shelf life as these fatty acids tend to oxidise rapidly and therefore rancidity and colour deterioration is accelerated (Wood et al 2003).

A number of factors can affect the fatty acid composition of various fat depots in pigs. Generally as the age of the pig increases, the fat becomes more saturated (Cameron *et al.* 1990). The rate of fat deposition can also affect the concentration of polyunsaturated fatty acids within the tissue, where the concentration generally increases when the rate of fat deposition slows (Bee *et al* 2004; Rehfeldt *et al* 1994). Unlike ruminants the fatty acid composition of the tissue of pigs is largely a reflection of the fatty acid pattern of the diet (Wiseman and Augunbiade, 1998), particularly in regards to the essential fatty acids such as linoleic and linolenic acid which are preferentially deposited within tissue and can only be obtained through the diet. Ambient temperature also influences fatty acid composition with pigs raised in cooler environments tending to have higher levels of unsaturated fatty acids and softer fat compared to pigs raised in warm environments (Tume and D'Souza, 1999).

Objectives

The aim of this study was to quantify the effect of housing systems currently used in Australia on the fatty acid composition of subcutaneous backfat in the growing pig.

Materials and methods

The experimental design is a 2 x 2 factorial with two housing types, conventional versus deep litter, and two slaughter ages, 13 weeks (about 50 kg liveweight) and 24 weeks (about 110 kg liveweight).

One hundred and fifty two Large White x Landrace female pigs were obtained at weaning from a high health status commercial piggery at 3 weeks of age. Pigs were stratified by weaning weight into two housing treatments, conventional or deep litter and within each treatment pigs were allocated to a predetermined slaughter date based on age. Eight pigs from each housing treatment were slaughtered at 13 and 24 weeks of

age. In the conventional housing treatment pigs were housed in 8 groups of 9 pigs per pen. Each group was randomly allocated to 8 pens in a conventional weaner facility until 9 weeks of age and then randomly allocated to 8 pens in a conventional grower/finisher facility until slaughter. In the deep litter housing treatment eighty pigs were housed together in one large group. At 9 weeks of age the piglets were moved from the deep litter weaner facility to a deep litter grower finisher facility.

The conventional weaner facility was within an insulated thermostatically controlled building. Pens had a mesh floor in the drinking and dunging area and a solid concrete lying area which was heated. Each pen was 1.2 x 3.1 m and equipped with 4 nipple drinkers and a multiple space feeder. The conventional grower/finisher facility was within an insulated shed and pigs were housed in concrete pens with a solid concrete lying area and a slatted area for dunging. Pens were 2.4 x 3.1 m and equipped with two nipple drinkers and one single spaced feeder per pen.

The weaner deep litter facility was within an open ended canvas covered hoop structure 9 x 14.4 m. The shelter had a concrete feeding and drinking platform with the remainder of the shelter bedded with wheat straw. Extra straw bales were placed with the shelter to provide added protection from the weather. The deep litter housing system was quipped with two multiple spaced feeders and 6 bowl drinkers. The grower finisher deep litter facility was an open ended canvas covered hoop structure that had been divided down the length into two pens. The experimental pigs were housed in one pen (4.5 x 22 m) and at one end of the shelter was a feeding and drinking platform equipped with a multiple spaced feeder and four bowl drinkers.

The pigs were phase fed commercial, cereal based diets *ad libitum* as per industry practice. They had *ad libitum* access to fresh water. Individual liveweights and feed supplied per pen were recorded weekly.

The pigs were transported to a commercial abattoir (one and a half hours travel time) and slaughtered within one hour of arrival. Within 40 minutes post slaughter fat was collected from the hot carcasses. Subcutaneous backfat samples were taken (15g from the dorsal midline in line with the last rib) and stored in two 5 ml polypropylene containers on dry ice. The samples were transported to the lab in dry ice and stored at -80^{o}c until the fatty acid profiles were determined.

Fatty acid profiles were be determined by extracting the lipid from the tissue samples (Bligh and Dyer, 1959). Fatty acid methyl esters prepared and the fatty acid composition was determined via gas chromatography following the AOAC Official Methods of Analysis (1981).

Data were analysed by using Genstat 2002 (Lawes Agricultual Trust, Rothamsted Experimental research Station: Rothamsted, UK) to conduct a two-way analysis of variance.

Results and discussion

There were no significant differences ($P>0.05$) in liveweight, hot standard carcass weight and subcutaneous backfat thickness at the P2 site between housing treatments within slaughter groups (Table 1.)

The fatty acid profiles of pigs slaughtered at 13 and 24 weeks of age are described in Table 2. The profiles indicate that as pigs age, the level of saturated fatty acids within subcutaneous backfat significantly increases ($P<0.001$), whilst the level of polyunsaturated fatty acids, 18:2 and 18:3 was significantly reduced ($P<0.001$). Subsequently the overall proportion of saturated to unsaturated fatty acids increased with age ($P<0.001$). This is in agreement with numerous studies (Cameron *et al.* 1990; review by Tume and D'Souza, 1999) who reported that an increase in weight of the pig was also accompanied by increased fat firmness through an associated increase in saturated fatty acids. Linoleic (18:2) and linolenic acids (18:3) are essential fatty acids and cannot be synthesised by the pig, therefore these fatty acids must be sourced from the diet (Wiseman and Agunbiade, 1998). The percentage of monounsaturates 16:1 and 18:1 did not change over time.

Pigs housed on deep litter had significantly higher percentages of 14:0 (myristic) ($P=0.04$), 16:1 (palmitoleic) ($P=0.01$) and a lower percentage of 18:0 (stearic) ($P=0.05$) in subcutaneous backfat compared to pigs housed in conventional systems. Myristic and palmitoleic acids have been positively associated with firmer fat (Piedrafita et al. 2001). Palmitoleic acid has also been found to be positively correlated to pork

flavour (Cameron *et al*. 1990; Cameron *et al.* 2000; Kimata *et al*. 2001) while stearic acid has been negatively associated with pork flavour attributes (Kimata *et al*. 2001). Hence the higher percentage in myristic and palmitoleic acids in reported in this experiment, may indicate that pork from pigs raised in deep litter housing systems may have firmer fat compared to pork from pigs raised in conventional housing systems. This may also improve the cutability of both fresh and processed pork, and enhance shelf life via a reduced rate of oxidative rancidity. The higher palmitoleic and lower stearic acid percentage in pigs raised in deep litter housing systems may also result in improved flavour, as palmitoleic acid is positively correlated with flavour while stearic acid is negatively correltated with flavour, compared to pigs raised in conventional housing systems. In contrast, Bee *et al*. (2004) reported that pigs raised outdoors only had a lower percentage of stearic acid (18:0) compared to pigs raise indoors. Although there were differences in the levels of individual fatty acids reported in this experiment, there was no significant difference in the total proportion of saturated and unsaturated fatty acids ($P>0.05$) (Table 3).

Conclusions

The results from this experiment indicate that pigs housed on deep litter had significantly higher levels of myristic (associated with improved fat firmness) and palmitoleic acid (associated with improved fat firmness and flavour), and a significantly lower level of stearic acid (associated with reduced flavour) in subcutaneous backfat compared to pigs housed in conventional systems. Therefore raising pigs in deep litter housing systems may have a positive effect on both carcass quality and eating quality compared to pork from pigs raised in conventional housing systems.

References

AOAC. 1981. Fatty acids in oils and fats. Official methods of analysis of the association of official analytical Chemists, AOAC. Washington, DC, USA.

Bee, G., Guex, G. and Herzog, W. 2004. Free-range rearing of pigs during the winter: Adaptations in muscle fibre characteristics and effects on adipose tissue composition and meat quality traits. J. Anim. Sci. 82:1206-1218.

Bligh, E.G. and Dyer, W.J. 1959. A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol. 37:911-917.

Cameron, N.D., Enser, M., Nute, G.R., Whittington, F.M., Penman, J.C., Fisken, A.C., Perry, A.M. and Wood, J.D. 2000. Genotype with nutrition interaction on fatty acid composition of intramuscular fat and the relationship with flavour of pig meat. Meat Sci. 55:187-195.

Cameron, N.D., Warriss, P.D., Porter, S.J. and Enser, M.B. 1990. Comparison of Duroc and British Landrace pigs for meat and eating quality. Meat Sci. 27:227-247.

Gentry, J.G., McGlone, J.J., Miller, M. F. and Blanton, Jr. J.R. 2004. Environmental effects on pig performance, meat quality, and muscle characteristics. J. Anim. Sci. 82:209-217.

Gentry, J.G., McGlone, J.J., Blanton, Jr. J.R and Miller, M. F. 2002. Alternative housing systems for pigs: Influences on growth, composition, and pork quality. J. Anim. Sci. 80:1781-1790.

Kimata, M., Ishibashi, T. and Kamada, T. 2001. Studies on relationship between sensory evaluation and chemical composition in various breeds of pork. Japanese J. Swine Sci. 38:45-51.

Lambooij, E., Hulsegge, B., Klont, R.E., Winkelman-Goedhart, H.A., Reimert, H.G.M. and Kranen, R.W. 2004. Effects of housing conditions of slaughter pigs on some post mortem muscle metabolites and pork quality characteristics. Meat Sci. 66:855-862.

Nilzen, V., Babol, J., Dutta, P.C., Lundeheim, N., Enfalt, A.C. and Lundstrom, K. 2001. Free range pigs with access to pasture grazing - effect on fatty acid composition and lipid oxidation products. Meat Sci. 58:267-275.

Piedrafita, J., Christian, L.L. and Lonergan, S.M. 2001. Fatty acid profiles in three stress genotypes of swine and relationships with performance, carcass and meat quality traits. Meat Sci. 57:71-77.

Rehfeldt, C., Nurnberg, K. and Ender, K. 1994. Effects of exogenous porcine somatotropin on the development of fat cells and fatty acid composition in backfat of live finishing pigs. Meat Sci. 36:321-331.

Tume, R. and D'Souza, DN. 1999. A review of the impact of carcass fat properties on pork quality. Pig Research Report. A final report prepared for the Pig R&D Corporation, Australia. FSA 4/1377.

Wiseman, J. and Agunbiade, J.A. 1998. The influence of changes in dietary fat and oils on fatty acid profiles of carcass fat in finishing pigs. Livestock Prod. Sci. 54:217-227.

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.

Table 1. Liveweight, carcass weight and P2 backfat of pigs housed in conventional or deep litter housing systems and slaughtered at 13 and 24 weeks of age.

Age	13 weeks				24 weeks			
Housing type	Conventional	Deep litter	lsd	P-value	Conventional	Deep litter	lsd	P-value
Live weight (kg)	47.2	44.8	7.12	0.495	120.1	109.0	16.29	0.165
Hcwt (kg)	30.1	28.2	5.31	0.461	81.8	80.2	11.66	0.752
P2 (mm)	8.63	8.75	1.50	0.861	17.5	16.87	4.32	0.761

Table 2. Selected fatty acids indicated as a percentage of total fatty acids within the subcutaneous backfat of pigs slaughtered at 13 and 24 weeks of age

	Age			
	13 weeks	24 weeks	lsd	P-value
14:0 (%)	1.34	1.58	0.087	<0.001
16:0 (%)	21.50	24.80	0.692	<0.001
16:1 (%)	2.52	2.70	0.325	0.272
18:0 (%)	10.85	13.00	0.979	<0.001
18:1 (%)	39.73	39.49	1.51	0.753
18:2 (%)	17.53	13.20	1.065	<0.001
18:3 (%)	1.84	1.35	0.128	<0.001
Total Saturated (%)	35.51	40.82	1.53	<0.001
Total Monounsaturated (%)	43.72	43.53	1.63	0.816
Total Polyunsaturated (%)	20.78	15.65	1.23	<0.001
Saturated:unsaturated	0.552	0.692	0.041	<0.001

Table 3. Selected fatty acids indicated as a percentage of total fatty acids in the backfat and belly fat of pigs raised in conventional or deep litter housing systems

	Housing			
	Conventional	Deep Litter	lsd	P-value
14:0 (%)	1.543	1.615	0.069	0.042
16:0 (%)	23.89	23.91	0.501	0.951
16:1 (%)	2.809	3.12	0.239	0.012
18:0 (%)	11.91	11.28	0.633	0.052
18:1 (%)	40.02	39.63	1.090	0.472
18:2 (%)	14.19	14.68	0.837	0.246
18:3 (%)	1.49	1.58	0.100	0.064
Saturated (%)	38.98	38.40	1.041	0.270
Monounsaturated (%)	44.22	44.11	1.200	0.863
Polyunsaturated (%)	16.8	17.48	0.982	0.169
Saturated:unsaturated	0.64	0.63	0.028	0.396