LXXII. THE NUTRITIVE VALUE OF LARD.

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With Plate XII.

During the last few years a considerable amount of attention has been devoted to the study of the distribution of the so-called fat-soluble accessory factor, or vitamin A, in naturally occurring oils and fats. The results of these investigations tend to show that the oils and fats derived from the animal kingdom are, as a rule, decidedly richer sources of this essential dietary constituent than those prepared from vegetable sources. Most authorities, however, regard lard as an exception, having found it practically devoid of vitamin A. Quite early in the study of the growth-promoting vitamins McCollum and Davis [1913] observed that butter fat is of much higher nutritive value for growth than lard.

A similar conclusion was reached by Osborne and Mendel [1913], who suggested that the difference might be ascribed to the fact that lard is a fat derived from storage depôts, whereas butter fat is a product of the synthetic processes of the mammary gland. Many later workers have confirmed these experimental results, and lard has usually been regarded as of little or no value as a source of the fat-soluble A factor.

When one considers the enormous quantities of lard which are prepared for edible purposes at the present time, the importance of ascertaining why lard is thus deficient will be realised. So far as we are aware, no systematic attempt to solve this problem has been made; and only one reference bearing on this question has been encountered in the literature.

Osborne and Mendel [1915] refer to one experiment which they carried out in order to ascertain whether the inefficiency of lard is due to the technical processes to which the fat of pigs is subjected in preparation for the market. Pig fat, direct from the slaughter-house, was finely divided and filtered through filter paper at a temperature just above its melting-point. The filtered product, which they termed "Laboratory Lard," was found to be as inadequate for growth as the commercial products. This result led the authors to conclude that the inferior nutritive value of lard is not due to the heating which the fat may have received in the course of preparation. This experiment must, however, be regarded as of little value, since apparently no test of the growth-promoting power of the unheated pig fat was made.

In view of the very great importance of the question of the food value of lard, we decided to subject the matter to an experimental study, particularly since it had been observed by Drummond and Coward [1920, 1] that some specimens of raw pig fat contain appreciable amounts of the vitamin A.

Since it is now experimentally proven that the mammalian organism does not possess the power to synthesise the vitamin A, and that it is dependent on its diet for supplies of this essential factor, we concluded that the investigation must proceed along two lines, first, a study of the influence of the diet of the pigs on storage of the vitamin in the fat depôts, and secondly, an investigation of the influence of the technical processes of lard manufacture on the vitamin when present in the pig fat.

The first series of experiments was carried out at the farm attached to University College, Reading, and we desire to thank Prof. Pennington, the Director of the farm, for granting us facilities for the work. The rat feeding tests were carried out at University College, London.

I. Influence of diet of pigs on the vitamin content of pig fat.

Experimental.

A litter of Berkshire pigs farrowed in the early part of 1920 was selected for this experiment. With the exception of one pig, which was a weakling, all the animals were strong and healthy. They were permitted to remain with the sow until weaned at the age of eight weeks, when they were given a ration of toppings (wheat pollards) and whey.

At the age of nine and a half weeks they were divided into five groups. Groups I–IV, which were to be placed on controlled diets, each contained a hog and a sow, whilst Group V, which were the real controls, contained two hogs.

Groups I and II were kept in large, well-designed, stone-floored experimental styes, since it was intended to give them a diet deficient in vitamin A. Groups III and IV were kept in a form of moveable pen improvised by one of us, which permitted the animals to have access to a new plot of green pasturage every day. Group V were reared in the usual manner employed on this farm, and not only received a mixed diet, but also had free run of a small grass paddock.

Group I were given a seriously deficient diet, namely one of toppings and a "synthetic whey." This latter constituent was prepared from caseinogen, lactose, olive oil and salt mixture so as to represent the composition of the whey used in the other experiments, as determined by frequent analysis.

Experiments on rats indicated that this diet was almost devoid of all three vitamins A, B and C. It was not, therefore, considered likely that the pigs would thrive at all on the food mixture. To our astonishment both animals showed excellent increments of weight for a considerable period of time.

Fig. 1 shows the growth of the hog of this series. It will be seen that the initial growth is considerable in spite of the deficient nature of the ration. Ultimately the animals in this group showed retardation of growth, and lost their healthy appearance. We do not, however, intend to discuss this side of the experiments at this point since we have made a number of other observations on the growth of pigs on deficient diets which will form the subject of a later communication.

Group II were fed on a food mixture of similar composition to that employed for Group I, but the whey was the natural product. Tests of the whey made on rats indicated that it contained insignificant traces of the factor A.

Group III received a basal diet identical with that given to Group II, namely whey and toppings, but in addition were allowed to have an unlimited supply of fresh green food, an addition which they welcomed and of which they made good use.

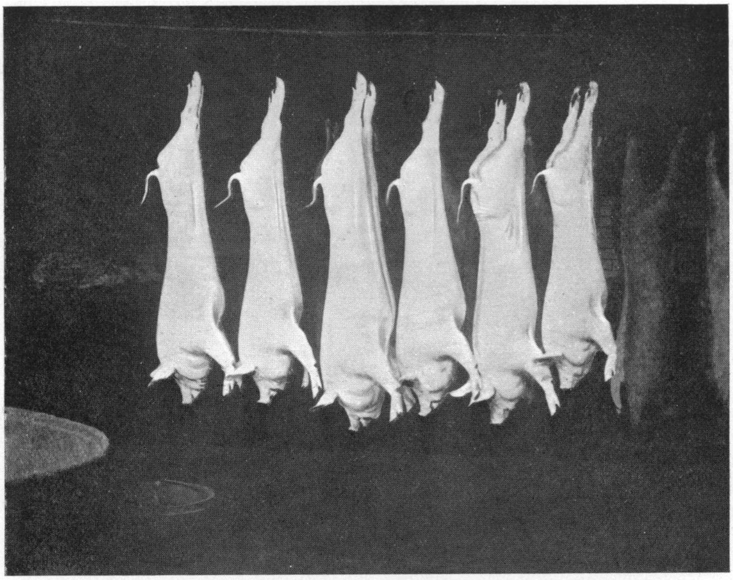
Group IV received no whey, and were confined to a diet of toppings and green foods. Group V received a well-balanced and varied farm diet, including ample grass.

Growth curves of one animal (hog) from each group are given in Figs. 1–5, but, as we have remarked above, we do not intend to discuss this side of the investigation here. Records of food intake were made daily in the case of Groups I–IV, and frequent analyses of the toppings and whey were carried out to control the intake of nutrients. Attached to the growth curves are diagrams indicating the average daily food consumptions at various periods of the experiments.

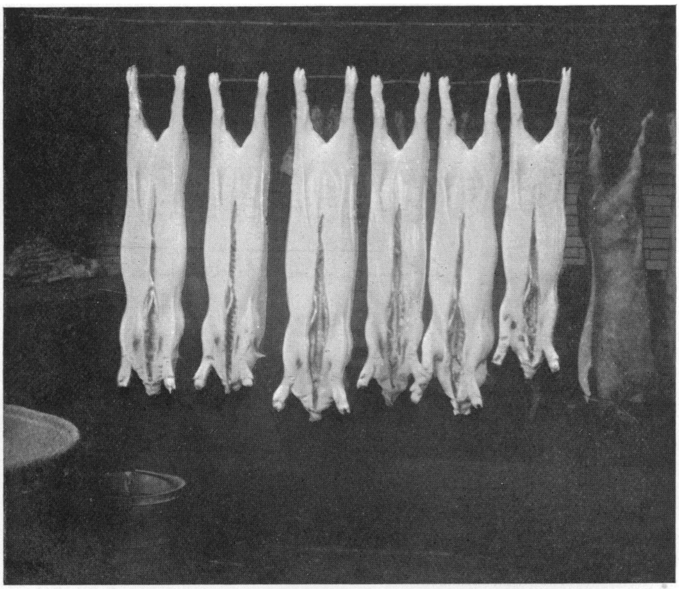
At the end of nearly three months on the experimental diets, the condition of the hogs on the deficient diets 1 and 2 and the size of the control animals led us to conclude that a suitable point had been reached for testing the body fats for storage of the factor A. In view of the fact that our material was limited, we decided to slaughter the hogs of each group only, retaining the sows for the purpose of other observations which we desired to make. Accordingly this plan was carried out.

The hogs were sent to the butcher 24 hours before being slaughtered. A post-mortem examination did not reveal any noticeable abnormality in the organs of the animals. After the carcases had been "dressed" in the usual manner, samples of back fat and perinephritic fat (fleck or leaf) were removed. Photographs of the dressed carcases are given which show the relative sizes of the animals from each group (Plate XII). The small size of the hog fed on the deficient diet given to Group I is obvious, as are the well-developed bodies of the two animals in the control Groups III and V, especially in the latter.

The fats were tested for the presence of the factor A by observing the



1. Side view.



2. Front view.

Photographs of the slaughtered pigs.

From left to right

Group	Sex	Diet	Weight lbs
II	♂	Toppings, whey	122
IV	,,	Toppings, grass	103
V	,,	Full diet with grass	150
V	,,	,, ,,	—
III	,,	Toppings, whey and grass	120
I	,,	Toppings, synthetic whey	84

influence of daily supplements of known weight on the growth of rats, whose growth had been brought to a standstill by a deficiency of that substance.

Small cubes of the fat weighing approximately 1·5 g. were administered to each rat before the daily ration of the basal diet devoid of the factor A

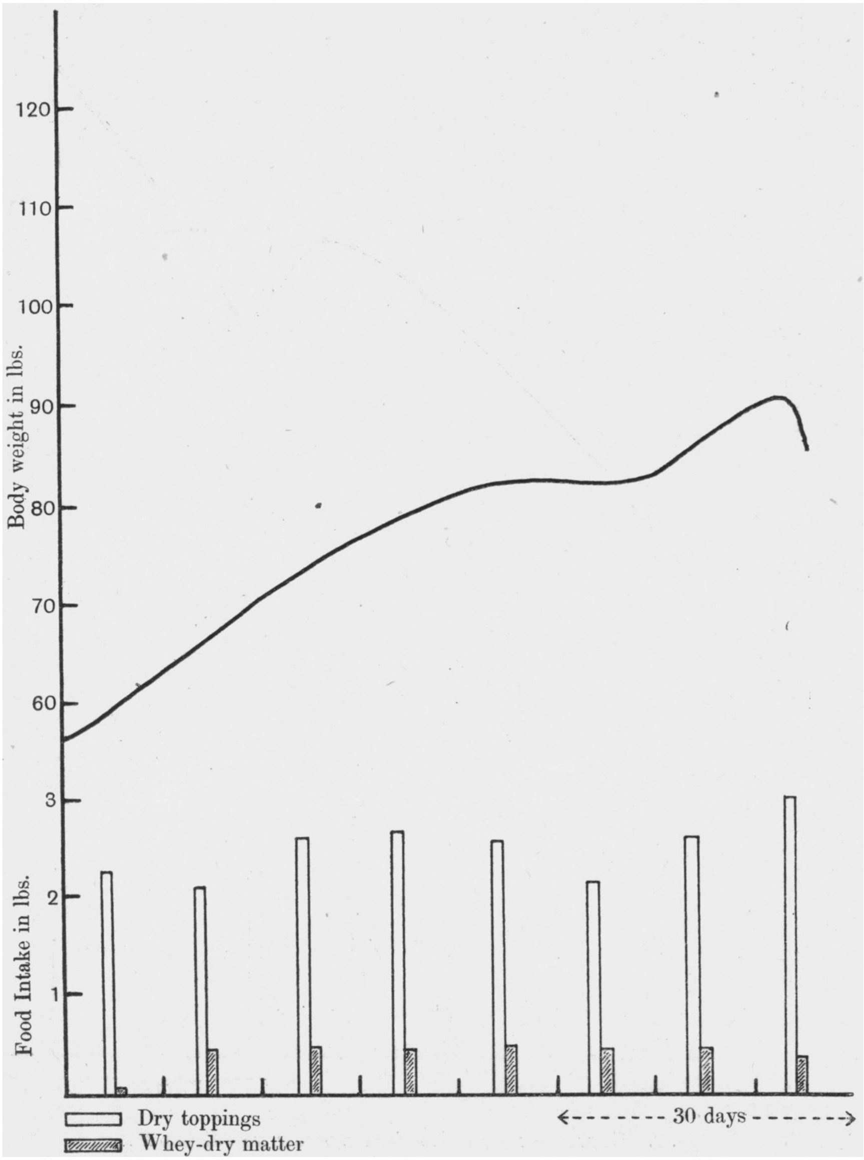


Fig. 1. Growth curve and food intake of hog from Group I.

was given. Practically without exception the whole of the supplements were consumed. The results of these feeding tests are in our opinion quite striking. The body fats derived from pigs in Groups I and II fed on diets deficient in the vitamin A were found to be of no value as sources of that essential substance for the rat (Curves 1–11, Fig. 6). On the other hand, there is marked evidence that the body fats of the grass-fed animals, particularly those

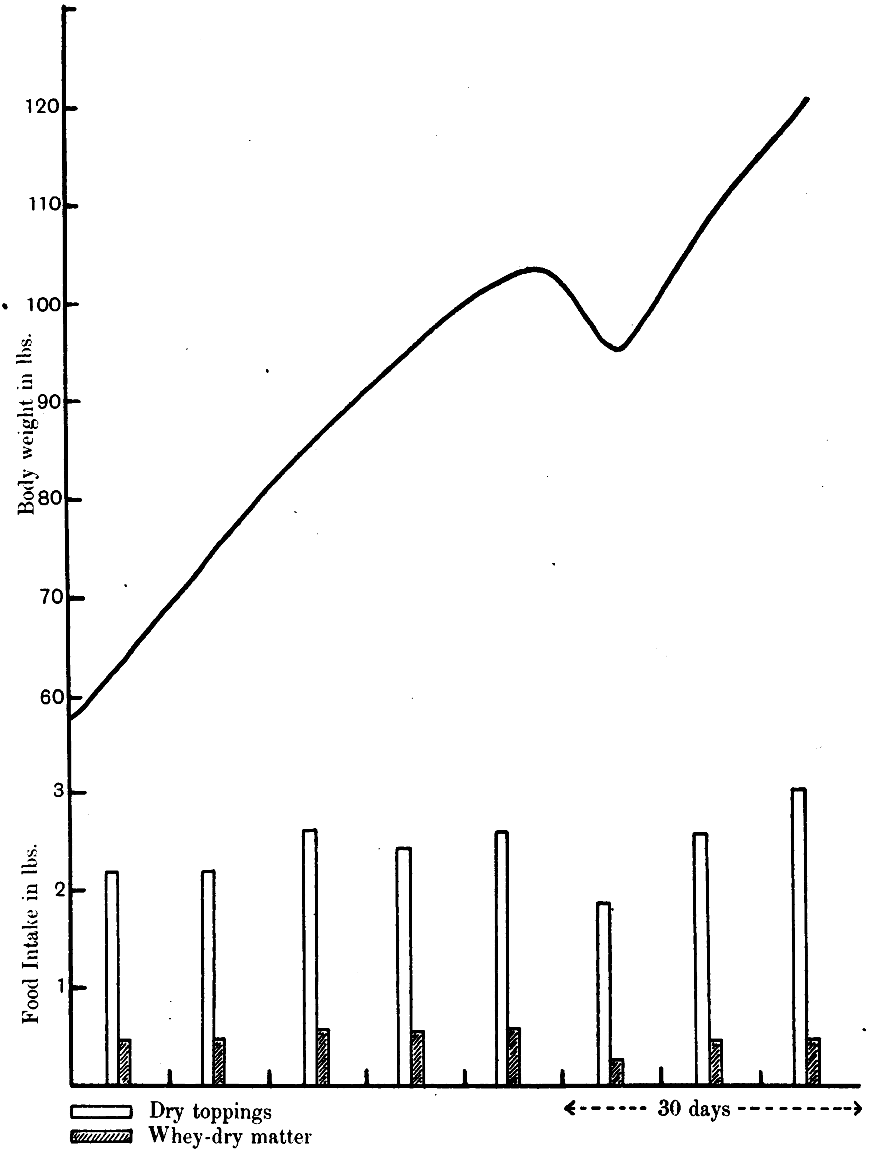


Fig. 2. Growth curve and food intake of hog from Group II.

receiving a mixed farm ration in Group V contained appreciable amounts of the important growth-promoting accessory substance (Curves 12–28, Fig. 6).

The fats from the abdominal cavity and from the subcutaneous deposits were tested separately in each case.

These experiments demonstrate that storage of the vitamin A will occur in the body fat of the pig, provided that the animal receives a diet containing considerable amounts of that substance. This finding is of importance since

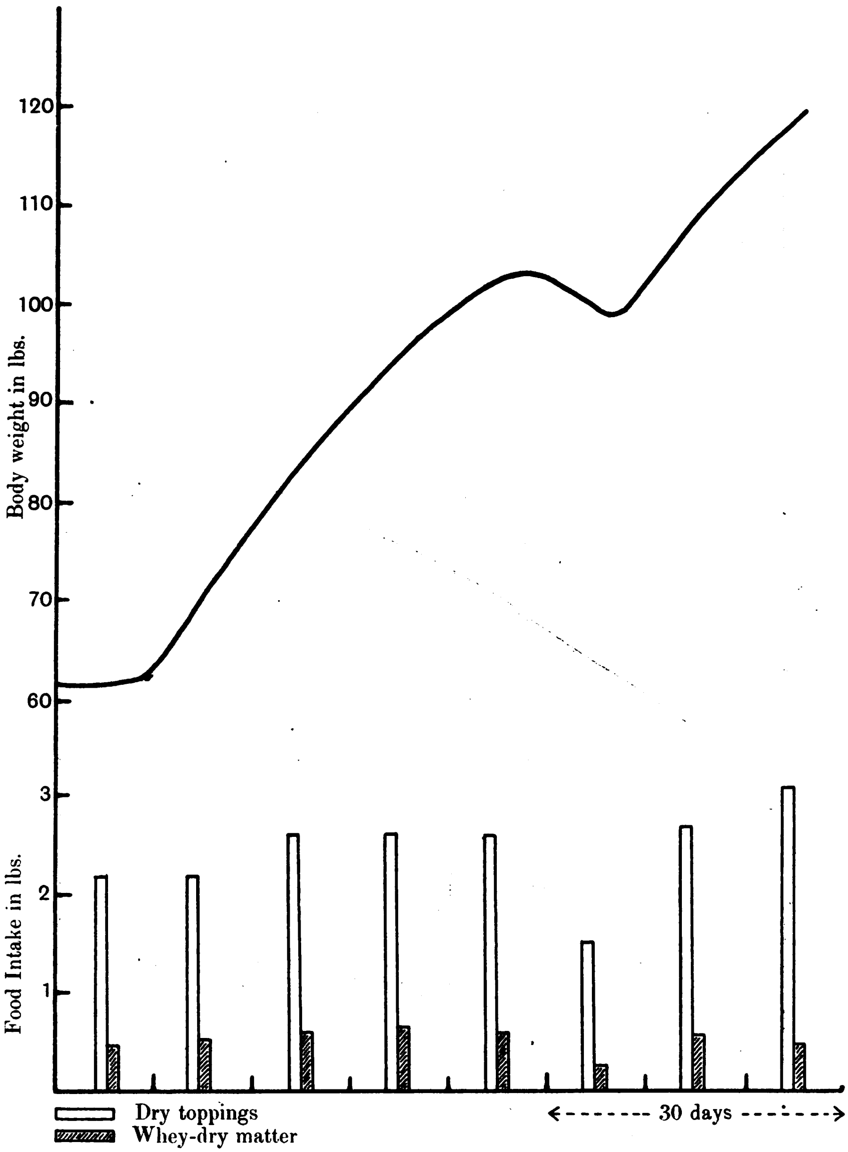


Fig. 3. Growth curve and food intake of hog from Group III.

it shows that the pig is not an exception to the rule that storage of the fat-soluble vitamin A in the fat depôts occurs in animals under suitable conditions.

It does not appear that pig fat is, weight for weight, as rich in vitamin A as is the body fat of other animals fed on a similar type of diet. This may, however, be due to the fact that the mass of adipose tissue is so much greater in the former species, and that the concentration of vitamin per unit weight of fat would tend to be smaller than in a species such as the cow, where fat deposition is less marked.

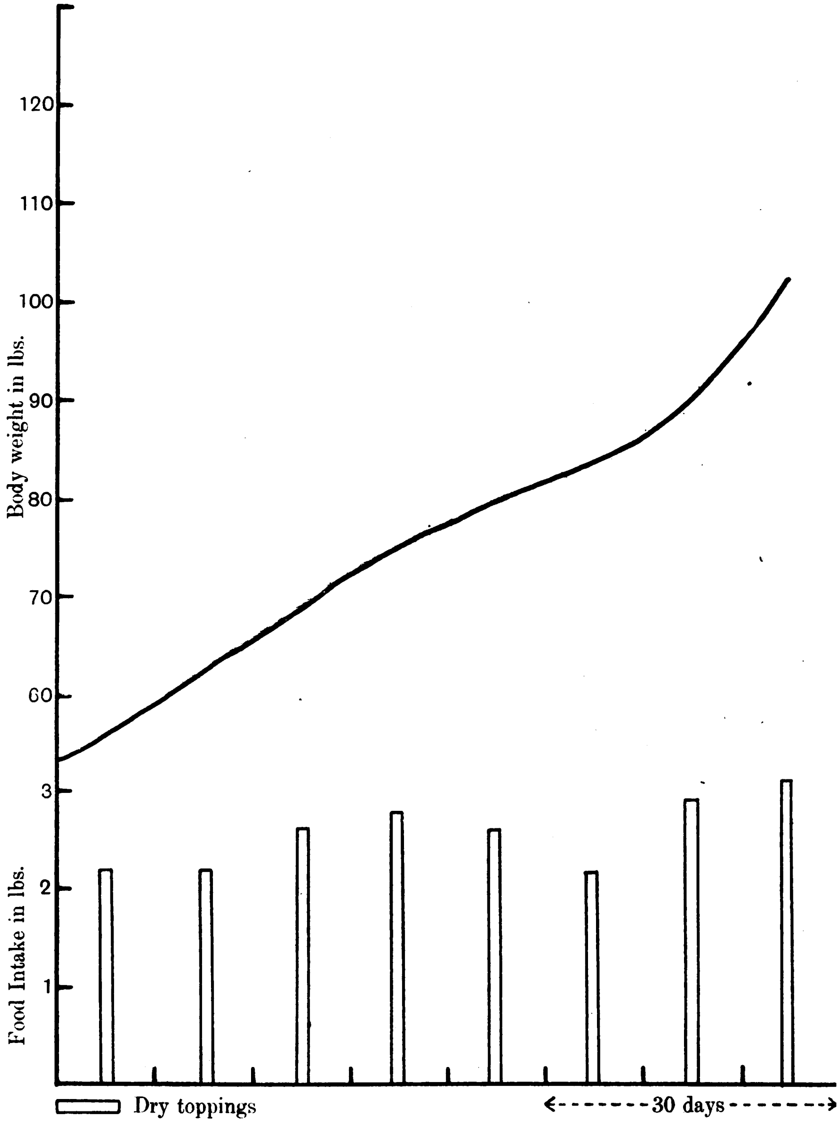


Fig. 4. Growth curve and food intake of hog from Group IV.

II. Influence of the processes employed in the manufacture of lard on the vitamin present in pig fat.

The enormous quantities of pig fat that are converted into lard for human consumption every year may be judged from the fact that in 1912 the total weight of lard exported from the United States was over 500 million lbs. A considerable proportion of this production is utilised for margarine manufacture, an industry which has grown to many times the size it was in 1912. It is therefore of very great importance to ascertain the influence of the method of preparation employed in lard manufacture on the nutritive value of the fat. Having found by the feeding experiments described above that

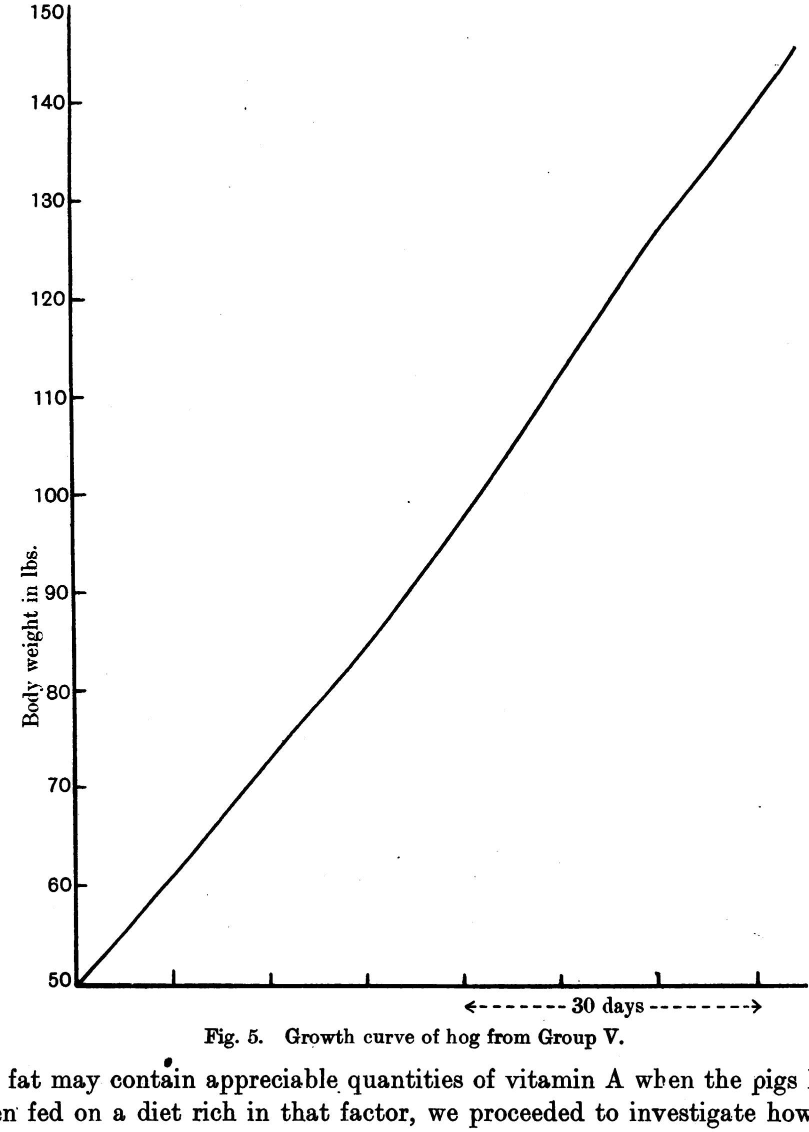


Fig. 5. Growth curve of hog from Group V.

pig fat may contain appreciable quantities of vitamin A when the pigs have been fed on a diet rich in that factor, we proceeded to investigate how the accessory factor is affected by the processes of lard manufacture and refinement. Lard manufacture in this country is not carried out on anything approaching the enormous scale that may be seen in America, and there are distinct differences between the methods employed there and in this country. The oldest and simplest method of lard preparation still survives in the country parts of England, and we had the opportunity of seeing one preparation by this method. It is only employed by local pig butchers or farmers who handle small numbers of swine, and the amount prepared in this manner is negligible when one considers the total production of lard; the product is largely used for consumption in the immediate locality. This process consists

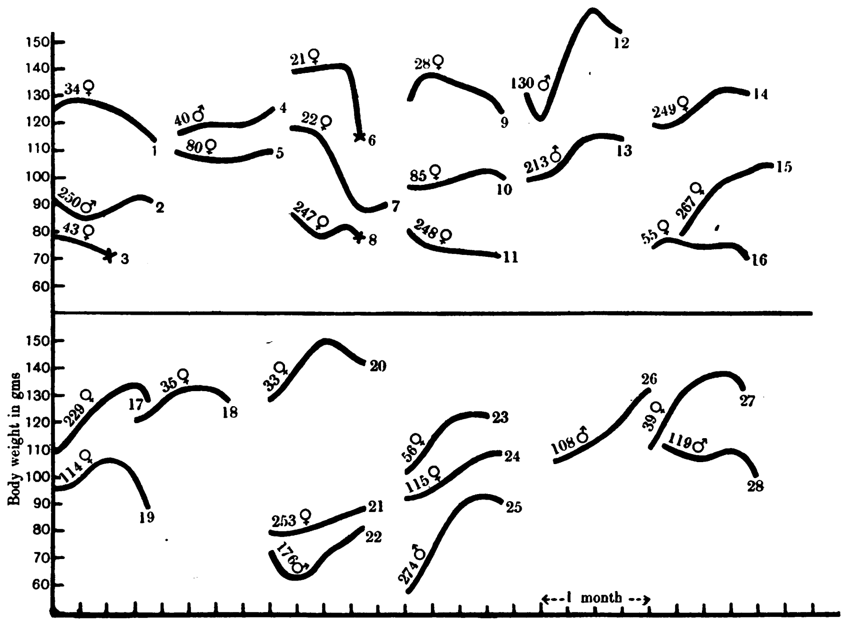


Fig. 6. Growth curves of rats whose diets were supplemented by a daily ration of 1·5 g. fat from the slaughtered pigs.

Rats 1–3 Group I (back fat);	Rats 14–16 Group III (abdominal fat);
„ 4–5 Group I (abdominal fat);	„ 17–19 Group IV (back fat);
„ 6–8 Group II (back fat);	„ 20–22 Group IV (abdominal fat)
„ 9–11 Group II (abdominal fat);	„ 23–25 Group V (back fat);
„ 12–13 Group III (back fat);	„ 26–28 Group V (abdominal fat).

The preliminary period of inhibited growth on the basal ration is omitted.

in heating the pig fat in an open pan over a fire, stirring meanwhile. The melted fat is from time to time skimmed from the surface, reheated to drive off moisture, strained, and poured into bladders. Lard prepared in this manner usually has a brownish tint due to admixture with products derived from the charred tissue. In view of the very small amount of lard which is prepared by this simple farmhouse method, we decided that it was unnecessary to investigate its food value.

For permission to view a large modern lard manufactory in this country we are indebted to Mr R. J. Harris, of the firm of Harris and Co., Bacon Curers, Calne, Wiltshire. To him, and to Mr O. Jones, the chief chemist at that factory, we wish to express our appreciation of the very kind manner in which they assisted us in our investigation, by placing much information and numerous samples at our disposal. The method employed in this factory is essentially as follows:

The pigs which are drawn from a large area of the surrounding country are slaughtered and the carcases dressed in the usual manner. When cold, the abdominal fat or fleck, which has been stripped and hung up beside the carcase, is minced in a large mechanical mill. The fatty pulp passes into a steam-jacketed pan provided with stirrers, where it is heated to a temperature of about 82°. The fat which separates from the tissues runs off into a second steam-heated pan, where heating at a temperature just above boiling-point (102°) is maintained with stirring for about 10 or 15 minutes to drive off any moisture. The hot dehydrated fat is then clarified either by passing it through a filter press or by allowing it to stand in a settling tank. The lard is now ready to be converted into a suitable solid form and packed for the market. The details of these latter processes have no bearing on the subject of this paper and are therefore omitted.

Very little pig fat other than the perinephritic deposits is used for lard making in this factory, and consequently the product is one of very high standard. The dimensions of the lard industry in the United States have necessitated the adoption of a system of classifying lards. Many of the preparations are made from inferior sources of fat.

The Rules of the Chicago Board of Trade define the following brands of edible lard. (*a*) Neutral Lard No. 1, which is a high quality lard prepared only from the abdominal leaf. (*b*) Neutral Lard No. 2, a similar product prepared from the back fat. These two types are carefully prepared and since they have not been "cooked," they do not keep well. Their chief use is in the manufacture of high class margarines. Only a small amount of lard is prepared by this method in this country. (*c*) Leaf Lard. This is essentially a product which has been prepared by a process similar to the one we have described in detail above. (*d*) Choice Lard or Kettle-rendered Lard, and (*e*) Prime Steamed Lard are products of much lower standard. The latter is indeed usually prepared from the trimmings of the carcases and not from the true fat deposits. They are frequently rendered by the use of high pressure steam, and since they are unpalatable and discoloured in the crude state, they are usually treated by "blowing," or some such process involving oxidation, in order to remove colouring substances and a somewhat unpleasant odour and taste.

We began our investigation by examining an average sample of the pig fat such as is used at Calne for lard manufacture. Curves 4–6, Fig. 7 show that this sample contained an appreciable amount of the fat-soluble vitamin. This confirms the observations by Drummond and Coward [1920, 1] that pig fat may contain the factor A. We also tested a sample of lard which had been made from the same batch of pig fat. This proved to be inactive (Curves 1–3,

Fig. 7) as did several other samples of lard made there on other occasions. Apparently the processes of manufacture were responsible in some manner for the removal or destruction of the vitamin. Naturally the inactivation of the vitamin present in the pig fat will depend on the amount present, which will presumably depend to some extent on the age of the pigs when slaughtered, and to a greater extent on the diet upon which they had been reared.

It was impossible to obtain precise information regarding the diet which had been given to the pigs from which the samples of fat ultimately made into lard were taken. We were informed, however, that it is general in the areas from which the majority of the pigs are drawn to supplement the usual type of diet of toppings, barley meal, whey, etc. with kitchen refuse and green foods. Grass feeding of swine is not carried out to any large extent in this country.

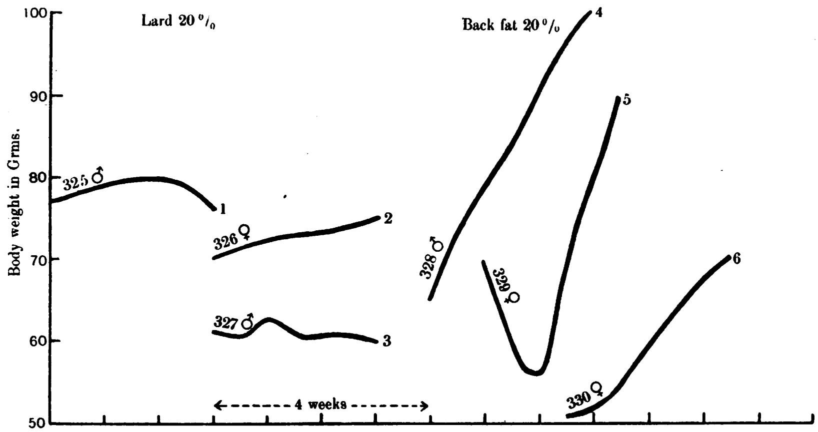


Fig. 7. Growth curves of rats whose diets contained 20 % lard (1–3) and back fat (4–6) respectively.

The preliminary period of inhibited growth on the basal ration is omitted.

The cause of the loss of vitamin during lard manufacture is in our opinion largely due to oxidation, since it has recently been shown that the factor is rapidly inactivated at high temperatures by air or oxygen or by ozone in the cold [Hopkins, 1920, 1, 2; Drummond and Coward, 1920, 2; Zilva, 1920].

The concentration of vitamin A in pig fat, even in grass-fed animals, appears to be considerably lower than in fat derived from grass-fed cattle, and much lower than that usually found in butter, so that when it is remembered that butter fat exposed over a large surface to air at temperatures about 100° may be inactivated in a time as short as one or two hours, it can be understood how the pig fat loses its accompanying vitamin during the heating and stirring used in its conversion into lard.

Recently a paper has appeared in which Daniels and Loughlin [1920] claim to have examined samples of lard which showed considerable growth-promoting power. Not only good growth, but reproduction and satisfactory rearing of the young were accomplished by their rats when their diet contained 28 % of a commercial preparation of lard. It is possible that the sample with which they worked was one prepared from a pig fat of very rich vitamin content, and that appreciable amounts of that factor had escaped destruction.

Since this communication was completed a sample of lard prepared at Calne from some very active back fat has been examined by us and has been found to possess some activity although not nearly as pronounced as that observed by Daniels and Loughlin. This suggests that some of the fat-soluble vitamin may remain in the lard after treatment in certain cases.

SUMMARY.

1. The pig is able to store up supplies of vitamin A in the body fat when fed upon a diet containing ample supplies of that factor, as for example when grass-fed.

2. When the diet of the pig is deficient in vitamin A, as for example when the diet consists almost entirely of toppings and whey, no appreciable amounts of that dietary factor can be detected in the body fat.

3. The processes employed in the manufacture of lard on a large scale in this country cause a very marked destruction of the vitamin present in the pig fat.

4. The low nutritive value of lard is therefore believed to be due to two causes. First, the diet usually given to fattening pigs in this country is seldom rich in vitamin A, so that the average sample of pig fat contains little or none of that substance; secondly, the processes of lard manufacture undoubtedly cause the destruction of much of the vitamin present in the original pig fat, probably owing to the exposure of the fat to oxygen at high temperature.

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