EFFECT OF DIETARY OIL AND PROTEIN LEVEL ON CARCASS AND FAT QUALITIES AND PROCESSING CHARACTERISTICS IN PIGS

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Background

The use of dietary fats and oils to alter the fatty acid profile in meat animals to produce healthier and higher quality meat suitable for processing as well as consumption has been well documented, for example by Enser *et al*. (2000). In Ghana and other developing countries, local vegetable oils and agro-industrial by-products (AIBP) such as palm oil, palm kernel oil, palm kernel meal, coconut meal and cotton seed meal, are being used in animal feed, and recommended inclusion levels have been established (Okai, 1998). The economic incentive of using palm products is their relatively favourable cost compared to cereals and other oilseeds due to increasing global production (Shahidi, 1990). Furthermore, palm oil is cholesterol free, trans fatty acid free and fortified with carotenoids, tocopherols and tocotrienols (Sulaiman *et al*., 2001). There is, however, no information on the effect of Ghanaian AIBPs on the fatty acid profile of pork and pork fat. The processing characteristics of pork fat are influenced by its fatty acid composition. Poor slicing quality of floppy bacon is caused largely by soft fat (Morgan *et al*., 1994). High concentrations of saturated fatty acids (SFA) particularly stearic acid (18:0) as well as low concentrations of unsaturated fatty acids, mainly linoleic (18: 2), improve firmness/hardness of fatty tissues (Wood *et al*., 1985). The physical properties of fat also influence fat loss during cooking of comminuted meat products (Evans and Ranken, 1975; Teye *et al*., 2004).

Objectives

The objective of this study was to evaluate the effects of palm and palm kernel oils, and lysine level on the fatty acid composition of pork fat, fat firmness and the quality of belly bacon and frankfurter sausage.

Materials and methods

Sixty crossbred pigs (0.5 Duroc, 0.25 Large White, 0.25 Landrace) were used, with equal numbers of males and females. Each group of 10 were fed one of six diets in a 3x2 factorial design with 3 oil types (40 g/kg) and 2 lysine levels (HL-11 and LL-7 g/kg). Palm oil (PO) and palm kernel oil (PKO) were compared with soya bean oil (SBO). Pigs were housed in straw-based pens and fed *ad libitum*. Animals were reared from an initial mean live weight of 40 kg and slaughtered at an average live weight of 100 ± 10 kg. Measurements taken were cold carcass weight (CCW), pH_{45} min, pH_u (24h), drip loss, texture in *M. longissimus*, P2 backfat thickness and fat firmness at two positions (shoulder fat firmness SFF, loin fat firmness, LFF) at 2ºC with a custom-made digital penetrometer. Analysis of backfat fatty acid composition was by gas-liquid chromatography following extraction into chloroform. Slip point was determined by the open capillary method (BSI, 1985). Ten 4 mm thick slices from each cured belly were subjectively evaluated for slice integrity and classified as grade A, B or C. Bacon cohesion (BC) was assessed by a tensile test on cylindrical samples of 25 mm diameter. Pork frankfurter sausages, formulated with 5 kg lean and 2 kg fat from the shoulder and neck, were cooked individually in sealed vacuum-packed type polyethylene bags at 80ºC for 1h. Fat loss in the exudates was determined gravimetrically. Data were analysed by general linear model (Minitab 13). Correlations between fatty acids and fat firmness, bacon quality and fat loss from sausages were determined.

Results and discussion

Means for cold carcass weight, P2, pH45 and pHu, drip loss, texture of m. longissimus, backfat firmness and slip point are given in Table 1. Table 2 shows the means for fatty acid composition. The relationships between fatty acid concentration and fat firmness slip point, bacon and sausage qualities are given in Table 3. Oil type did not have a significant effect ($P > 0.05$) on carcass quality (Table 1), as also found by Okai (1998) and Rentfrow *et al*. (2003). PKO and PO significantly ($P \leq 0.001$) increased fat firmness and slip point, relative to SBO (Table 1). The LL resulted in a significantly higher (P<0.01) shoulder fat firmness. PKO increased the concentrations of lauric (12:0), myristic (14:0), palmitic (16:0) and stearic (18:0) acids and decreased linoleic acid (18: 2). Valencia *et al*., (1993) found a similar result in poultry, consequently making the fat firmer (Wood *et al*., 2003). The LL diet increased the concentrations of 16:0 and 18:0 and decreased 18:2 and 18:3 concentrations (Table 2). PKO as well as the LL diet significantly (P≤ 0.001) reduced the P/S ratio (Table 2), apparently lowering the nutritional value of the fat. Fat firmness and slip point had moderate to strong positive relationships with SFA and 18:0/18:2 ratio, and strong negative relationships with PUFA (Table 3). Sausage fat loss was positively related to SFA and C18:0/C18:2, and negatively related to PUFA, as observed previously (Teye *et al*., 2004). There was no significant correlation between the grade A bacon slices and fatty acid concentrations (Table 3). Rentfrow *et al*. (2003) reported a similar finding, which is, however, contrary to what was observed by Teye *et al*. (2004) who found a positive correlation (r=0.5**) existed between 18:0 and grade A bacon slices.

Conclusions

Fatty acid composition and backfat firmness were affected by dietary oil, with PKO and PO increasing fat firmness. PKO produced the most saturated fat and the lowest P/S ratio, which is considered having adverse implications to human health. The work suggests that PO could be used to improve pork fat firmness in lean pigs without adversely affecting its healthiness. The LL diet increased the concentration of saturated fatty acids and fat firmness. High concentrations of medium chain saturated fatty acids (12:0, 14:0 and 16:0) may not be suitable for frankfurter type sausage production due to high fat losses. Optimum inclusion levels of palm products for quality meat production need to be determined in all countries where these products are being used, such as in Ghana.

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Table 1. Effect of dietary oil and lysine level on pork carcass and fat qualities

	PKO	PO	SBO	sed	sig.	HL	LL	sed	sig.
CCW (kg)	73.6	73.7	73.7	0.11	ns	73.6	73.8	0.10	ns
P2 (mm)	12.7	13.2	13.6	0.98	ns	12.8	13.6	0.80	ns
pH_{45}	6.3	6.3	6.4	0.06	ns	6.3	6.3	0.06	ns
pH_u	5.4	5.4	5.5	0.03	ns	5.4	5.5	0.03	ns
Drip loss (g/100 g)	4.3	4.3	4.9	0.63	ns	5.0	4.2	0.52	ns
LD texture (kg)	6.0	6.3	6.0	0.44	ns	6.2	6.1	0.36	ns
SFF (Pe)	952^b	810^a	733^a	28.2	***	814^a	877^b	23.0	**
LFF (Pe)	781^b	672^a	588^a	60.8	**	651	711	49.5	ns
Slip point (ºC)	32.8^b	28.1^a	27.8^a	1.15	***	29.0	30.1	0.94	ns

Pe: Penetrometer units; Means in the same row prior to each 'sig.'-column with different superscripts differ significantly. ns- not significant; ** $P \leq 0.01$; *** $P \leq 0.001$

Table 2. Effect of dietary oil and lysine level on backfat fatty acid composition (g/100g fatty acid)

	PKO	PO	SBO	sed	sig.	HL	LL	sed	Sig.
C12:0	1.14^b	0.06^a	0.06^a	0.06	***	0.40	0.44	0.04	ns
C14:0	3.86^b	1.14^a	1.14^a	0.11	***	2.01	2.09	0.09	ns
C16:0	24.3^c	22.8^b	21.4^a	0.39	***	22.5	23.2	0.32	*
C18:0	13.0^b	11.7^a	11.6^a	0.40	**	11.7^a	12.5^b	0.32	*
C18:1n-9	34.0^a	39.1^b	33.0^a	0.68	***	34.8	35.9	0.55	ns
C18:2n-6	12.6^a	14.9^b	21.9^c	0.66	***	17.6^b	15.4^a	0.05	***
C18:3n-3	1.31^a	1.45^{ab}	1.53^b	0.09	***	1.91^b	1.53^a	0.06	***
C18:0 / C18:2	1.1^c	0.8^c	0.5^a	0.05	***	0.7^a	0.9^b	0.04	***
P/S	0.3^a	0.5^b	0.7^c	0.03	***	0.6^b	0.5^a	0.02	***
Total lipids (g/100g)	81.0	79.5	81.0	1.95	ns	78.8^a	82.2^b	1.59	*

Means in the same row prior to each 'sig.'-column with different superscripts differ significantly. ns: not significant; * $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$

Table 3. Correlations between fatty acid concentration and qualities of backfat and pork products

	SFF	LFF	Slip point	BC	% Grade A slices	Total sausage fat loss
C12:0	0.6***	0.3*	0.6***	0.4**	-0.04^{ns}	0.6**
C14:0	0.6***	0.3*	0.6***	0.4**	-0.02^{ns}	0.6**
C16:0	0.6**	0.3*	0.7***	0.02^{ns}	0.03^{ns}	0.6**
C18:0	0.5***	0.3*	0.8***	0.02^{ns}	-0.06^{ns}	0.4^{ns}
C18:2	-0.6***	-0.5***	-0.5***	-0.02^{ns}	-0.19^{ns}	-0.7***
C18:3	-0.6***	-0.5***	-0.5***	-0.01^{ns}	-0.14^{ns}	-0.6**
C18:0 / C18:2	0.8**	0.5***	0.7***	0.3^{ns}	0.10^{ns}	0.7**

ns: not significant; * $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$