The effect of fatty acid composition on the suitability of pig backfat for the production of bacon

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SUMMARY

Firm white fat is an important quality attribute of bacon in the UK. The fatty acid composition of the fat contributes not only to the consistency, but also to colour since soft fat is translucent and the tissue appears discoloured because other tissue components become visible through the fat. The consistency of the fat is determined by the presence of hard saturated fatty acids and soft unsaturated fatty acids.

When the concentration of linoleic acid in the fat exceeds 15% of the total fatty acid, the fat will be soft and will need to be frozen before slicing. The concentration of linoleic acid is inversely proportional to fat thickness and pigs with fat less than 9 mm thick may be soft. At lower concentrations linoleic acid is still important, but the best predictor of fat consistency is the concentration of stearic acid. As the concentration of stearic acid increases the fat becomes harder. If the ratio of stearic acid to linoleic acid exceeds 1.47 the fat is sufficiently hard to be used for the production of vacuum-packed, rindless bacon which will retain the shape of individual rashers in the pack.

INTRODUCTION

The consistency of the adipose tissue is an important quality aspect of bacon in the United Kingdom. Soft fatty tissue may result in uneven slicing of the rind as the rashers are cut and the tissue may appear discoloured because its translucency, at display temperatures, allows more of the colour of the non-lipid components to be revealed. Firm backfat is particularly necessary for the production of shingled vacuum-packs of rindless rashers to ensure that the definition of the fatty tissue of individual rashers is retained. If, however, the backfat is too hard, lobules of fat cells may fall out of the tissue, after slicing, with the production of lacy fat.

Backfat of bacon pigs contains 70% - 95% lipid, the bulk of which consists of triacylglycerols. The fatty acid composition of the triacylglycerols has long been accepted as making a major contribution to the consistency of the tissue (Ellis & Isbell, 1926). Connective tissue, which forms approximately 2% - 3% of backfat must also contribute to the consistency of the tissue, but its effects are difficult to quantify. Therefore many studies of the effect of fatty acid composition on the consistency of backfat have related composition to the consistency of the extracted lipid. At present there is no accepted objective method to measure the consistency of backfat and studies rely upon a subjective assessment using finger pressure on the exposed adipose tissue.

The effect of fatty acids on the consistency of the lipid depends upon their structure. Long-chain saturated fatty acids have melting points above body temperature and will harden the fat, whereas monounsaturated and polyunsaturated fatty acids have low melting points and will soften the fat. The contributions of individual fatty acids or combinations of fatty acids to consistency have been reported in several studies. Elliot and Bowland (1969) found that the sum of the proportions of all the unsaturated fatty acids was a good predictor of melting point. However, Ellis and Isbell (1926) previously observed that the proportion of linoleic acid alone was inversely related to the subjectively assessed grade and the melting point of the fat. Hard fat contained less than 9%, soft fat 13% to 20% and oily fat in excess of 18% linoleic acid. The softening effect of high concentrations of linoleic acid is generally accepted but at concentrations below 14% the consistency appears to be independent of linoleic acid (Lea, Swoboda & Gatherum, 1970). In that situation the ratio of the concentrations of palmitoleic acid plus oleic acid to palmitic acid plus stearic acid, termed the monoene:saturated (M:S) ratio, was best related to the slip point. In lipid from pig backfat with less than 12% linoleic acid we have observed that the proportion of stearic acid alone was the best single fatty acid determinant of melting point and was superior to the M:S ratio (Wood, Enser, MacFie, Smith, Chadwick, Ellis & Laird, 1978).

Although soft fat is generally considered undesirable there have been few reports on the relationship between the type of product and the consistency and composition of the backfat. Furthermore, changes in trade practices such as centralized slicing and packing, allow consistency problems to be overcome through freezing the bacon before slicing. We have therefore investigated the relationship between fatty acid composition and the consistency of the lipid in backfat from vacuum packs of rindless rashers subjectively assessed as having a satisfactory consistency or an unsatisfactory consistency because of soft fat. We have also determined the fatty acid composition of bacon with soft fat which requires freezing before slicing and of bacon which gives acceptable rashers when sliced in the unfrozen state.

EXPERIMENTAL

Vacuum-packs of rindless rashers assessed on the basis of the consistency of the fat were supplied by manufacturers and retailers. The samples were not reassessed, but as a control, satisfactory samples were always obtained with the unsatisfactory ones. Fat samples were also obtained from carcasses held at 4°C which were subjectively assessed as hard, medium or soft by an experienced grader. Samples of bacon which required freezing for satisfactory slicing and bacon which could be sliced unfrozen were obtained from the same factory. The lipids were extracted either with chloroform:methanol (2:1, v/v) or, after freeze-drying the tissue, with diethyl ether. Slip point and melting point were determined by the British Standard method and AOAC method respectively. Fatty acids were prepared by saponification in the usual manner and methylated with diazomethane. The methyl esters were analysed by gas-liquid chromatography using a 5 ft. x 1/8 in. column of 12% polyethylene glycol adipate on 100 - 120 mesh Gas-Chrom Q at 180°C with argon as the carrier gas.

RESULTS

The fatty acid composition of lipid from the inner backfat of rindless rashers from vacuum packs is shown in table 1. Samples with satisfactory consistency contained significantly higher proportions of the saturated fatty acids, palmitic acid and stearic acid, but myristic acid was not significantly different from that in the unsatisfactory soft samples. The unsaturated fatty acids, palmitoleic acid and linoleic acid, were present at higher concentrations in the unsatisfactory samples but the concentration of oleic acid did not differ significantly between the two groups. Since it is recognised that hard fat is needed for the production of good quality vacuum packs of rindless rashers we compared the fatty acid composition of these samples with samples from backfat which had been subjectively assessed as hard, medium or soft. The fatty acid composition of the lipids from the satisfactory rindless rashers was almost identical to that from the hard pork (Table 1) and clearly represents the hard end of the consistency range. However, the fatty acid composition of the unsatisfactory rindless rashers resembled that of the medium pork rather than the soft pork, except for linoleic acid which was present at the same concentration as in soft pork. The melting point and slip point of the lipid from unsatisfactory rindless rashers were the same as those of lipid from pork of medium consistency.

The correlation between the slip point of the lipid and the concentration of stearic acid was highly significant when all the rindless rashers and the hard and soft pork were considered together, $r = 0.928$, $P<0.001$ (Fig. 1). Stepwise analysis of variance showed that stearic acid alone accounted for 86% of the variance in the slip point but the addition of linoleic acid increased this significantly ($P<0.001$) to 90.8%. The subjective assessment of consistency was less satisfactory in relation to slip point than the proportion of stearic acid. The slip points of lipid from satisfactory rindless rashers ranged from 29.8°C to 43.2°C and for unsatisfactory samples from 20.8°C to 39.8°C (Fig. 1).

Table 2 Fatty acid composition of lipid from samples of bacon which were satisfactory or unsatisfactory for slicing in the unfrozen state.

		Fatty acids, % by weight					
Fatty acid:		Myristic	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic
Inner layer:	Unsatisfactory	1.3 ± 0.1[a]	26.4 ± 0.4	2.9 ± 0.1	14.3 ± 0.4	39.8 ± 0.3	14.6 ± 0.5
	Satisfactory	1.3 ± 0.1	26.3 ± 0.3	2.5 ± 0.1	16.0 ± 0.4	38.8 ± 0.4	12.5 ± 0.4
Significance of difference		NS	NS	NS	**	NS	**
Outer layer:	Unsatisfactory	1.4 ± 0.1	22.0 ± 0.4	3.2 ± 0.1	11.1 ± 0.4	40.8 ± 0.6	17.2 ± 0.5
	Satisfactory	1.3 ± 0.1	23.7 ± 0.3	3.3 ± 0.1	11.9 ± 0.4	40.7 ± 0.6	15.3 ± 0.3
Significance of difference		NS	**	NS	NS	NS	**

**P<0.01, NS not significant P> 0.05   [a] Mean ± SEM for 10 samples in each group

Table 1 Fatty acid composition, melting point and slip point of lipid from the inner fat layer of soft, medium and hard pork and satisfactory and unsatisfactory rindless rashers from vacuum packs.

	Soft pork (26)[b]		Hard Pork (21)	Medium Pork (12)	Unsatisfactory bacon (44)		Satisfactory bacon (18)
Fatty acid, % by weight							
Myristic C14:0	1.8	**[a]	1.5	1.7	1.5	NS[a]	1.4
Palmitic C16:0	21.3	***	27.1	23.3	23.2	***	26.8
Palmitoleic C16:1	4.4	***	3.0	3.6	3.4	**	2.8
Stearic C18:0	8.9	***	16.2	11.5	12.2	***	16.2
Oleic C18:1	49.8	***	45.7	48.9	46.5	NS	45.4
Linoleic C18:2	12.9	***	6.2	10.1	12.4	***	6.7
Melting point of lipid, °C	38.6	***	47.8	42.1	43.1	***	47.9
Slip point of lipid, °C	22.9	***	39.0	28.7	28.9	***	39.1

[a] Significance of difference between adjacent columns, *** P<0.001, **P<0.01, NS not significant P>0.05

[b] Number of samples

The fatty acid composition of lipid from bacon considered to be too soft to slice without freezing is shown, in comparison with harder unsatisfactory samples, in table 2. The only significant differences were a higher percentage of steric acid and a lower percentage of linoleic acid in the inner backfat layer from the satisfactory samples. In the outer backfat layer there was no difference between the two groups in the percentage of stearic acid but the proportion of palmitic acid was higher and the proportion of linoleic acid was lower in the satisfactory hard samples. As expected, the proportion of stearic acid was lower and the proportion of linoleic acid was higher in the outer fat layers compared with their respective inner layers.

High concentrations of linoleic acid in pig backfat may be produced by feeding diets high in linoleic acid or as a result of a decrease in the dilution of dietary linoleic acid by fatty acids synthesized by the pig, as happens in lean pigs. The latter appears to be an important cause of the high concentrations of linoleic acid in the present study as shown by the relationship between backfat thickness at the P_2 position and the proportion of linoleic acid in the inner backfat, $r = 0.658$, $P<0.001$ (Fig. 2). Samples in addition to those in table, 2 but which were selected on the same basis, have been included in figure 2.

DISCUSSION

It is clear from these results that, if the consistency of pig backfat is judged subjectively on a three-point scale of hard, medium and soft, only hard samples are suitable for the production of satisfactory vacuum packs of rindless rashers. The mean fatty acid composition and the melting points and slip points of the lipid from the hard pork and satisfactory rindless rashers coincided. These results also confirm our previous finding that stearic acid is the best single fatty acid to use as a predictor of slip point (Wood et al., 1978). However, analysis of variance demonstrated that linoleic acid had a significant role in determining the consistency and improved the prediction of the slip point over stearic acid alone, although its concentration was less than 12%, a level at which Lea, Swoboda and Gatherum (1970) considered it had no effect. Despite these results it is not possible to define the dividing line between satisfactory and unsatisfactory rindless rashers in terms of either slip point or stearic acid content. The slip points of unsatisfactory soft rashers overlapped those of the satisfactory hard samples over 45% of the range (Fig. 1). A similar overlap occurred for the proportion of stearic acid which was 7.3% to 16.7% in the unsatisfactory rindless rashers and 12.8% to 19.3% in the satisfactory rashers. This situation may result from differences in the selection criteria or inconsistencies in the subjective assessment of the samples. However, when we took account of the contribution of linoleic acid to consistency and plotted the ratio of stearic acid to linoleic acid against slip point, the overlap, in terms of fatty acid composition, was almost removed. All except one satisfactory sample had a ratio above 1.47 and all except one unsatisfactory sample had a ratio below this value. Why this ratio should provide better discrimination than the slip point, between subjectively assessed samples, is not clear although it may be related to the differences in the temperatures at which the assessments and slip points are made.

The fatty acid composition of the lipid in the study of bacon with different temperature requirements for slicing clearly differs from that in the study of rindless rashers. The proportion of linoleic acid was generally higher than in the rindless rashers and was in the range where Ellis and Isbell (1926) considered it played a major role in softening the fat. Our results would agree with this, since in the inner fat layer linoleic acid was one of only two fatty acids, the other being stearic acid, whose concentrations differed between the soft and satisfactory samples (Table 2). In the outer layer linoleic acid was also higher in the soft samples but there was no difference in the concentration of stearic acid between the two groups. The concentration of palmitic acid in the outer layer of satisfactory samples was higher than in the soft sample, suggesting either that it replaced stearic acid as the most important saturated fatty acid which hardens the fat or that it is not important and the consistency wholly depends upon the proportion of linoleic acid. The high concentration of linoleic acid in the backfat of the soft samples was clearly due, in part, to the leanness of the pigs (Fig. 2) and a concentration of 15% at a P_2 of 10 mm is similar to that which we reported previously (Wood & Enser, 1982). As in the rindless rasher study, there was no clear separation between soft and satisfactory samples in terms of fatty acid composition but since the mean concentration of linoleic acid in the outer layer of the satisfactory samples was just over 15% and that in the inner layer of the soft samples was just below 15%, that value would seem to be a reasonable arbitrary point to separate the two groups. Despite a high concentration of linoleic acid bacon can be sliced satisfactorily in the frozen state.

References

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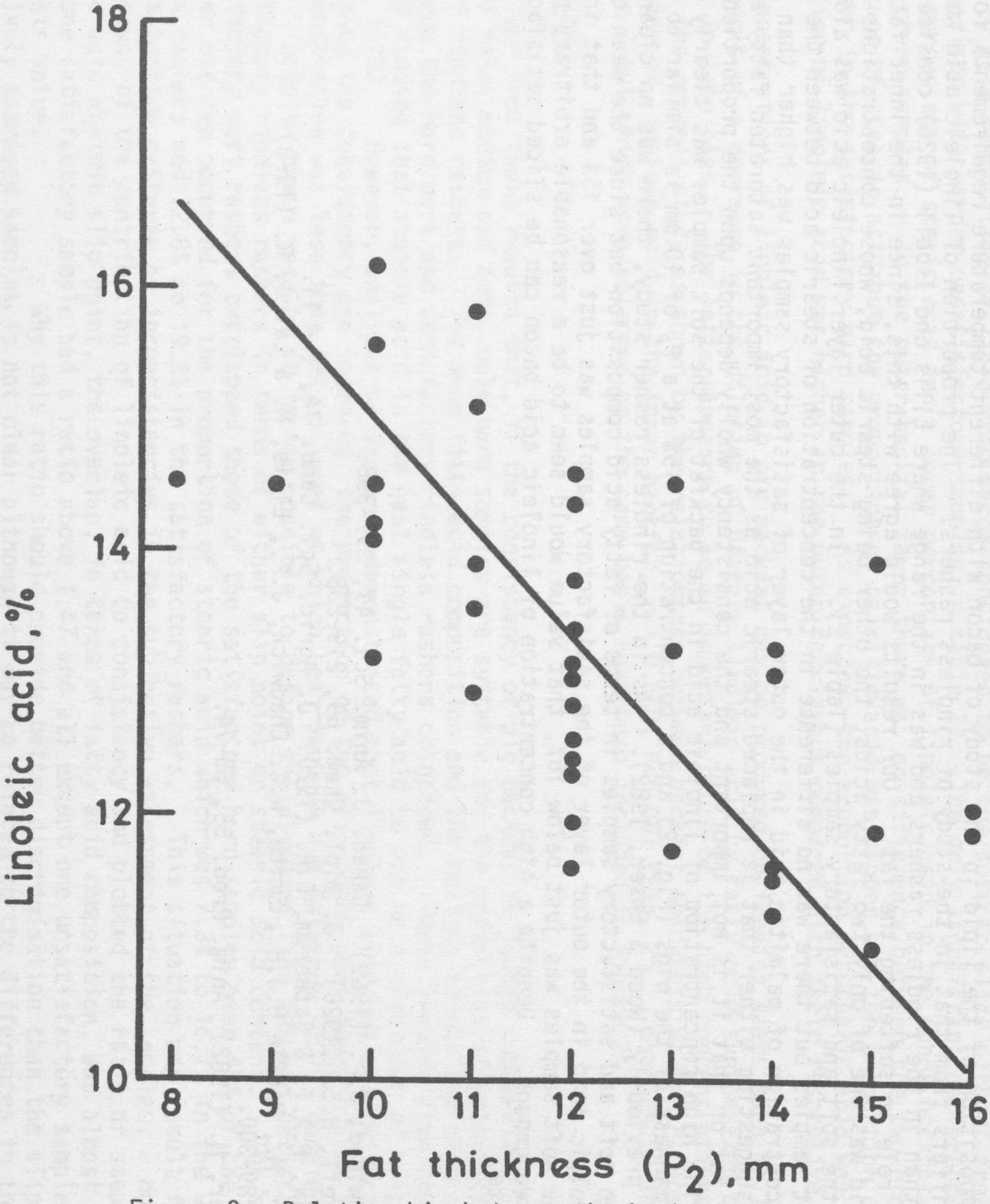

Figure 2 Relationship between the backfat thickness and the proportion of linoleic acid in the backfat lipids.

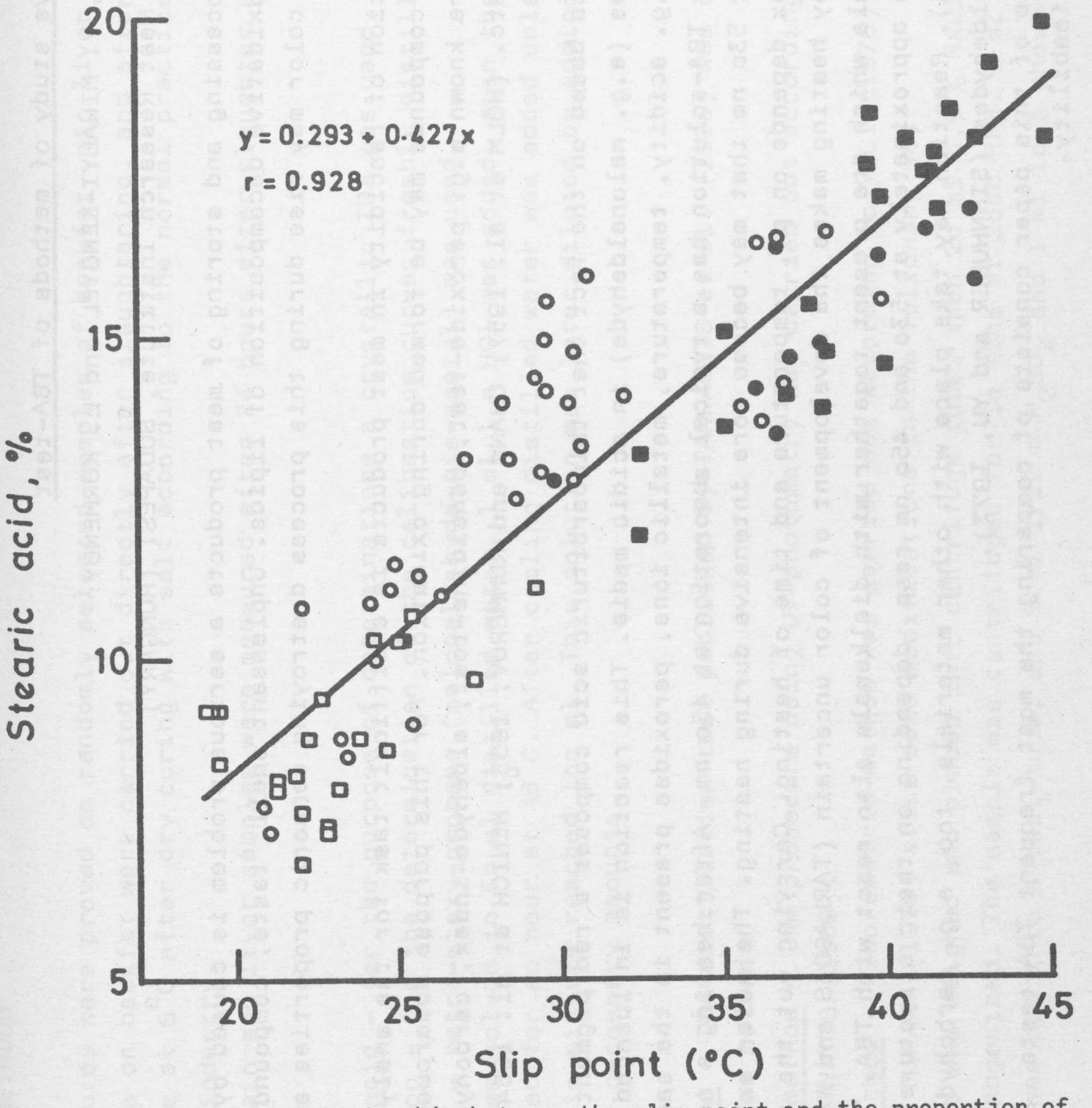

Figure 1: Relationship between the slip point and the proportion of stearic acid in lipids from the inner backfat of ■ hard pork, □ soft pork, ● satisfactory rindless rashers and o unsatisfactory rindless rashers.