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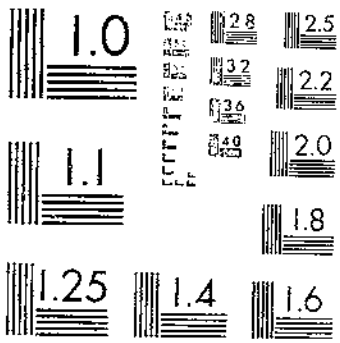

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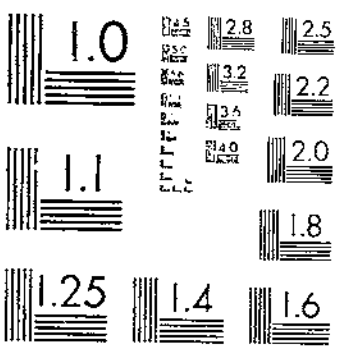

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CHANGES IN QUANTITY AND COMPOSITION OF FAT IN HOGS FED A PEANUT RATION FOLLOWED BY A CORN RATION [1]

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CONTENTS

THE RELATION OF PEANUT FEEDING TO SOFT PORK

When peanuts are fed to hogs as the basal constituent of the ration, the fat deposited in the adipose tissues is not greatly different in composition from the ingested peanut oil. The carcasses of hogs thus fed are soft or oily even after thorough chilling, in contrast with the firm carcasses of hogs which have received hardening feeds throughout life.

Experiments (*4*, *5*)[3] have shown that a gradual hardening of the adipose tissue takes place when a ration of corn and nonsoftening supplements is fed after the peanut ration. In general, the greater the gain on the peanut ration the greater the gain on the hardening ration that is required to produce a given degree of firmness of the adipose tissue in the chilled carcass or a given fat-constant value of the fat. These results, which are based on a large number of hogs self-fed in groups, have shown that, when the initial weights of the hogs exceeded 85 pounds, moderate firmness was not attained until the gain on the hardening ration was more than three times that on the softening ration. In the usual case the gain on the peanut ration was more than 40 pounds, with the result that the hogs weighed 300 pounds or more before moderate firmness was attained. In addition

[1] This work was conducted as a part of the project, cooperative soft pork investigations, which later was combined with the national project, cooperative meat investigations. Work on the firmness of fat of peanut-fed hogs, of which the experiments in the present study formed a part, has been conducted by the agricultural experiment stations of Georgia, Mississippi, North Carolina, South Carolina, and Virginia, in cooperation with the Bureau of Animal Industry, U.S. Department of Agriculture.

[2] H. S. Isbell and S. J. Dahl, of the Animal Husbandry Division, assisted the author materially in obtaining the data. E. Z. Russell, O. G. Hankins, and J. H. Zeller, of the same division, provided the experimental animals for the laboratory work, and K. F. Warner, also from this division, slaughtered the animals and prepared the carcasses for analysis.

[3] Italic numbers in parentheses refer to Literature Cited, p. 13.

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to their excessive weight and degree of finish, these hogs varied widely in firmness from soft to hard.

Better success in hardening has attended the feeding of hogs with initial weights of less than 50 pounds. A report (*7*, *p. 9*) of this work shows that lightweight pigs which gained from 20 to 60 pounds on a peanut ration and, later, 190 pounds on a corn-and-tankage ration usually produced carcasses of a satisfactory firmness.

These results indicated that the weight at the beginning of the peanut feeding, as well as the ratio of softening to hardening gain, materially influenced the firmness of the carcass. The underlying reasons for these general relationships, together with the exceptions and variations, remained for further study.

Since the firmness of pork is dependent in large measure on the composition of the fat (*2*), it is only reasonable to assume that the increase in firmness which occurs in the hardening of peanut-fed hogs is intimately related to the admixture of firm body fat with the oily fat previously stored. It follows that the composition and firmness of the fat in the adipose tissue at slaughter will be dependent on the proportions and the composition of the soft and hard fats stored during the two feeding periods.

The hog normally deposits fat at an increasingly rapid rate per unit of live-weight increase, within limits, when no important changes in the ration are made (*1*). Thus, on a ration of corn with nonsoftening supplements, hogs store more fat during the period of weight increase from 200 to 250 pounds than during the period of weight increase from 50 to 100 pounds.

Evidence from early experiments indicated that feeds of high oil content, such as peanuts, accelerated fat deposition above the normal rate. It is difficult, therefore, to predict from the gains in weight the probable gain in fat in the successive feeding periods on the peanut and the corn rations.

The differences in fatness between carcasses of hogs of similar weight are frequently of such magnitude that they are evident on cursory examination. Lack of finish has been found to be associated with softness of the carcass (*4*).

OBJECT OF STUDIES

Studies on the function of body-fat storage in the hardening of peanut-fed hogs were prompted by these considerations. The chief object of these studies was to determine the underlying factors involved in fat deposition in the hog when both softening and hardening feeds were used. Attention has been given not only to the influence, on firmness, of the proportions of body fat stored during successive periods on softening and on hardening feeds but also to the variations due to differences in rates of fat storage. A rather complete study has been made of the quantity of fat deposited and the composition of this fat.

EXPERIMENTAL WORK

These experiments were carried out at the United States Animal Husbandry Experiment Farm at Beltsville, Md. Since information was desired on the approximate quantity and composition of the body fat at the beginning of the experiment, at the close of the peanut-

feeding period, and at intervals during the hardening period, killings of representative animals were made at appropriate intervals.

All pigs were reared under the same conditions but not during the same year. Nonsoftening feeds were used in the rations of the sows and of the pigs up to the beginning of the experiments. The Chester White, Berkshire, Duroc-Jersey, and Poland China breeds were represented.

The group of hogs constituting lot A in the present study averaged approximately 100 pounds in weight at the beginning of the experiment. Their softening ration contained whole peanuts and a mineral mixture, self-fed. Lot B consisted of pigs which averaged approximately 40 pounds at the beginning of the experiment. Their softening ration included tankage, whole peanuts, and a mineral mixture, also self-fed. Although well-developed hogs, such as those in lot A, make satisfactory gains on peanuts and mineral mixture, experiments have shown that immature weanling pigs weighing less than 50 pounds apparently require additional supplements. In view of the work of Hankins and Zeller (*6*), tankage was added to the peanuts and minerals in the ration of lot B, though another supplement might have served equally well, as shown by experiments of Halverson, Hostetler, and Sherwood (*8*). They concluded that alfalfa meal and a mineral mixture were the only additional supplements to peanuts necessary to produce satisfactory gains in pigs ranging from 35 to 60 pounds. No work has been reported on the value of these supplements for hogs weighing 100 pounds or more.

Since the gains of the heavyweight pigs without tankage and of the lightweight pigs with tankage have been regarded as normal and satisfactory, comparison of the results of the two lots has been made. The main question involved, that of rate of fat deposited in relation to total gain, is not believed to be seriously affected by the difference in feeding with regard to tankage. Information gained during the progress of numerous soft-pork experiments has attested to the fact that extreme changes of diet are necessary to influence the fatness of the body. Thus, the restriction of the feed intake of a peanut ration to one-half of a full feed level failed to reduce materially the rate of fat storage.[4]

Following the feeding period on the peanut ration, on which the hogs in lot A were usually permitted to gain from 50 to 60 pounds and those in lot B from 40 to 50 pounds, a hardening ration of yellow shelled corn, tankage, and a mineral mixture was given. The groups of hogs continued on the self-feed basis.

Three of the hogs in lot A were killed for analysis at the beginning of the experiment. Three were killed at the end of the peanut-feeding period, when they had gained an average of 58 pounds on the softening ration. Finally, eight representative animals were slaughtered singly or in pairs after their gains on the hardening ration had reached multiples of approximately 2, 2.5, 3, 3.5, 4, and 5 times their gains on the softening ration.

The composition of the 40-pound pigs in lot B at the beginning of the peanut-feeding period was based on analyses made during the course of other experiments conducted over a somewhat longer period

[4] ELLIS, N. R., and ZELLER, J. H. THE EFFECTS OF LIMITATION OF THE FEED ON THE ECONOMY OF GAIN AND THE COMPOSITION OF THE BODY OF HOGS. [Unpublished manuscript.]

than the present ones. However, three pigs were killed at the end of the peanut-feeding period, when they had gained an average of 48 pounds on the softening ration. The remaining six animals in lot B were slaughtered during the hardening period, their gain multiples ranging from 2 to 5, like those in lot A.

After the hogs were removed from the feed lot for slaugher, they were kept without feed for a 24-hour period, were weighed, and then slaughtered. Since an estimate of the total quantity of fat in the entire body was required, the samples prepared for analysis included those body parts known to contain significant quantities of fat. All parts were included except the hair and toes, which were removed in the scraping process. The viscera and blood were sampled immediately after slaughter. The carcasses were chilled and graded for firmness (*4*). After fat samples had been taken, the carcasses were divided into commercial cuts and separated on a total-carcass basis into skin, bone, and meat fractions. Analyses for water, protein (N. times 6.25), fat (ether extract), and ash were then made. The composition of the entire body was calculated from the analyses of the parts. The total thus obtained was termed the "total analyzed weight."

Fat analyses were made of samples of back and leaf fats taken according to a routine procedure (*4*) and of samples of fat prepared from the meat fraction as samples for body analysis. The fat analyses included refractive index, iodine number, melting point, and titer test on part or all of the samples, together with lead-salt separations made of the meat fat. From these separations of the fat the percentages of mixed saturated, oleic, linoleic, and arachidonic acids were estimated (*2*).

The data from the analyses have been used to estimate the weight of the several body constituents present in the animal body and the gain in the total fat and fat fractions preceding the experimental period and during the softening and the hardening periods.

RESULTS OF EXPERIMENTS

FEED CONSUMPTION

The average feed consumption (table 1) of the hogs, as judged from the results for the group from which they were selected, was typical of that commonly obtained with hogs on the rations used (*4*). From tables 1 and 2 it may be seen that the quantity of the peanut ration consumed per unit of gain was lower than that of the corn ration. The large quantity of peanut oil ingested, as indicated by the ether extract of the peanuts, readily accounts for the extreme softening of the body fat which always occurs. From the feed-consumption and the feed-analysis data it was estimated that the lot A hogs consumed 121 pounds and the lot B hogs 95 pounds of peanut oil for every 100 pounds of gain in live weight which they made during the softening period. The ingestion of these high levels of oil is especially noteworthy, as is shown later in the effects on the quantity and composition of the oily fat stored by the hogs.

TABLE 1.—*Quantity of feed and calculated ether extract consumed per 100 pounds of gain by 2 lots of hogs of different initial weights*

Feeding period and feeds used	Lot A (100 pounds initial weight)		Lot B [1] (40 pounds initial weight)	
	Total feed	Ether extract	Total feed	Ether extract
Softening:	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Shelled peanuts [2]	276.0	121.0	211.0	94.8
Tankage			46.0	3.1
Mineral mixture	9.3		2.0	
Total	285.3	121.0	259.0	97.9
Hardening:				
Shelled corn	513.5	19.5	349.6	13.7
Tankage	28.1	1.8	48.5	3.3
Mineral mixture	6.0		1.3	
Total	547.6	21.3	399.4	17.0

[1] Data from the 3 lot B hogs killed at the end of the softening period not included.
[2] Weight of shelled peanuts was about 69.5 percent of the weight of the whole peanuts fed.

TABLE 2.—*Weights and gains of 2 lots of hogs of different initial weights on the softening and hardening rations*

LOT A (100 POUNDS INITIAL WEIGHT)

Hog no. [1]	Breed [2]	Initial weight	Total gain on—		Average daily gain on—		Approximate gain ratio	Weight at close of feeding period
			Softening ration	Hardening ration	Softening ration	Hardening ration		
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*		*Pounds*
4	CW	100	57		0.74			157
5	Mix	98	59		.79			157
6	B	99	58		.62			157
Average		99	58		.72			157
7	B	109	60	125	.87	0.74	1:2.1	294
8	Mix	106	61	152	.88	.77	1:2.5	319
9	DJ	100	60	153	1.05	1.17	1:2.6	313
10	PC	102	58	174	.91	1.51	1:3.0	334
11	H	95	53	187	.95	1.29	1:3.5	335
12	CW	104	56	196	.90	1.21	1:3.5	356
13	B	114	51	207	.91	1.36	1:4.1	372
14	PC	109	54	282	.96	1.68	1:5.2	445
Average		105	57	185	.93	1.22	1:3.25	346

LOT B (40 POUNDS INITIAL WEIGHT)

15	PC	39	34		0.41			73
16	CW	38	51		.61			89
17	CW	38	58		.69			96
Average		38	48		.57			86
18	PC	40	43	86	.77	1.54	1:2.0	169
19	DJ	52	39	81	.70	1.45	1:2.1	172
20	PC	48	47	135	.84	1.65	1:2.9	230
21	CW	30	43	200	.77	1.43	1:4.7	273
22	CW	38	44	195	.79	1.39	1:4.4	277
23	PC	47	40	203	.71	1.84	1:5.1	290
Average		42	43	150	.76	1.55	1:3.6	235

[1] Hogs 1 (CW), 2 (CW), and 3 (Mix) were slaughtered previous to the softening period.
[2] CW, Chester White; B, Berkshire; DJ, Duroc-Jersey; PC, Poland China; H, Hampshire; Mix, mixed breeding.

WEIGHTS AND GAINS OF HOGS

The data on weights and gains of the two lots of hogs for the softening and the hardening periods are given in table 2. As a group, the lot A hogs gained more rapidly than the lot B hogs on the peanut rations. However, the difference probably is no greater than that between 100-pound and 40-pound pigs on other feeds. At the close of the hardening period, in lot A 7 of the 8 hogs weighed more than 300 pounds each. In lot B, the maximum weight was 290 pounds.

The approximate gain ratio between softening and hardening periods is also given in table 2. In lot A a ratio of 1:2.5 was associated with a final weight of more than 300 pounds, whereas in lot B a ratio of 1:5.1 was possible for a hog which weighed 290 pounds. In lot B the smaller gain on the softening ration was an important factor in keeping the final weight at less than 300 pounds when the total gain on hardening feed was sufficient to give a ratio of 1:5.1.

COMPOSITION OF THE BODY

The age of the hogs at slaughter, the slaughter and analysis weights, and the percentages of water, protein, fat, and ash in the carcasses are given in table 3.

TABLE 3.—*Slaughter weights and composition of bodies of hogs used in experiment*

Hog no.	Age at slaughter	Weight at slaughter	Total analyzed weight	Composition of body			
				Water	Protein	Fat	Ash
	Days	*Pounds*	*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*
LOT A (100 POUNDS INITIAL WEIGHT)							
1	202	94	87.8	57.84	13.95	25.60	2.60
2	204	100	94.0	58.90	14.46	24.08	2.61
3	205	98	91.3	56.20	14.35	26.88	2.59
Average	203	97.3	91.0	57.65	14.25	25.52	2.60
4	264	150	142.3	46.60	12.30	38.70	2.35
5	262	151	145.8	45.99	10.83	41.24	1.67
6	290	153	145.3	48.05	13.25	36.65	2.12
Average	272	151.3	144.5	46.88	12.13	38.86	2.15
7	427	294	284.4	38.29	11.31	47.89	2.51
8	462	301	298.5	36.31	11.18	50.65	1.84
9	403	310	292.6	36.90	10.33	51.15	2.06
10	416	334	308.6	38.80	10.70	48.55	2.15
11	394	335	316.4	38.04	10.88	48.50	2.00
12	423	353	334.9	35.30	9.84	52.80	2.05
13	398	370	351.2	42.23	12.20	43.12	2.44
14	415	445	433.0	35.20	9.73	53.19	1.92
Average	417	342.8	327.4	37.72	10.77	49.48	2.11
LOT B (40 POUNDS INITIAL WEIGHT)							
Average of 3 pigs taken from other experiments	77	41	38.3	60.52	15.52	20.41	3.45
15	166	73	68.1	53.20	12.11	32.73	2.26
16	177	84	72.2	51.84	13.08	31.72	3.10
17	179	90	83.5	52.32	13.42	31.68	2.54
Average	174	82.3	74.6	52.45	12.87	32.04	2.63
18	211	161	153.6	46.09	11.44	40.16	2.51
19	211	165	157.0	46.53	11.76	39.32	2.57
20	237	229	221.7	41.27	10.94	45.53	2.31
21	295	268	257.3	37.42	9.51	51.24	2.16
22	295	275	259.5	37.34	9.48	51.17	2.13
23	265	277	264.3	39.91	9.91	47.71	2.28
Average	252	229.7	218.9	41.43	10.51	45.86	2.33

The results of particular interest on composition of the carcass are those on fat content. In lot A the fat content of the three hogs analyzed at the beginning of the softening period averaged 25.52 percent. The three hogs analyzed at the close of the softening period had a much higher fat content, 38.86 percent. The increase made by the hogs in lot A was greater than that made by those in lot B, the percentages of fat content for lot B before and after peanut feeding being 20.41 and 32.04, respectively. Furthermore, hogs 15, 16, and 17, which were slaughtered at the end of the peanut-feeding period, were fatter than hogs 1, 2, and 3, which had received only nonsoftening feeds, even though the latter group averaged 15 pounds more in weight. It is apparent, therefore, that the peanut ration caused a greater increase in fatness than normally occurs on rations low in fat, such as corn and tankage.

A corresponding increase over the normal occurred in hogs 4, 5, and 6. Hogs of similar weight [5] fed on rations of corn with nonsoftening supplements had a fat content of approximately 32.5 percent, which is about 6.3 percent less than the average fat content of hogs 4, 5, and 6. Furthermore, hogs 15, 16, and 17 were as fat at slaughter weights of from 73 to 90 pounds as these corn-fed hogs, which weighed approximately 150 pounds. The apparent excessive fattening which occurred in both lots A and B during the softening period is of particular importance in its bearing on the hardening requirements of the hogs. During the hardening period, in general the increase in fatness continued but was less rapid. There were exceptions in both lots, hog 13 in lot A and hog 23 in lot B having especially low fat contents as compared with others of similar weights.

In the grading of carcasses for firmness in the cooperative meat investigations already mentioned, hog carcasses are divided into five grades: Hard, medium hard, medium soft, soft, and oily. All grades are represented in this experiment (table 4). Hogs 1, 2, and 3, used as controls for lot A, were moderately soft, as shown by gradings of soft and medium soft. These are the usual gradings of hogs of 100 pounds weight or less (4). The three laboratory animals used as controls for lot B were not graded, although the fat constants given in table 4 indicate moderate softness. Peanut feeding produced a pronounced change toward oiliness in both lots. Five of the six hogs, nos. 4, 5, 6, 15, 16, and 17, were graded oily. The refractive index and iodine numbers show corresponding changes.

The data for hogs 15, 16, and 17 indicate that the fat of these animals was more oily than that of hogs 4, 5, and 6. This does not mean that in the former group there was deposited a fat of a correspondingly greater degree of oiliness than in the latter group, although some differences could be expected because of age or stage of growth. As already indicated, the difference can be accounted for in large measure by the fact that at the beginning of the softening period the hogs in lot A, because of their greater age and weight, had a larger quantity of moderately soft fat to which was added the oily fat deposited on the peanut ration. Although a change of the oily condition to one of moderate softness occurs relatively rapidly after changing to the hardening ration, a comparison of gradings of the lot A hogs killed at intervals during the hardening period fails to show

[5] Unpublished data.

a consistent increase in firmness beyond that of soft, with widening of the gain ratio. The heaviest hogs, nos. 13 and 14, with approximate gain ratios of 1:4.1 and 1:5.2, respectively (table 1), were both medium soft. Hogs 11 and 12, intermediate in weight, were graded medium hard and hard, respectively. They had lower refractive index and iodine-number values than hog 10, which had a narrower gain ratio and was graded soft.

TABLE 4.—*Firmness grades, fat constants, and fatty-acid distribution of carcasses of hogs* [1]

LOT A (100 POUNDS INITIAL WEIGHT)

Hog no.	Firmness grade of carcass [2]	Refractive index, 40° C.			Meat fat			Fatty acids (meat fat)					
		Meat fat	Back fat	Leaf fat	Iodine number	Melting point	Titer test	Iodine number total unsaturated	Mixed saturated	Unsaturated			
										Oleic	Linoleic	Arachidonic	Total
					°C.	°C.			*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	MS	1.4601	1.4603		70.5								
2	S	1.4599	1.4601		68.4		37.1	111.1	33.0	48.2	14.0	0.14	62.3
3	MS	1.4604	1.4602		73.1								
4	S	1.4614	1.4614	1.4607									
5	O	1.4620	1.4621	1.4616	84.1	22.5	30.7	113.7	22.0	54.2	18.4	.18	72.8
6	O	1.4618	1.4618	1.4613									
7	S	1.4599	1.4600		69.9	27.9		103.0	27.5	58.0	9.4	.09	67.5
8	S	1.4602	1.4602	1.4595	73.3	33.8		104.9	26.9	57.2	10.8	.08	68.1
9	S	1.4600	1.4599	1.4596	71.9	29.8		103.9	28.6	56.3	10.0	.06	66.3
10	S	1.4603	1.4602		73.3	33.1		103.8	26.5	57.9	10.1	.09	68.0
11	MH	1.4601	1.4602	1.4599	70.7	35.6		103.1	27.2	58.4	9.5	.08	68.0
12	H	1.4598	1.4599	1.4596	71.3	28.6		100.6	27.0	60.1	7.7	.08	67.9
13	MS	1.4602	1.4602	1.4592	71.4	32.7		103.0	27.5	56.5	10.0	.07	66.5
14	MS	1.4599	1.4599	1.4591	68.1			103.0	29.2	56.8	9.5		66.3

LOT B (40 POUNDS INITIAL WEIGHT)

(3)		1.4605		1.4600	74.6	26.4		112.0	26.5	51.0	15.3	0.02	66.5
15	O	1.4632	1.4630	1.4632	94.5								
16	O	1.4631	1.4628	1.4625	91.5		29.4	117.5	18.9	53.5	23.1	.05	76.6
17	O	1.4629	1.4624	1.4623	91.7								
18	MS	1.4607	1.4601	1.4598	70.0		33.6	105.4	29.2	55.1	11.2	.05	66.3
19	MS	1.4602	1.4601	1.4593	67.4		34.5	105.3	31.2	53.5	10.8	.04	64.3
20	MH	1.4600	1.4595	1.4591	65.6		36.1	102.6	31.9	54.7	8.8	.04	63.5
21	H	1.4596	1.4593	1.4591	62.5		36.1	103.4	33.7	52.1	8.9	.04	61.0
22	H	1.4598	1.4595	1.4592	62.8		36.1	102.5	33.0	53.9	8.5	.02	62.4
23	MS	1.4597	1.4595	1.4592	62.0		36.2	104.2	33.2	52.6	9.7	.03	62.3

[1] In the cases indicated by blanks the analyses were not made. Both titer tests and melting points were considered unnecessary in the usual case.
[2] H, hard; MH, medium hard; MS, medium soft; S, soft; and O, oily.
[3] Average of 3 pigs taken from other experiments. Carcasses not graded for firmness.

Apparently the medium soft grades of hogs 13 and 14 may be explained by their relatively low fat content. Table 3 shows an abnormally low fat content for hog 13, whereas hog 14 had a value similar to that of hog 12, although the former was approximately 100 pounds heavier. In other words, had the proportionate increase in fatness according to weight of animal occurred, hog 14 should have attained a value considerably above 53.19 percent. Further discussion of the relation of fat content to firmness is given later.

In lot B an orderly increase in firmness, as determined by gradings and fat constants, occurred in hogs 18 to 22, inclusive. Hog 23 was graded medium soft, although the fat constants indicate firm fat.

This hog had a low content of body fat, as compared with hogs 21 and 22, which were only a few pounds lighter in weight (table 3). Possibly its adipose tissues were not so extensive nor so completely filled with fat, a finding which has been frequently observed (*5*).

With gain ratios comparable for the two lots, the hogs in lot B generally had greater firmness than those in lot A. The decrease in iodine number from a maximum of 94.5 for one of the hogs slaughtered at the close of the softening period to a minimum of 62 shows the marked change in fat composition which it is possible to produce under the feeding conditions used in lot B.

Comparison of the firmness data of these hogs with the data of other hogs from the same feeding experiments showed that the animals selected for the present study were typical for the various weights and gains represented in the groups. For the other hogs there were similar discrepancies in the relationship between increasing firmness and widening of the gain ratio or increase in weight, with extremes of hard and soft among individuals with gain ratios of 1:4 or wider.

In line with the marked changes, due to the hardening ration, in the values for the fat constants, especially in lot B, the content of the mixed saturated and the unsaturated acids in the body fats of the hogs show definite and characteristic changes.

The results of fatty acid separations are given in table 4. The mixed saturated acids obtained by the lead salt-ether method of separation were not further fractioned. The unsaturated acids which were identified were oleic, linoleic, and arachidonic. As in an earlier work (*2*), the arachidonic acid was identified from its bromine addition product. It occurred in relatively small quantities and, although considerable importance has been attached to its presence in animal tissues during recent years, it played little part in the softness of the pork.

The decrease in the mixed saturated acids and increase in the linoleic acid to approximately equal levels in the lard of peanut-fed hogs have been previously observed (*2*). The changes during the hardening period were not so marked in lot A as in lot B and are in harmony with the firmness gradings and fat constant values. In lot A the failure of the mixed saturated acids to reach 30 percent or more appears to have been an important factor in explaining why so few hogs were hard or medium hard. The single animal which was graded hard had a low value of 7.7 percent for linoleic acid, although the oleic acid content was the highest for the group.

Comparison of the values for mixed saturated acid and for oleic acid shows a tendency toward lower mixed saturated and higher oleic acid content in hogs 7 to 14 in lot A than in hogs 18 to 23 in lot B. The reasons for the increase in percentage of mixed saturated acids in hogs 18 to 23 are not apparent, although the fact that these hogs were younger than hogs 7 to 14 when they were fed the softening ration was undoubtedly of primary importance. Similar differences between groups fed under the same feeding plan but at different experiment stations were observed in the work already mentioned (*2*).

The variations among individuals in lots A and B, as well as differences between lots, in both the fat content of the body and the percentages of fatty acids in this fat have been such as to account in large measure for the failure of certain hogs to attain the normal degree of firmness expected from the gains in weight. The percentages of

fatty acids are necessarily influenced by the quantity of fat as a whole which is stored in the successive feeding periods. In view of this, it seemed desirable to calculate for each hog the quantities of total fat and of the principal fatty acid fractions deposited in each feeding period, including the period previous to the experiment.

These calculations were based on the data in tables 2, 3, and 4 and other data in the laboratory. The quantities of the fatty-acid fractions are shown in figures 1 and 2. The values for the average composition of hogs 1, 2, and 3 furnish the means for estimating the composi-

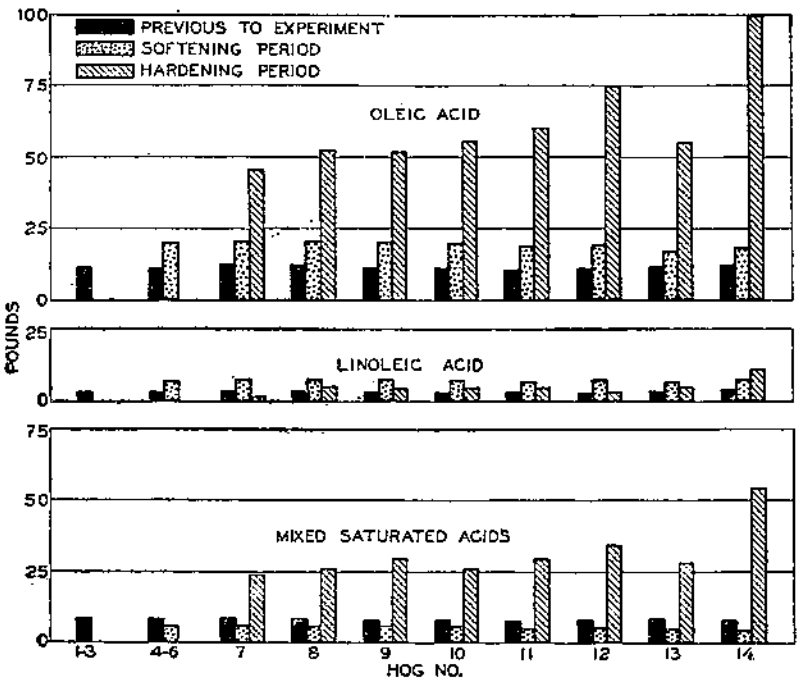

FIGURE 1.—Estimated increase in the principal fatty acids, by feeding periods, deposited in the adipose tissues of the hogs in lot A.

tion of hogs 4 to 14, with corrections for their weights, at the beginning of the peanut feeding. Then, from the difference in composition between the values for hogs 4, 5, and 6 and for hogs 1, 2, and 3 the actual quantity of total fat, as well as of the several fatty-acid fractions, deposited during the softening period was estimated. These calculations were then extended to the animals on the hardening ration. Similar methods were applied to lot B. The estimates for initial composition of the latter were made on the basis of data available in this laboratory for three hogs used in other experiments, as previously stated.

A comparison of gain ratios based on live weight and fat content for the hogs on the hardening rations is shown in table 5. The figures for lot A are in close agreement. Hog 13 was an exception. As already shown, this animal was unusually low in fat content at the time of slaughter and had evidently failed to fatten at the usual rate. The data on the other seven hogs in lot A indicate that the rate of fat

storage remained rather constant during the experiment, with the result that the ratio of fat in gain increased in proportion to the increase in ratio of gain in live weight.

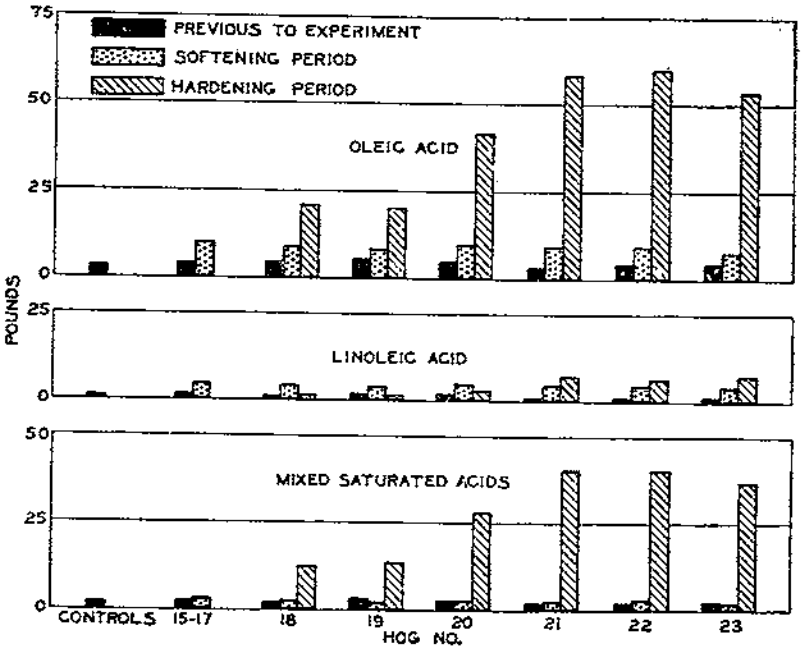

FIGURE 2.—Estimated increase in the principal fatty acids, by feeding periods, deposited in the adipose tissues of the hogs in lot B.

TABLE 5.—*Comparison of gain ratios based on gain in live weight and fat content*

LOT A (100 POUNDS INITIAL WEIGHT)

Hog no.	Ratio of softening gain to hardening gain based on—		Hog no.	Ratio of softening gain to hardening gain based on—	
	Gain in live weight	Weight of fat in gain		Gain in live weight	Weight of fat in gain
7	1:2.1	1:2.2	11	1:3.5	1:3.2
8	1:2.5	1:2.5	12	1:3.5	1:3.6
9	1:2.6	1:2.6	13	1:4.1	1:3.2
10	1:3.0	1:2.7	14	1:5.2	1:5.5

LOT B (40 POUNDS INITIAL WEIGHT)

18	1:2.0	1:2.1	21	1:4.7	1:6.3
19	1:2.1	1:2.2	22	1:4.4	1:6.1
20	1:2.9	1:3.8	23	1:5.1	1:6.2

A marked widening of the fat ratios with increasing gain ratios based on gain in live weight occurred in lot B. This is especially the case with hogs 21 and 22, in which the fat ratio was more than 1:6 for gain ratios of approximately 1:4.5. These findings indicate that dur-

ing the period of growth when live weight was between 30 and 100 pounds the rate of fat storage per unit of live-weight increase on the softening ration was not so great as that later attained on the hardening ration. Such a condition materially lessens the gain required on the latter ration to produce a given degree of firmness. As already indicated, the individual differences in ratios played a prominent part in the firmness of the carcasses and the composition of the fat of the hogs in this experiment.

The rates of fat formation, as evidenced by the figures on gain ratios, which prevailed in lot B were especially favorable for the more rapid hardening. The fact that these hogs when fed the peanut ration did not deposit so much fat for a given gain as they did later during equivalent gain makes possible these wide ratios. For hogs weighing more than 100 pounds at the beginning of the softening period, the rate of fattening attained on peanuts apparently remained unchanged during the subsequent feeding of corn.

As would be expected from the percentage values and from the relatively long feeding period, the quantity of oleic acid formed during the hardening period is the greatest. On the other hand, the quantity of linoleic acid deposited during this period was usually less than in the earlier softening period. Indeed, the only exceptions were those cases in which the gain ratios were 1:4 or wider. By far the greater portion of the mixed saturated acids was deposited during the final period.

Of equal importance to the differences between periods is the relative storage of the fatty acids within a given feeding period. In the softening period the ingestion of large quantities of peanut oil furnished a plentiful source of oleic and linoleic acids but little of the mixed saturated acids. The fat deposited in the body during this period was similar in composition to that of the ingested oil. The linoleic acid ranked second in quantity to oleic acid. The hardening period brought a change in the proportions. In the synthesis of fat from carbohydrates the predominating fatty acids formed are oleic, palmitic, and stearic, in the order named. Thus, the chief difference between the two periods as to relative ranking lies in the replacement of linoleic acid by the mixed saturated acid group.

In the discussion of the composition of the fat, emphasis has been placed on the fatty acid distribution. These acids occur in the fat in various glyceride combinations. The many possible combinations of mixed glycerides, as well as simple glycerides, with wide range in melting points add complexity to the question of firmness of the fat. It is probable that the feeding of widely different feeds in successive periods produces a different series of glycerides from that which would be formed were the same materials fed together. Although no information on the glycerides as such is available on the samples studied, the foregoing should serve to indicate their influence on the firmness of the fat. Nevertheless, the fatty acid distribution remains of primary importance. In order to obtain even moderately firm body fat in hogs which have become soft, sufficient saturated acids must be added to offset the unsaturated acids.

From the data on composition of the hog carcasses as it relates to the changes in fat content and in the fatty acid composition of the body fat, it is evident that fat storage is an important factor in the

hardening of peanut-fed hogs. In the usual hardening procedure the softening effects of the oily fat can be offset only by additional deposition of hard fat—that is, fat high in mixed saturated acids and low in unsaturated acids, particularly the linoleic—to the extent that the resulting mixture approaches that of normal firm fat.

SUMMARY

Two groups of hogs averaging approximately 100 pounds and 40 pounds in initial weights were compared in a study of the quantitative relationship of storage of fat to firmness as influenced by the use of peanuts and of corn in successive feeding periods.

A higher rate of fat storage prevailed during the period the hogs were on the peanut ration than when they were on the corn ration. The group of hogs which averaged 100 pounds at the beginning of the experiment stored the oily fat at a somewhat more rapid rate than the group which averaged 40 pounds at the beginning of the experiment.

Hogs which continued on the hardening ration until the gains reached multiples ranging from two to five times the amount stored on the softening ration generally showed increasing firmness. The gain in total fat was generally more closely related to firmness than the gain in live weight. For the same gain ratio, greater firmness was produced in the hogs in the lower initial weight group.

Analyses of fat samples showed marked decreases in saturation as a result of peanut feeding and an increase in saturation or firmness after the feeding of the corn ration.

The addition of hard fat, formed from the nonfatty constituents of the hardening ration, to the oily fat already formed during the peanut-feeding period produced a gradual hardening of the body fat as a whole. The group of saturated acids replaced linoleic as second to oleic acid when the corn ration was substituted for the peanut ration.

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