The effect of the dietary concentration of linoleic acid on its deposition and on the consistency of pig backfat

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Introduction

High proportions of linoleic acid, n-6 C18:2, in the lipid have long been recognised as a cause of softness of pig backfat (Ellis and Isbell, 1926). The proportion of linoleic acid deposited depends upon its concentration in the diet (Dahl and Persson, 1965; Brooks, 1971). Linoleic acid constitutes approximately 40% of the fatty acids in cereal-based diets but the total fat content is usually only 2%-3% and in ad libitum fed pigs the fatty acids synthesized endogenously contribute over 70% of the deposited lipid. Since linoleic acid cannot be synthesized, its proportion in the deposited fat is much less than in the diet and will remain below 15% in which case the fat will be acceptably firm. However, if the synthesis of fatty acids is decreased, either by increasing the fat content of the diet or by decreasing the total feed intake, this concentration may be exceeded. With modern rapidly growing lean pigs, restriction of food intake to give a P_2 fat thickness of 9mm-10mm may produce soft fat (Wood and Enser, 1982). Because linoleic acid is an essential fatty acid, it is a necessary component of the pigs' diet. The recommended allowance (AFRC, 1983) is 3% of digestible energy in pigs up to 35kg live-weight and 1.5% of digestible energy during subsequent growth but it is not known whether such concentrations fed in current high energy rations produce fat with an unsatisfactory consistency.

The assessment of backfat consistency has depended, until recently, upon a subjective finger probe method or has been related to the physical characteristics of the lipid extracted from the tissue. However, a mechanical probe technique, developed at this Institute, has made it possible to quantify tissue consistency (Dransfield and Jones, 1984). The aim of this study was to determine the relationship between the proportion of linoleic acid deposited in backfat in pigs fed three concentrations of linoleic acid and to relate this to the firmness of the tissue. Because of the high linoleic acid content recommended for young pigs, pigs at 35 kg and 85 kg live weight were examined.

Methods

Groups of 20 weanling pigs were fed starter diets containing 0.8%, 1.1% and 1.8% linoleic acid, referred to as low, medium and high, with 22% crude protein and 15 MJ/kg DE. When they reached 35 kg live weight, 5 pigs from each group were slaughtered. The remainder were changed to finisher diets containing 1.0%, 1.2% and 1.4% of linoleic acid respectively, 19% crude protein and 14 MJ/kg DE and were slaughtered at 85 kg live weight. The diets were fed ad lib until the end of week 8 after which the pigs were restricted to 2.6 kg/day. The pigs were penned in groups and the group feed intake and weekly live weight gain recorded.

After slaughter, carcass weight and P_2 fat thickness were recorded and the consistency of the backfat was assessed subjectively on a scale from 1 (soft) to 8 (hard). Samples of backfat were then removed from over the last rib and their composition determined. The consistency of an adjacent piece of backfat was determined on an Instron materials testing machine (Dransfield and Jones, 1984). The lipid content of the feeds and backfat was determined by extraction of freeze-dried material with diethyl ether in a Soxhlet apparatus. The lipid was saponified and, after extraction, the fatty acids were methylated with diazomethane. The fatty acid composition was determined by gas-liquid chromatography on a 25m x 0.32mm, Sil 88 WCOT (Chrompack Ltd.). Fatty acids were identified by comparison with standards and peak areas were determined with an Infotronics 304-50 computing integrator (LDC, Milton Roy).

Table 1. Fat content and fatty acid composition of the diets

Dietary linoleic acid		Fat content (% of dry feed)	Fatty acids, % by weight[a]			
			Palmitic	Stearic	Oleic	Linoleic
Starter	High	7.2	21.3	11.5	33.7	25.3
	Medium	6.5	23.0	13.9	37.3	17.4
	Low	5.6	23.6	14.8	38.1	14.1
Finisher	High	4.5	19.4	8.7	32.7	31.1
	Medium	4.5	20.4	9.4	36.7	26.6
	Low	3.8	21.0	9.6	36.6	25.6

[a] Minor components to 100%

Results

The fat content and fatty acid composition of the diets is shown in Table 1. Despite the differences in fat content between the diets, the average daily gain, feed conversion ratio, carcass weight and backfat thickness were similar for all treatments in each slaughter group and not obviously related to differences in dietary fat (Table 2). Higher amounts of dietary linoleic acid resulted in higher proportions of linoleic acid in the backfat at both slaughter weights (Table 3). The proportions of linoleic acid were lower, however, in the pigs slaughtered at 85 kg than in the younger pigs, presumably as a result of greater dilution of the dietary fat by fatty acids synthesized de novo in the older pigs. The proportion of the other major fatty acids; palmitic, stearic and oleic were all higher in the heavier pigs. Linolenic acid, also an essential fatty acid, reflected the changes in linoleic acid but was present at one tenth the concentration. The proportion of linoleic acid present in the inner layers of backfat was inversely correlated with backfat thickness in all treatments but the relationship was only significant for high and medium linoleate feeds (Table 4). The firmness of the backfat measured by using the finger as a probe (fat score) or mechanically with the Instron probe decreased as the proportion of linoleic acid in the diet increased (Table 5). However, the subjective fat score unlike the mechanical test did not distinguish between the consistency of samples from the medium and low linoleate group. Within diet groups the firmness of the backfat, assessed mechanically, was inversely related to the concentration of linoleic acid in the backfat lipid but the relationship was not significant for backfat from the low linoleate group (Table 4).

Discussion

None of the pigs slaughtered at 85 kg had soft fat as judged by the traditional finger probe technique. This was also confirmed by the concentration of linoleic acid in the backfat since the data of Ellis and Isbell (1926) suggest that more than 15% is necessary to produce soft fat and none of the final slaughter groups reached this level. Backfat from the pigs fed the high linoleate starter diet and slaughtered at 35 kg live weight had 17% linoleic acid but the fat layer was too thin to probe in this group. The higher concentrations of linoleic acid in the young pigs are clearly the result of dietary fatty acids forming a higher proportion of the deposited fatty acids than in the older pigs since the medium linoleate starter and finisher diets contained similar proportions of linoleic acid. The medium linoleate starter diet contained 2.8% of its digestible energy as linoleate; close to the 3% recommended by AFRC, but under conditions favouring its deposition the concentration did not exceed 15% in backfat. Even when this was followed by a finisher diet in which linoleate accounted for 3.2% of the digestible energy, double the AFRC recommendation, the final linoleate concentration was only 11%. The feeding of a high linoleate starter diet containing 50% more than the AFRC recommended level, although it produced an unacceptably high concentration at 35 kg, did not result in excessive concentrations at 85 kg on a finisher diet containing 2.5 times the recommended allowance. One may therefore conclude that high concentrations of linoleic acid during early growth need not lead to high concentrations at bacon weight. The pigs in this study were not particularly lean and one would expect that leaner animals produced through a more restricted growth rate would have higher concentrations of linoleic acid (Wood and Enser, 1982). An approximation of the effect of increased leanness can be obtained from the regression of the proportion of linoleic acid in the backfat on backfat thickness for the three diets. Pigs on the low and medium linoleate diets would not have exceeded 15% linoleate at backfat thicknesses of 5mm. However, this concentration would have been exceeded by pigs on the high linoleate diet at a P_2 of less than 11-12mm.

The determination of the firmness of the backfat by the finger probe procedure did not discriminate between the pigs fed the medium and low linoleate diets whereas the mechanical probe recognised a significant difference between their consistency. The probe force, taken over all treatments, was highly inversely correlated with the proportion of linoleic acid in the lipid and linoleic acid and linolenic acid were the only fatty acids whose concentration differed significantly between all groups. The concentration of stearic acid was similar in all three groups suggesting that it contributed little to differences in consistency amongst these animals, contrary to our previous finding (Wood et al., 1978).

We conclude therefore that when large differences in the concentration of linoleic acid in backfat are produced by feeding different diets, they are responsible for differences in consistency measured by the mechanical probe and that the latter is a better discriminator of consistency than the finger probe. The deposition of linoleic acid is related to the dietary concentration and the concentration recommended to fulfil its essential fatty acid function is unlikely to lead to the production of soft fat even in lean pigs.

References

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Table 2. Pig growth and carcass measurements

	Average daily gain (kg)	Feed conversion ratio (kg feed/kg live weight gain)	Cold carcass weight (kg)	Fat thickness P_2 (mm)
Starter diet				
High	0.86	1.72	25.4	6.8
Medium	0.78	2.02	25.9	7.0
Low	0.81	1.87	25.5	6.3
Finisher diet				
High	0.87	2.65	67.8	14.1
Medium	0.87	2.74	67.6	16.0
Low	0.89	2.79	69.8	15.5

Table 3. Fatty acid composition of backfat inner layers of pigs fed diets containing high, medium and low levels of linoleic acid

Slaughter group 1. Live weight 35 kg

FATTY ACID	HIGH	MEDIUM	LOW
Myristic	1.5 ± 0.1	1.4 ± 0.1	1.4 ± 0.1
Palmitic	22.9 ± 0.4	23.8 ± 0.7	23.5 ± 0.7
Palmitoleic	2.0 ± 0.4	1.7 ± 0.5	1.9 ± 0.3
Stearic	9.4 ± 0.4[a]	11.3 ± 0.3[b]	10.8 ± 0.5[b]
Oleic	39.7 ± 1.0	41.0 ± 0.8	41.9 ± 1.3
Linoleic	17.0 ± 1.2[a]	13.6 ± 1.8[ab]	9.8 ± 0.5[b]
Linolenic	1.7 ± 0.2[a]	1.2 ± 0.1[a]	0.8 ± 0.1[b]

Slaughter group 2. Live weight 85 kg

FATTY ACID	HIGH	MEDIUM	LOW
Myristic	1.1 ± 0.03	1.2 ± 0.4	1.2 ± 0.05
Palmitic	24.3 ± 0.5[a]	25.0 ± 0.4[a]	26.0 ± 0.3[b]
Palmitoleic	1.3 ± 0.1[a]	1.3 ± 0.1[a]	1.6 ± 0.1[b]
Stearic	12.4 ± 0.3	12.8 ± 0.4	12.9 ± 0.3
Oleic	42.8 ± 0.5[a]	44.8 ± 0.5[b]	45.9 ± 0.5[b]
Linoleic	13.9 ± 0.4[a]	11.0 ± 0.4[b]	8.6 ± 0.1[c]
Linolenic	1.2 ± 0.04[a]	1.0 ± 0.03[b]	0.8 ± 0.02[c]

Results expressed as mean % by weight ± SEM for 5 animals per treatment in slaughter group 1 and 15 animals per treatment in slaughter group 2.

a/b/c Means within lines with different superscript letters differ significantly, P<0.05.

Table 4. Regression analysis of the relationship between the proportion of linoleic acid in the lipid and backfat thickness and firmness.

Dietary linoleic acid	x	y	a	b	r
High	Backfat thickness	% linoleic	20.7	-0.482	0.76**
Medium	"	"	16.4	-0.335	0.69**
Low	"	"	10.3	-0.104	0.31NS
High	% linoleic	Probe force	1.12	-0.062	0.60*
Medium	"	"	1.46	-0.097	0.73**
Low	"	"	1.27	-0.082	0.33NS
All groups	"	"	1.09	-0.062	0.73**

Table 5. Backfat firmness by subjective fat score and Instron probe.

	Fat score (1 - 8)	Probe (2.5mm, kg force)
High linoleate	3.7 ± 0.3[a]	0.26 ± 0.04[a]
Medium linoleate	4.6 ± 0.3[b]	0.39 ± 0.05[b]
Low linoleate	4.9 ± 0.2[b]	0.56 ± 0.05[c]

[a,b]Numbers within columns with different superscripts differ significantly, P<0.05.

Fat score: 1 soft - 8 hard.