CCX. THE BODY FATS OF THE PIG.

I. INFLUENCE OF INGESTED FAT ON THE COMPONENT FATTY ACIDS.

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AN opportunity to study the component fatty acids present in the depôt fat of pigs, on similar lines to the recent examination of butter fats [Hilditch and Sleightholme, 1931] and of tallows [Banks and Hilditch, 1931], was afforded when Prof. J. C. Drummond and Captain Golding supplied us with specimens of the back fats and perinephric or leaf fats from three sets of pigs which had been fed on a control diet (i) alone or supplemented with (ii) a solid or (iii) a liquid fat.

The animals were from two litters and were fed on the experimental diet from the age of 3 months until 7 months, when they were slaughtered; the average weight at the commencement of the feeding tests was about 50 lbs., and that at death about 200 lbs.

Four pigs were fed solely on a control ration consisting of 60 % barley meal, 20 % flaked maize, 15 % soya bean meal and 5 % dried yeast (with 2 lbs. ground limestone per 100 lbs. mixture); four pigs received the control ration with 3 % of shea butter fat added; and five pigs received the control ration with 3 % of arachis oil added.

The shea butter fat was supplied through the Imperial Institute and, according to an analysis made in this laboratory, its component fatty acids were myristic (0.4 %), palmitic (8.5 %), stearic (35.9 %), oleic (49.9 %) and linoleic (5.3 %) acids. The arachis oil employed was not specifically examined, but the composition of arachis oil fatty acids is of the following order [Jamieson, Baughman and Brauns, 1921]: 6–8 % palmitic, 5–6 % stearic, 3–4 % arachidic, 3 % lignoceric, 53–61 % oleic, and 22–25 % linoleic acid. The control ration itself was estimated to contain 1.5 % of fat and 12 % of proteins.

The specimens of back fat supplied were divided in each case into two parts along the approximately central "streak" or seam of connective tissue, and the component acids of the fats in the "outer" (*i.e.* nearer the skin)

layer and the "inner" layer were determined separately: differences in composition parallel with the noticeable differences in softness of the inner and outer layers were observed in all three sets of fats. Of the perinephric fats, those from the control ration animals and from the control ration with shea fat pigs were slightly infected by moulds when received; changes due to the onset of rancidity may affect to some extent the accuracy of the linoleic acid figures in these instances.

The quantity of material available was restricted, especially as regards the back fats; but, fortunately, the mixture of fatty acids in lard is comparatively simple and we believe that the data presented below are of the usual order of accuracy for fractionation analyses. It has not, of course, been practicable, with these small quantities of mixed fatty acids, to seek for evidence of the possible presence of minor amounts of the higher saturated acids characteristic of arachis oil in the fats from pigs in the diet of which 3 % of this oil had been included. We also considered it unnecessary, for the immediate purpose, to determine the small amount (up to 0.4 %) of highly unsaturated arachidonic acid which Brown and Deck [1930] have shown to be present in normal lards.

The fats were separated from tissue, *etc.*, by extraction with hot acetone, the final traces of which were removed by heating in a vacuum at 100°. The saponification equivalent, iodine value and refractive index (at 60°) of each fat, and the setting-point of the corresponding mixed fatty acids, are collected in Table I.

Table I.

Feed	Body fat	Saponification equivalent	Iodine value	n_D^{60}	Mixed acids. Setting- point
Control ration	Outer back	286.1	62.6	1.4512	38.8°
" "	Inner back	286.7	55.0	1.4507	41.8°
" "	Leaf (perinephric)	286.0	45.7	1.4500	44.2°
Control + 3 % shea fat	Outer back	286.1	65.2	1.4519	38.5°
" "	Inner back	285.4	57.0	1.4510	41.0°
" "	Leaf	284.7	43.9	1.4503	45.0°
Control + 3 % arachis oil	Outer back	283.7	68.9	1.4520	37.0°
" "	Inner back	285.8	61.7	1.4508	40.1°
" "	Leaf	286.7	55.1	1.4501	44.0°

The component fatty acids were estimated in each case by preliminary separation into "solid" and "liquid" acids by crystallisation of the lead salts from 95 % alcohol, followed by fractional vacuum distillation of the methyl esters of each group; the details of the procedure were the same as in the case of the corresponding analyses of beef tallows [Banks and Hilditch, 1931], except that the amount of esters handled precluded in most cases any re-fractionation of the primary ester fractions. Since the tabulation of the complete fractionation data occupies excessive space, the final results only are summarised in Table II: the figures in brackets indicate the weights of mixed fatty acids employed in each fractionation analysis.

Table II. *Component fatty acid analyses of the nine pig fats.*

Acid	Solid acids	Liquid acids	Total	Fatty acids (excluding unsaponifiable matter)	
				% (wt)	% (mols.)
Feed: control only. Outer back fat (29.7 g.).					
	(38.1 %)	(61.9 %)			
Myristic	—	2.03	2.03	2.0	2.4
Palmitic	24.51	—	24.51	24.6	26.3
Stearic	10.58	—	10.58	10.6	10.2
Oleic	3.01	50.15	53.16	53.3	51.8
Linoleic	—	9.46	9.46	9.5	9.3
Unsaponifiable	—	0.26	0.26	—	—
Feed: control only. Inner back fat (88.3 g.).					
	(45.7 %)	(54.3 %)			
Myristic	—	1.40	1.40	1.4	1.7
Palmitic	29.51	—	29.51	29.6	31.6
Stearic	13.94	—	13.94	13.9	13.4
Oleic	2.25	44.80	47.05	47.2	45.6
Linoleic	—	7.87	7.87	7.9	7.7
Unsaponifiable	—	0.23	0.23	—	—
Feed: control only. Leaf (perinephric) fat (97.1 g.).					
	(51.0 %)	(49.0 %)			
Myristic	—	3.65	3.65	3.6	4.4
Palmitic	28.40	—	28.40	28.5	30.2
Stearic	21.33	—	21.33	21.4	20.5
Oleic	1.27	39.95	41.22	41.3	39.9
Linoleic	—	5.18	5.18	5.2	5.0
Unsaponifiable	—	0.22	0.22	—	—
Feed: control + 3 % shea fat. Outer back fat (48.75 g.).					
	(37.3 %)	(62.7 %)			
Myristic	—	3.64	3.64	3.7	4.4
Palmitic	24.93	1.05	25.98	26.1	27.8
Stearic	9.42	—	9.42	9.5	9.1
Oleic	2.95	47.15	50.10	50.3	48.6
Linoleic	—	10.37	10.37	10.4	10.1
Unsaponifiable	—	0.49	0.49	—	—
Feed: control + 3 % shea fat. Inner back fat (30.7 g.).					
	(41.5 %)	(58.5 %)			
Myristic	1.09	3.57	4.66	4.7	5.5
Palmitic	26.50	—	26.50	26.6	28.2
Stearic	10.01	—	10.01	10.0	9.6
Oleic	3.72	47.22	50.94	51.0	49.2
Linoleic	—	7.71	7.71	7.7	7.5
Unsaponifiable	0.18	—	0.18	—	—
Feed: control + 3 % shea fat. Leaf (perinephric) fat (73.2 g.).					
	(50.1 %)	(49.9 %)			
Myristic	0.07	2.75	2.82	2.8	3.3
Palmitic	30.84	—	30.84	30.8	32.7
Stearic	17.87	—	17.87	17.9	17.2
Oleic	1.32	43.57	44.89	44.9	43.3
Linoleic	—	3.58	3.58	3.6	3.5
Unsaponifiable	—	—	—	—	—
Feed: control + 3 % arachis oil. Outer back fat (50.2 g.).					
	(37.1 %)	(62.9 %)			
Myristic	—	1.53	1.53	1.5	1.9
Palmitic	23.47	0.69	24.16	24.3	26.0
Stearic	8.95	—	8.95	9.0	8.7
Oleic	4.68	47.20	51.88	52.2	50.7
Linoleic	—	12.93	12.93	13.0	12.7
Unsaponifiable	—	0.55	0.55	—	—

Table II (*cont.*)

	Feed: control + 3 % arachis oil.		Inner back fat (74.0 g.).		
	(41.7 %)	(58.3 %)			
Myristic	0.16	1.37	1.53	1.5	1.8
Palmitic	24.38	—	24.38	24.5	26.2
Stearic	13.67	—	13.67	13.7	13.3
Oleic	3.49	45.55	49.04	49.3	47.9
Linoleic	—	10.98	10.98	11.0	10.8
Unsataponifiable	—	0.40	0.40	—	—

	Feed: control + 3 % arachis oil.		Leaf (perinephric) fat (117.7 g.).		
	(45.3 %)	(54.7 %)			
Myristic	—	1.70	1.70	1.7	2.0
Palmitic	24.98	0.58	25.56	25.6	27.4
Stearic	18.16	—	18.16	18.2	17.5
Oleic	2.16	42.03	44.19	44.2	43.0
Linoleic	—	10.29	10.29	10.3	10.1
Unsataponifiable	—	0.10	0.10	—	—

DISCUSSION.

It is desirable, as in previous communications, to consider the constitution of these various fatty acid mixtures from the point of view of molecular proportion rather than weight percentage. In Table III the molar characteristics of the mixed fatty acids are arranged primarily so as to display the variations in the corresponding depôt fats due to the different diets: section (i) shows the molar distribution of the individual acids, and in section (ii) column I gives the total molar percentage of saturated acids, column II that of the combined stearic, oleic and linoleic acids, column III that of stearic acid, and column IV the molar proportion of linoleic in the unsaturated acids present.

Table III.

(i) *Molar distribution of individual acids.*

Fat	Feed	Myristic	Palmitic	Stearic	Oleic	Linoleic
Outer back	Control	2.4	26.3	10.2	51.8	9.3
"	" + 3 % shea	4.4	27.8	9.1	48.6	10.1
"	" + 3 % arachis	1.9	26.0	8.7	50.7	12.7
Inner back	Control	1.7	31.6	13.4	45.6	7.7
"	" + 3 % shea	5.5	28.2	9.6	49.2	7.5
"	" + 3 % arachis	1.8	26.2	13.3	47.9	10.8
Leaf (perinephric)	Control	4.4	30.2	20.5	39.9	5.0*
"	" + 3 % shea	3.3	32.7	17.2	43.3	3.5*
"	" + 3 % arachis	2.0	27.4	17.5	43.0	10.1

(ii) *Molar percentages of total saturated acids (I), total C₁₈ acids (II), stearic acid (III) and proportion of linoleic acid in the unsaturated acids (IV).*

Fat	Feed	I	II	III	IV
Outer back	Control	38.9	71.3	10.2	15.1
"	" + 3 % shea	41.3	67.8	9.1	17.1
"	" + 3 % arachis	36.6	72.1	8.7	20.0
Inner back	Control	46.7	67.7	13.4	14.3
"	" + 3 % shea	43.3	66.3	9.6	13.1
"	" + 3 % arachis	41.3	72.0	13.3	18.3
Leaf (perinephric)	Control	55.1	65.4	20.5	11.5*
"	" + 3 % shea	53.2	64.0	17.2	7.5*
"	" + 3 % arachis	46.9	70.6	17.5	18.9

* These figures may be slightly low, owing to rancidity.

The data in Table III show certain similarities and certain differences when compared with the corresponding figures for tallows [Banks and Hilditch, 1931, Tables VIII, IX, X]. In the depôt fats of both cattle and pigs, palmitic acid is present in relatively the most constant proportions (25–33 mols. %). Furthermore, in both classes, variation in the proportion of saturated to unsaturated acids as a whole (column I) is not accompanied by anything approaching the same variation in the total content of C_{18} acids (or, therefore, of palmitic and myristic acids): whilst the extreme limits of total saturated acid content lie between 36.6 and 55.1 mols. %, those of the total C_{18} acid group range only from 64.0 to 72.1 mols. %. Thus, both in the pig body fats and in the tallows, variation in the amount of unsaturated acids is mainly compensated for by corresponding changes in the stearic acid content.

Differences between the pig and cattle depôt fats consist chiefly in the lower content of myristic acid in most of the former class and especially in the higher proportion of linoleic acid present. Thus, whilst in tallows the relative amount of linoleic acid rarely exceeds 10 %, and is frequently only about 5 %, of the combined oleic and linoleic acids, the corresponding proportions in the pig fats studied range from 10 % or a little less to as much as 20 %: also, the proportion of linoleic acid (i) clearly increases with increase of unsaturation in fatty oil forming part of the diet and (ii) also increases (at all events when unsaturated fatty oils are absent from the diet) from the perinephric fat to the outer layers of the back fat.

The general effects produced by the inclusion of either a hard or a soft fat in the diet may next be considered. The shea butter fat used contained 45 mols. of saturated acids with 55 mols. of unsaturated acids, that is, it was less saturated than the inner back or leaf fats from the control-fed pigs. Its ingestion caused little alteration in the total saturation of the depôt fats, but the total C_{18} acid content was somewhat lower than in the corresponding control fats, so that the palmitic and (especially) the myristic acid contents increased (although the relative proportion of palmitic (with myristic) to stearic acid in the shea fat itself is far below the corresponding ratio in any of the pig fats).

The arachis oil feed had a very marked influence upon the total unsaturation of the fats, which increased in each case (the alteration being greatest in the leaf fat and least in the outer back layer), and also upon the relative proportions of linoleic and oleic acid. The unsaturated acids contained about 20 % of linoleic acid, this proportion being approached in the leaf and inner back fats as well as in the outer back layer. On the other hand, increase in unsaturation in the arachis oil feed experiments was remarkably closely balanced by diminution in stearic acid—the molar percentages of palmitic (with myristic acid) being 29.4, 28.0 and 27.9 in the leaf, inner and outer back fats respectively.

It is noticeable that alteration in the diet had relatively less effect on the composition of the outer layer of back fat than on that of the inner layer or

of the leaf. The analyses, also, point to an essential difference between the average composition of the fat between the "streak" and the skin, and that of the fat on the inner side of the "streak." The former is definitely the most unsaturated and also contains the highest proportion of linoleic to oleic acid: the latter approximates more nearly in composition to its corresponding perinephric fat than to the outer back fat, although it is in general less saturated than perinephric fat. The data may perhaps be summed up in the statement that, whilst ingested fat has a marked effect on the character of the leaf and inner back fats, that of the outer layer of back fat is, to a considerable degree, similar in spite of such variation in diet as is represented by the present series of feeding experiments.

The relative constancy of the outer back fat in composition may, of course, be determined by adjustment of the fat nearest the skin to a more or less constant consistency adapted to the average temperature conditions of the external atmosphere. Henriques and Hansen [1901] give details of the melting-points and iodine values of body fats similar to our figures and conclude that these characteristics are mainly determined by the external temperature. It is desirable, in this connection, to ascertain whether the layers of fat on either side of the "streak" are homogeneous, or whether there is a progressive alteration as the outer skin is approached: it is hoped in due course to examine the whole of the back fat from a single animal, divided into two or more sections on each side of the "streak," in order to settle this point.

Some further observations must be offered with reference to the tendency to constant molar content of the total C_{18} acids (or, alternatively, of the saturated acids other than stearic), which has now been remarked in the case of the component fatty acids of butter-fats, tallows and lards. In the tallows it was pointed out that the available data showed the possible existence of two classes, one containing about 62 mols. %, and the other about 70 mols. %, of total C_{18} acids. The present series of analyses takes us a little further: the range of this figure, for the pig fats now studied, is from 64.0 to 72.1 mols. % of C_{18} acids, and, broadly speaking, fats with a high content of oleic and linoleic acids have values towards the upper limit for the total C_{18} acids, and conversely. In other words, although the general constancy of the total C_{18} acid content is marked in comparison with the variation in total unsaturated acid content, yet, within this generalisation, it seems clear that increase of oleic and linoleic acids is not completely balanced by diminution in stearic acid, but that, to a subordinate extent, the total C_{18} acid content is swollen and that of the other saturated acids, palmitic and myristic, somewhat diminished.

The results given in this paper thus support the tentative suggestions offered at the conclusion of the discussion of the glyceride structure of tallows [Banks and Hilditch, 1931], namely:

(i) that ingested vegetable fats are utilised by disposal of excess of linoleic and oleic acids by oxidation, leaving a residue of palmitic (with minor quan-

tities of myristic and stearic), oleic and linoleic acids more or less adapted to the requirements of the particular storage fat (conversion of carbohydrates, *etc.*, to fat is of course another, but separate, source of depôt fats);

(ii) that the stearic acid content of body-fats, which is relatively much greater than that of the fats present in a vegetable diet, is secured by processes involving "saturation" of unsaturated acids.

It further appears that, in the case of the pig, the amount of linoleic acid tolerated in the storage fat is considerably greater than in tallows, and, moreover, that it is in some degree related to that ingested in the diet; whilst inspection of the data in Table III shows that there is some evidence that, if stearic acid results from saturation of unsaturated acids, in the pig fats it is almost entirely oleic acid, and not linoleic acid, which diminishes as the content of stearic acid rises¹.

These views accord in general, if not in all details, with those at which Ellis and co-workers have arrived in the course of their recent studies on soft pork. The percentage of each individual component acid was determined in the cases of relatively few of the numerous samples of fat dealt with by these investigators, but we have found it of great interest to convert such data, where available, into molar proportions for comparison with our own results.

In a study of the influence of a ration low in fat upon the composition of the body fat of hogs, Ellis and Zeller [1930] quote individual acid figures for the composite body fat of hogs of varying age and weight. These are reproduced, in the form of molar proportions, in Table IV.

Table IV. *Composite body fats of hogs of varying age, fed on rations low in fat [Ellis and Zeller, 1930].*

(i) *Molar distribution of individual acids.*

Hog No.	Age (days)	Live wt. (lbs.)	Fat I. V.	Myristic	Palmitic	Stearic	Oleic	Linoleic
5	110	73	61.2	1.4	27.4	8.2	56.5	6.5
7	134	110	57.4	0.9	29.9	8.7	56.0	4.5
11	246	243	53.3	1.3	28.0	11.1	58.8	0.8
13	257	282	55.1	0.9	27.2	10.7	59.9	1.3

(ii) *Molar percentages of total saturated acids (I), total C₁₈ acids (II), stearic acid (III) and proportion of linoleic acid in the unsaturated acids (IV).*

Hog No.	I	II	III	IV
5	37.0	71.2	8.2	10.3
7	39.5	69.2	8.7	7.4
11	40.4	70.7	11.1	1.4
13	38.8	71.9	10.7	2.2

The fat content of the diet in this series did not exceed 0.5 %, whereas in the control feed of the pigs whose body fats we have analysed there was

¹ Ellis and Harkins [1925] express the opinion that linoleic acid is not so essential a factor in adipose tissue as is oleic acid, since the amount appears to be controlled by the amount furnished in the feed; whereas deposited linoleic acid is usually less than the total amount ingested, the amounts of total saturated acids and of oleic acid are greatly in excess of the supply in the feed.

1.5 % of fat, and the pigs were killed when about 210 days old and at an average live weight of about 200 lbs. The component fatty acids of the outer back fat of pigs fed on our control diet are almost identical with the mean of Ellis and Zeller's figures for hogs 7 and 11, and it will be noticed that the nearly constant total C_{18} acid molar content in Table IV (69.2–71.9 %) accords exactly with our observations. The chief difference is in the proportion of linoleic acid, which is lower than in our experience and finally diminishes to 2 % or less of the unsaturated acids; it may well be, therefore, as Ellis and Zeller suggest, that the linoleic acid in pig depôt fat is derived exclusively from assimilated vegetable linoleic acid.

Ellis and Isbell [1926] investigated the influence of ingested fats in a somewhat drastic manner by feeding pigs (*a*) on brewer's rice, tankage and grass, (*b*) on corn, skim milk and grass, (*c*) on soya beans alone and (*d*) on arachis nuts alone. Their figures for component fatty acids (reduced to molar proportions as in Table IV) are given in Table V.

Table V. *Body fats of hogs fed on various fatty diets*
[Ellis and Isbell, 1926].

(i) *Molar distribution of fatty acids.*

Feed	Fat from	I. V.	Myristic	Palmitic	Stearic	Arachidic	Oleic	Linoleic	Linolenic
Brewer's rice, etc.	Back	52.6	2.1	28.2	11.7	—	56.8	1.2	—
Corn, etc.	Meat	58.8	0.8	27.0	12.3	—	53.0	6.9	—
Soya beans alone	Back	90.7	0.9	18.7	9.2	—	39.6	31.4	0.2
„	Back	100.6	0.4	15.3	7.7	—	38.2	37.9	0.5
Arachis (Virginian)	Meat	84.1	0.5	16.8	7.3	0.2	55.9	19.3	—
(Spanish)	Meat	91.8	0.1	11.3	4.8	0.3	63.9	19.6	—

(ii) *Molar percentages of total saturated acids (I), total C_{18} acids (II), stearic acid (III) and proportion of linoleic acid in the unsaturated acids (IV).*

Feed	Fat from	I. V.	I	II	III	IV
Brewer's rice, etc.	Back	52.6	42.0	69.7	11.7	2.1
Corn, etc.	Meat	58.8	40.1	72.2	12.3	11.5
Soya beans alone	Back	90.7	28.8	80.4	9.2	44.3
„	Back	100.6	23.4	84.3	7.7	49.8
Arachis (Virginian)	Meat	84.1	24.8	82.5	7.3	25.7
„ (Spanish)	Meat	91.8	16.5	88.3	4.8	23.5

This remarkable series shows that, whilst a balanced ration containing not more than 5 % of vegetable fat leads to body fats of exactly the same type as those previously discussed (Tables III and IV), a ration of vegetable seeds alone leads to the following effects: (*a*) the complete breakdown of any constancy in the total C_{18} acids, and consequently considerable diminution in the molar content of palmitic acid, (*b*) increase in the linoleic acid to proportions approaching those in the ingested fats and (*c*) failure to produce stearic acid to compensate for the reduction in palmitic acid or, indeed, to the normal amount of 10–20 mols. % observed with an ordinary balanced diet. Ellis and Isbell attach some significance to the approximate ratio of

2 : 1 for palmitic and stearic acids in these extreme cases, but examination of the wider range of data in Tables III and IV proves that this ratio may range from over 3 : 1 to below 1.5 : 1; in our opinion these relative proportions are not so material as the general relationships between the total C_{18} acid content and that of palmitic (with myristic) acids, coupled with the balance, within the C_{18} group, between stearic and the unsaturated acids (especially oleic acid).

The concentration of fat in the diet beyond which the tendency to constant proportions of palmitic (with myristic) and of total C_{18} acids clearly disappears is further established by the recent experiments of Ellis, Rothwell and Pool [1931] in which pigs were fed on a basal diet of hominy, tankage, alfalfa meal and mineral mixture (containing less than 1 % fat) supplemented by varying amounts of cotton-seed oil, the component fatty acids of which are myristic (0.5 %), palmitic (22 %), stearic (2 %), oleic (30.5 %) and linoleic (45 %). Their results are reduced to molar proportions in Table VI.

Table VI. *Composite back fats of hogs fed on varying rations of cotton-seed oil [Ellis, Rothwell and Pool, 1931].*

(i) *Molar distribution of fatty acids.*

Feed	Fat I. V.	Myristic	Palmitic	Stearic	Oleic	Linoleic
Basal diet only	60.6	2.0	27.3	13.2	48.8	8.7
„ + 4 % C.S.O.	60.5	1.4	26.8	20.4	38.4	13.0
„ + 8 % „	64.4	1.0	23.5	22.6	35.0	17.9
„ + 12 % „	77.4	1.3	15.0	25.9	31.3	26.5

(ii) *Molar percentages of total saturated acids (I), total C_{18} acids (II), stearic acid (III) and proportion of linoleic acid in the unsaturated acids (IV).*

Feed	Fat I. V.	I	II	III	IV
Basal diet only	60.6	42.5	70.7	13.2	15.2
„ + 4 % C.S.O.	60.5	48.6	71.8	20.4	25.1
„ + 8 % „	64.4	47.1	75.5	22.6	33.8
„ + 12 % „	77.4	42.2	83.7	25.9	45.8

Thus, at some point between 4 and 8 % of added fat in the diet, the total C_{18} acid content ceases to be approximately constant and rises considerably, although in this instance the molar content of the C_{18} acids in the ingested cotton-seed oil itself is only 75.8 %. (It is noteworthy that, with the larger amounts of cotton-seed oil, the stearic acid content of the pig fats continued to augment, in contrast to the observations with animals fed on soya beans or arachis nuts; the parallel differences in the diet, compared with that of these oil seeds alone, are (i) the presence throughout of a substantial, if reduced, proportion of basal meat ration and (ii) the presence in the cotton-seed oil acids of about 24 mols. % of palmitic acid.)

The definite approach to a constant balance between palmitic (with myristic) acids and the total C_{18} acids which we have established in the cases of the body fats of pigs and cattle and of the milk fat of cows fed on what

may be termed a "normal" diet, coupled with the breakdown of this balance in the pig fats examined by Ellis and collaborators when more than a certain proportion of added fat was present in the diet, may be regarded in another way: a molar content of 30 % palmitic (with myristic) acid is attained in the pig depôt fats only when the quantity of ingested fat in the diet is small (not exceeding about 5 %). This is additional, if indirect, evidence that a considerable proportion of the normal depôt fat must be derived by synthesis in the animal from the non-fatty components of the diet, rather than by direct assimilation of fat. This deduction appears to be of at least equal importance, as regards the normal animal metabolic processes, to the more obvious one that, with an excessive fatty diet deficient in carbohydrates, *etc.*, the pig is capable, *faut de mieux*, of utilising directly much of the ingested fats for storage.

Lack of material, as stated previously, prevented us from including a study of the glyceride structure of the nine fats which we have examined. A full examination of the component fatty acids and glyceride structure of the corresponding fats from a single pig fed on a controlled diet is, however, nearly complete, and the additional data which will then be available will enable us to offer a possible general explanation of some of the features connected with the elaboration of animal fats and of the fundamental differences in glyceride structure between these and the vegetable seed fats.

SUMMARY.

The component fatty acids of the perinephric fats and the outer and inner layers of the back fats from pigs fed on a basic diet (i) alone or supplemented by 3 % of (ii) shea butter or (iii) arachis oil have been determined. The general relationships which were recently observed amongst the various classes of fatty acids of tallows are found to be present also in the pig body fats, more especially a tendency to approximate constancy in the molar content of C₁₈ acids in spite of variation in the total proportion of saturated to unsaturated acids; increase in saturation is mainly produced by increase of stearic acid and corresponding diminution in oleic acid.

The composition of the outer layer of back fat differed in each case from that of the inner layer, the latter being intermediate in type between the former and the perinephric fat, which it more closely resembled. The outer layer of back fat was the most unsaturated, but the differences between the three depôt fats were much reduced when the diet of the animals included arachis oil.

As regards the influence of ingested fat in the diet, the body fats from animals whose feed included the relatively saturated shea butter were not greatly different from those of the control-fed animals, but presence of arachis oil in the diet led definitely to increase of unsaturation in the stored fat and also to increase in the proportion of linoleic acid in the unsaturated acids.

Consideration of the experimental data in conjunction with the results of Ellis and collaborators on the feeding of pigs with rations containing high proportions of vegetable fat confirms our previous conclusions as to the general rules governing the composition of depôt fat of animals fed on a balanced diet, and shows clearly the amount of added fat (beyond about 5–8 % of the diet) which leads to the breakdown of these characteristics. Further, the data as a whole prove that much of the normal depôt fat of the pig must be derived from carbohydrate or other non-fatty part of the feed.

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REFERENCES.

- Banks and Hilditch (1931). *Biochem. J.* **25**, 1168.
Brown and Deck (1930). *J. Amer. Chem. Soc.* **52**, 1135.
Ellis and Harkins (1925). *J. Biol. Chem.* **66**, 101.
—— and Isbell (1926). *J. Biol. Chem.* **69**, 239.
—— Rothwell and Pool (1931). *J. Biol. Chem.* **92**, 385.
—— and Zeller (1930). *J. Biol. Chem.* **89**, 185.
Henriques and Hansen (1901). *Skand. Arch. Physiol.* **11**, 151.
Hilditch and Sleightholme (1931). *Biochem. J.* **25**, 507.
Jamieson, Baughman and Brauns (1921). *J. Amer. Chem. Soc.* **43**, 1372.