Soft Pork: A Serious Economic Problem

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THE occurrence of a soft or oily condition in chilled hog carcasses and in the retail pork products has formed a serious economic problem in this country for many years. Price discriminations against soft and oily carcasses have resulted because of difficulties attached to the marketing and use of the products, particularly the lard, bacon and certain fresh products. The producer has faced a complex problem in his attempts to realize the greatest profit from the sale of his product.

For many years the soft pork problem was largely confined to the peanut-growing sections of the South. However, the scope of the problem has materially enlarged in recent years. The inroads of the boll-weevil in the cotton-growing sections led to an expansion in the growing of peanuts and their use as a hog feed. The recognition of the soy bean as a soil improvement crop and as a valuable livestock feed has been followed by a rapid extension of its cultivation throughout the greater portion of the country. The soy bean has come to be recognized as a valuable protein feed which can be grown and used in conjunction with corn for hog feeding. In addition, other feeds which are more or less sectional as to their growth and utilization are known to produce soft pork and are being given serious attention in studies of the problem now under way.

Feed is generally recognized as the principal cause of soft pork. In most cases the feeds responsible for producing softness are so well adapted for use in the region where they are grown and fed that their elimination as a hog feed has not appeared to be practicable. Accordingly, methods have been sought to overcome the softness developed during a period when softening feeds have been fed; usually by subsequent feeding of hardening rations. In other words, the purpose has been to utilize the softening feeds at hand along with a sufficient quantity of hardening feeds to the best advantage in order to secure hogs of marketable hardness. Studies have been made of other factors which influence the process of fat formation or the character of fat formed, such as weight of the animal at the start of the feeding period, the total gain, and the rate of gain on different rations at various stages in the growth of the animal.

The firmness of the fat in the adipose tissue of the hog is almost entirely responsible for the firmness of the chilled carcass and the pork products. From the production standpoint, the problem as already indicated resolves itself largely into a study of fat metabolism. It is particularly one of anabolism since the hog builds up a very large store of fat when fed to the usual market weight of 200-225 pounds. The quantity and quality of the fats in the various hog feeds influence the firmness of the body fat. The fat derived from feed fat is not materially changed during the process of absorption and deposition. Most of the com-

mon hog feeds in this country not only contain a considerable quantity of fat but this fat is usually oily, i.e., composed of a large amount of unsaturated fatty acids.

The body fat not derived from ingested fat is synthesized from carbohydrate and occasionally from protein. Such fat is normally firm. The firm pork products of Europe are to be ascribed largely to the use of such feeds as barley, potatoes and skim milk which are all low in fat. The availability of such pork products has led the European bacon industry to discriminate against the softer products from the corn-feed hogs of this country. The firmness of the body fat, providing other factors are equal, will be greater when a large proportion of the deposited fat is derived from carbohydrate and protein and only a small proportion comes from the oils in the feeds. It is the relation between the fat synthesized by the animal and that derived from the feed which largely determines the relative firmness of the adipose tissue.

The hogs used in the present investigations are fed at the experiment stations in co-operatively arranged experiments. They are shipped to the U. S. Animal Husbandry Experiment Farm at Beltsville, Maryland, for slaughter, carcass grading of firmness, and laboratory study of the fats. The carcasses are graded by an official committee appointed by the co-operating agencies. The grades of firmness which are recognized are hard, medium hard, medium soft, soft and oily. Hogs grading hard or medium hard are regarded as acceptably firm on the market while those grading medium soft, soft or oily are unsatisfactory and subject to price discrimination.

Laboratory work on the soft-pork problem has two objects, first to measure the firmness of the carcasses in the terms of fat constants. In this work the refractive index of the back fat has been found to be a correlative measure of firmness. The second phase of the activities of the laboratory relates to work on fat metabolism involving quantitative studies on fat formation and on the fatty acid composition of the fat to throw additional light on various aspects of the problem.

The work is still in progress so the results on only a limited number of rations which have been studied the most extensively can be discussed.

The differences in the firmness of young immature pigs and fully developed, mature hogs when fed on ordinary rations with a moderately low fat content was observed early in the investigations. On a ration of corn with non-softening supplements, such as tankage or skim milk, the carcasses of young animals were soft but with increase in age and weight the carcasses became progressively harder. It was not until the hog of medium type weighed approximately 175 pounds that a strictly hard carcass was produced. Study has been made of the relation of the feed constituents, particularly the fat to the composition of the animal body and the composition of the body fat at a number of stages of growth for several litters of pigs. It was found that the progressive hardening was accompanied by a rapid increase in the rate of fat deposition, and this in turn caused a widening in the ratio of body fat derived from carbohydrate and protein (hard) to that derived from ingested fat (soft). In other words, the amount of fat deposited in a weanling pig for each pound of

gain of live weight was not far in excess of the amount of ingested oils. The body fat deposited at this stage was soft since only a small additional amount of synthesized fat was laid down in the tissues. In a well-grown 225-pound animal, the amount of fat deposited may be three times the amount ingested on the corn ration. The body fat deposited under such conditions is accordingly much firmer due to the large quantity of synthesized hard fat which is formed. The progressive development of firmness of the fat brought about in such a manner is shown in the change in fat composition. Such fat constants as the iodine number, refractive index and melting point have shown increase in firmness. Analysis of the fatty acids showed that the amount of linolic acid in the entire body of the animal at any given stage of growth was always less than the total amount consumed in the feed. The oleic acid and the total saturated acids were synthesized in increasingly large amounts and the quantities present were in excess at all times of those ingested. There was a steady decline in the percentage of linolic acid in the body fat accompanied by an increase in the percentage of total saturated acids.

Rations of rice polish or rice bran with protein supplements, ground soy-beans 1 part mixed with corn meal 3 parts, soy-beans with a medium ration of shelled corn, soy-beans alone, and peanuts alone have produced unsatisfactory carcasses which ranged in general in the order listed from medium soft to oily. The first 3 named rations produced largely medium soft and soft carcasses while the last 3 produced largely soft and oily carcasses. For initial weights ranging from approximately 50 to 150 pounds, the softness or oiliness is developed more quickly at the lower weights. When moderately softening rations, such as those containing rice polish and rice bran, were fed to pigs weighing 100 pounds or less, there was a period of rapid softening which was usually followed by a period of gradual hardening as the hog reached the stage of high fat storage. Rations of peanuts and soy-beans produced distinctly oily carcasses. On both rations there was a steady increase in the degree of softness with increase in gain which was apparently limited in the case of the peanut ration by the degree of unsaturation of the feed fat. Although soy-beans do not contain as high a percentage of oil as peanuts, the oil is more highly unsaturated. Soy-bean feeding has produced lards of higher iodine number than from peanut feeding. However, no cases have been found in which "soy-bean" lards have been as comparable in composition to soy-bean oil as the "peanut" lards have been to the peanut oil. In the majority of cases peanuts have produced greater oiliness of the carcass. It would appear that the peanut ration is such that synthesis is reduced to a minimum and that the fat deposited is largely the peanut oil ingested. This condition is probably due to the high oil content of the peanut ration.

The question as to the exact nature of the fat formed on a fat-free ration has been answered in large measure by results from the feeding of brewers' rice as the basal feed. This by-product of the rice milling industry usually contains less than 1 per cent of fat. The lard from hogs fed brewers' rice and protein supplement from weaning or shortly after until they reach a market weight of 200 pounds and over was extremely firm. The

iodine number and refractive index were both low while the linolic acid content in some cases fell below 2 per cent.

The results of a rather complete separation of the fatty acids on lards from hogs fed such basal feeds as brewers' rice, corn, soy-beans and peanuts is contained in the table. The predominating fatty acids were oleic, linolic, palmitic and stearic. The last two named occurred in a ratio of approximately 2:1. The linolic acid was particularly influenced by the amount present in the feed. The glyceride varied from 1.2 per cent in Sample 1 (brewers' rice) to 38.3 per cent in Sample 6 (soy-beans). Small amounts of linolenic acid occurred in Samples 5 and 6, but these amounts were much smaller than found in soy-bean oil. Likewise the arachidic acid in Samples 3 and 4 was much below that found in peanut oil. The largest amount of myristic acid was found in the lard from the hogs fed brewers' rice, i.e., where the largest proportion of the body fat had been synthesized. Peanut, soy-bean and corn oils are reported not to contain this acid.

The results thus far reported on the hardening of soft hogs have been principally on hogs of initial weights of 85 pounds and over which have been fed corn subsequent to the softening period. Brewers' rice has been used in place of corn in a few experiments conducted at stations adjacent to the rice-growing sections. When corn was fed subsequent to such softening feeds as peanuts, soy-beans, rice polish and rice bran, an increase in firmness resulted. The rate of hardening was usually much slower than the rate of softening. With increase in gain on softening feed, a corresponding increase in gain on hardening feed was required to produce a certain degree of firmness providing rates of gain within the periods were comparable. When the hardening period was extended,

Average Composition of the Fat of Hogs on Feeds Varying in Quantity and Quality of Oil

	Sample number and basic feed					
	1 Brewers' Rice	2 Corn	3 Peanuts	4 Peanuts	5 Soy-beans	6 Soy-beans
No. of hogs in lot	11	6	3	3	9	1
Total gain on experiment lbs.	178	201	58	149	65	98
Slaughter weight—lbs.	242	231	151	201	152	175
Carcass grade	Hard	Hard	Oily	Oily	Oily	Oily
Fat composition:						
Iodine number	52.6	58.8	84.1	91.8	90.7	100.6
Refractive index—40°C	1.4582	1.4587	1.4619	1.4633	1.4628	1.4636
Melting point °C.	39.7	37.5	22.5	liquid at 5°	22.0	28.1
Glycerides in fat:						
Oleic, per cent	58.4	54.3	56.7	64.6	40.4	39.8
Linolic, per cent	1.2	7.1	19.5	19.7	31.9	38.3
Linolenic, per cent	0.0	0.0	0.0	0.0	0.02	0.5
Arachidonic, per cent	0.2	0.06	0.12	0.05	0.08	0.05
Myristic, per cent	1.8	0.7	0.4	0.1	0.8	0.3
Palmitic, per cent	26.5	25.2	15.5	10.4	17.4	14.5
Stearic, per cent	12.2	12.8	7.5	4.9	9.4	8.0
Arachidic, per cent	0.0	0.0	0.2	0.3	0.0	0.0

there was an increase in firmness in proportion to the ratio of gains. The results have shown that a gain ratio of 1:3 on peanut-corn and 1:2 on soy-beans-corn still produced medium soft carcasses while wider ratios permitted the production of medium-hard carcasses.

In the case of soy-beans with a medium ration of corn, and rice polish or rice bran with protein supplements a gain in weight on corn with non-softening supplements equal to that on the softening feeds did not produce firm carcasses. Although the softness developed on the rations just named was not so great as on peanuts or soy-beans alone, it required considerably more gain on hardening feed than on softening feed to produce medium hard carcasses. Here, as in the case of peanuts and soy-beans alone, it was impossible under practical conditions, with feeding perods of 6 to 8 weeks duration, to secure firm carcasses at the usual market weights of 200 to 225 pounds. It was, however, possible to accomplish this purpose when brewers' rice was used in place of corn following rice polish or rice bran.

Study of the composition of the fats from hogs fed the various feed combinations just mentioned showed that there was a pronounced decrease in the unsaturation as the gain in weight on hardening feed increased. As would be expected, the fat constants and the percentages of the fatty acids seldom reached the level found in lards from hogs fed hardening rations throughout their growth. It is apparent that the hard fat formed on feeds like corn or brewers' rice is deposited in the same tissues as was the soft or oily fat during the softening period. The addition of more hard fat develops greater firmness of the adipose tissue. During the hardening period, the rate of fat formation is high which is especially favorable for the development of hard fat on a corn ration. However, the quantity of oily fat already present is too great to be readily offset by the addition of a hard fat in itself little different than that demanded in a firm carcass. Were it not for the relative scarcity of brewers' rice, this feed could be more widely used for it is evident that a highly carbonaceous feed with a low oil content is quite essential in a highly effective hardening feed. Other feeds of like properties may be found which will help the situation.

Note: A co-operative investigation of this problem has been in progress since 1919. The agencies engaged in the work are the Bureau of Animal Industry of the United States Department of Agriculture, a number of State and Federal experiment stations and the Institute of American Meat Packers. The State experiment stations which have taken part in the work are as follows: Alabama, Arkansas, California, Georgia, Indiana, Kentucky, Mississippi, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas and Virginia. This article is based on results of the co-operative investigations published to date as follows:

(1) U. S. D. A. Dept. Bull. 1407. Results of soft pork investigations.

(2) Bulletin in course of publication. Further results of soft pork investigations.

(3) Soft Pork Studies. I. Formation of fat in the pig on a ration moderately low in fat. Ellis, N. R. and Hankins, O. G. Jr. Biol, Chem., *66* (1925), 101.

(4) Soft Pork Studies. II. The influence of the character of the ration upon the composition of the body fat of hogs. Ellis, N. R. and Isbell, H. S. Jr. Biol. Chem., *69* (1926), 219.

(5) Soft Pork Studies. III. The effect of food upon body fat as shown by the separation of the individual fatty acids of the body fat. Ellis, N. R. and Isbell, H. S. Jr. Biol, Chem. *69* (1926), 239.