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Factors Affecting the Efficiency of Food Conversion by Pigs

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INTRODUCTION:—

WORLD meat production depends upon the supply of animal feed capable of conversion into a form suitable for human consumption and the efficiency with which this food is converted. The same applies on a national scale, and to the ultimate unit, the individual farm. To a great extent too the profit derived from livestock is dependent upon the efficiency with which the available foodstuffs are utilised.

"Whereas no class of animal can rightly be regarded as efficient converters of nutrients of feed into human foods, swine excel at certain aspects of the process." (Carrol and Krider, 1950). Maynard (1946) states that "pigs produce more live weight gain for a given weight of food than other classes of meat animal, and they recover in the edible part of their products a larger proportion of the total calories of their rations than any class of animals or poultry."

It is evident that, in its own sphere, the pig is an inherently valuable means of converting animal feed to flesh.

In most countries the above facts are not only recognised, they are consciously exploited.

In the U.S.A., for example, at least 50% of the corn crop is marketed as pork; in England and in Denmark crops are grown and grains imported for pig feeding. In other European countries, such as Germany and Hungary, the pig is used as a means of converting part of the potato and beet or maize crops into meat. In China the pig holds a place second only to poultry.

While the relative efficiency of pigs as compared with other classes of stock has ensured their importance in agriculture, it is the absolute efficiency attained in their use on the farm which determines their contribution to farm profit. In Britain and America, where food costs account for 75-90% of the total cost of production (Davidson, 1948, Carrol and Krider, 1950), this fact has been amply demonstrated (Menzies-Kitchen, 1937, Morris, 1938). In New Zealand where dairy by-products are the main source of feed supply for pigs, efficiency of feed conversion has received little attention. This factor, however, is just as important in this country as it is overseas and the economic returns from pigs on any farm are largely dependent upon the output of meat per gallon of skim milk available.

It has been said that "most pig producers are extremely sensitive to the selling price of their products, but little concerned about the efficiency of their production methods. They therefore exhibit an interest in the unimportant to the neglect of the important, because while the individual farmer can do little about price, he can do something about efficiency." (Carrol and Krider, 1950). This paper will deal with the general principles governing overall efficiency of production on a farm and the factors affecting these.

Source of Data:

Efficiency of production as applied to a single farm unit may be defined as the amount of meat produced per feed unit, or per 100 feed units available. We have also employed feed units used per pound of liveweight produced as a simple method of illustraing the principles involved. A feed unit under New Zealand conditions is regarded as one gallon of skim milk or one pound of meal.

The data upon which the calculations were made were taken from records of the breeding and fattening herd of the Ruakura Animal Research Station. Slaughter data were from station pigs killed at the station slaughterhouse or at a local bacon-curing works.

The Principles Governing Efficiency of Production on a Farm Unit:

The end point of production is the sale of meat as weaners, stores, or pork and bacon carcases. The ratio of total meat marketed to total feed consumed determines efficiency. This total feed has been shared between breeding and fattening stock, and is therefore the sum of the ration fed to the pregnant and lactating sows and to the litter in the creep, which may be classed as "sow overhead," and that fed to the weaned pigs, which is classed as "fattening cost.'

In any farrowing season, the total number of pigs weaned in a piggery share equally among them the feed cost of their dam's preceding gestation and lactation. Overall efficiency is therefore dependent upon three things:—

(1) Sow overhead
(2) Fattening costs
(3) Weight of meat marketed

Sow overhead is a combination of good faith and good business. The pregnant sow is fed in the hope that she will farrow a satisfactory litter. This is a deposit of faith. The ration fed to Ruakura sows during this period is shown in Table 1.

TABLE 1.

RATIONS FED TO PREGNANT SOWS AT RUAKURA

Period	Daily Ration (Feed units)	Totals	
Weaning to mating (1 week)	6	42)	
Mating to 4 weeks (pregnant)	6	168)	
4-14 weeks	2	140)	plus grass
14-16 weeks	6	84)	
		434	

The lactating sow is fed in a more business-like way, in that she is rationed according to the number of pigs suckling. The daily ration fed at Ruakura is 4 units per sow plus two-thirds feed units per piglet. In addition, after the third week, creep ration of skim-milk and meal are available to the suckers at all times. The average total creep consumption per pig is 20 feed units.

For a litter of six pigs, therefore, the sow overhead will be 1000 feed units, or 167 per pig weaned. As the pig grows, this 167 units is spread over the progressively increasing weight of the pig. The general effect is shown in Fig. 1.

This graph illustrates two important facts:—

(a) That the overhead per pound of live-weight falls at a decreasing rate;
(b) That overhead per pound of live-weight is dependent upon the number of pigs weaned.

Fattening Requirements:

The food requirement per pound of live-weight gain increases with the weight of the animal. (Smith, 1951). This relationship can be expressed by the regression of food requirement (Y) on live-weight (X), the formula being $Y = 1.72 + 0.15\ X$.

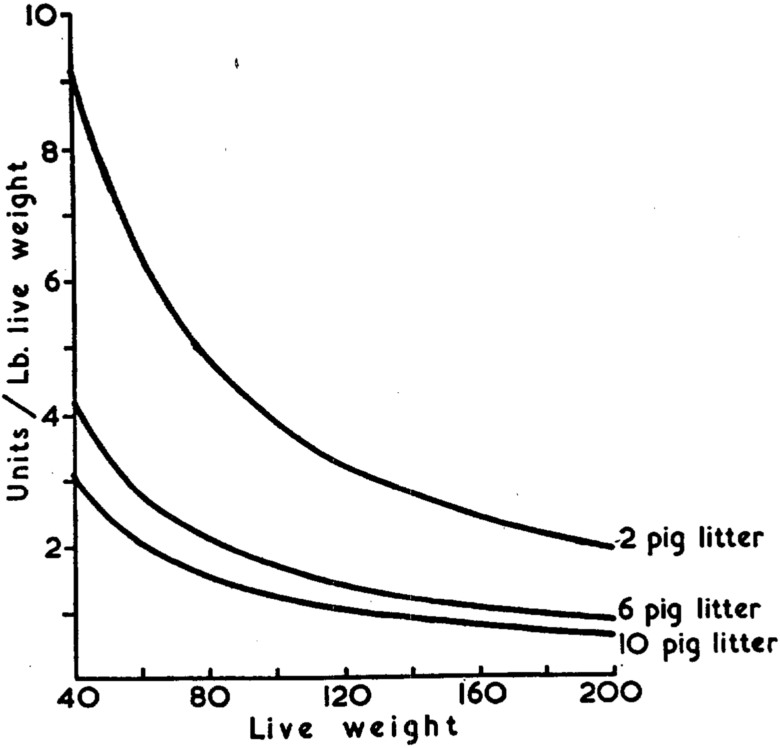

FIGURE 1.
The effect of litter size and increasing live-weight upon the sow overhead per pound of the total live-weight of the fattening pig.

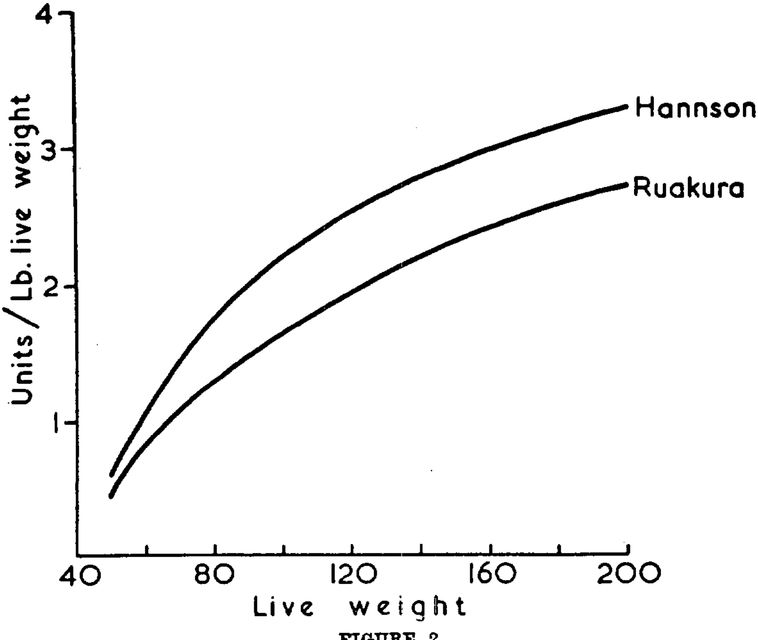

FIGURE 2.
The progressive post-weaning food requirement per pound of total live-weight for the fattening pig. Two levels illustrated.

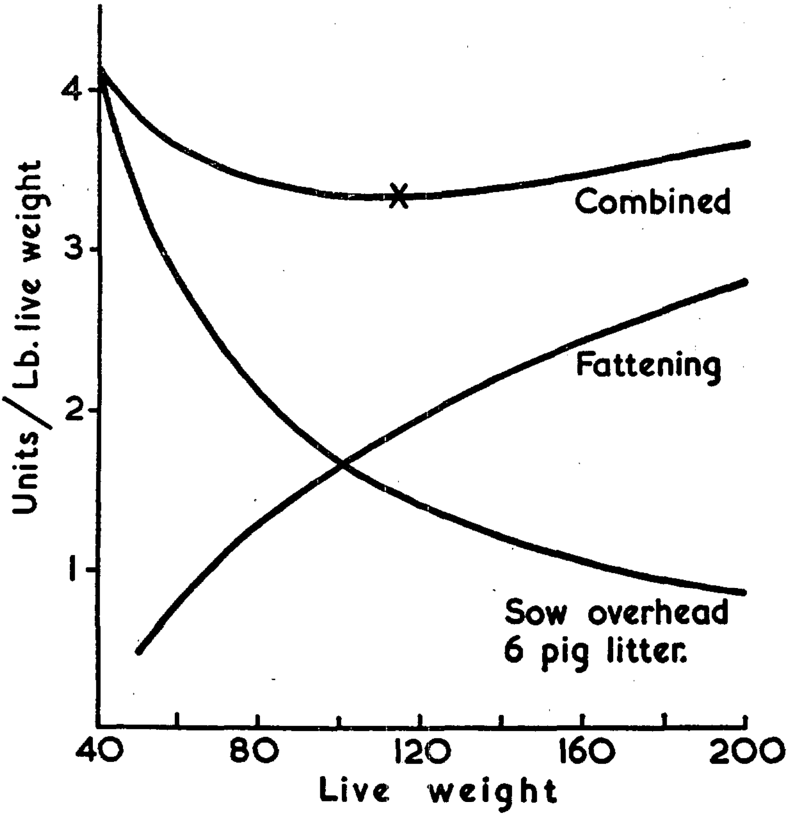

FIGURE 3.
The combined food consumption (sow overhead + fattening) per pound of progressive live-weight of the fattening pig.

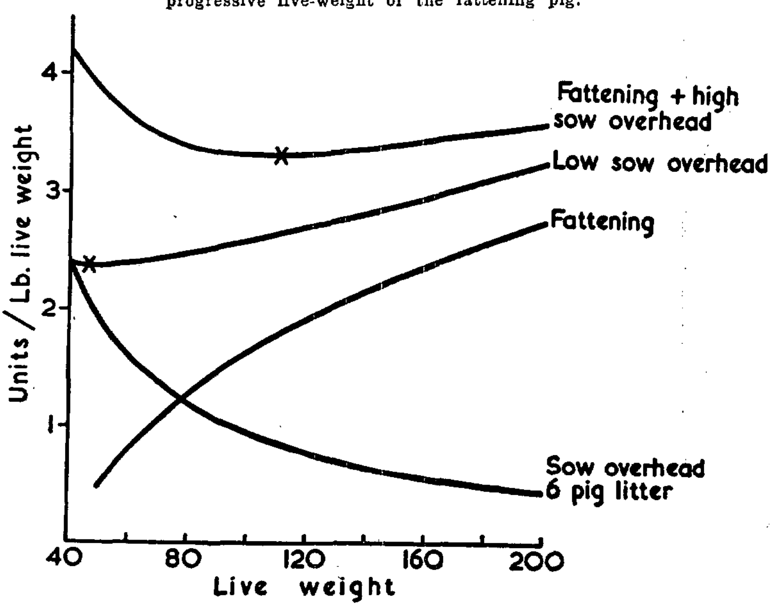

FIGURE 4.
The effect of reducing sow overhead by allowing dry sows pasture only, upon "critical weight."

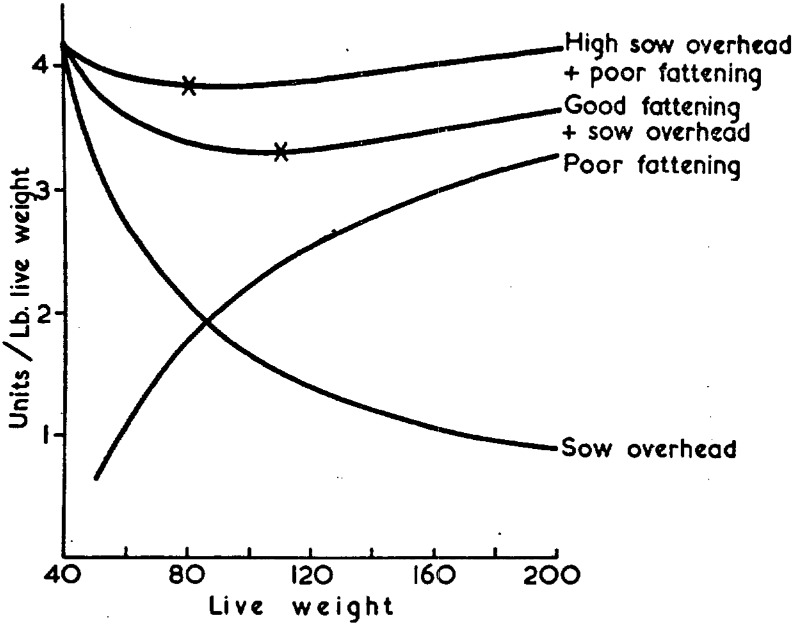

FIGURE 5.
The effect of lowering efficiency of food conversion during fattening upon "critical weight."

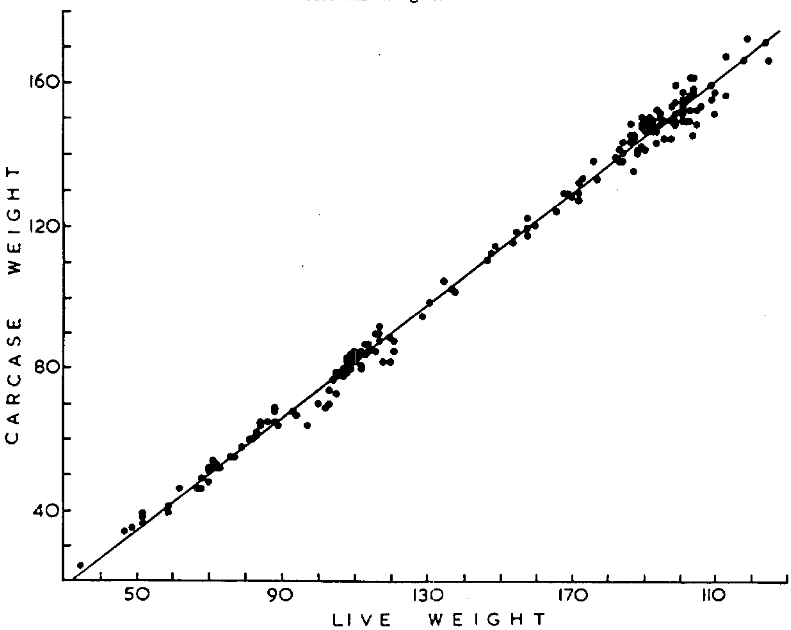

FIGURE 6.
The regression of carcase weight (Y) upon live weight X for 213 pigs,
$Y = 0.794X - 5.,64$.

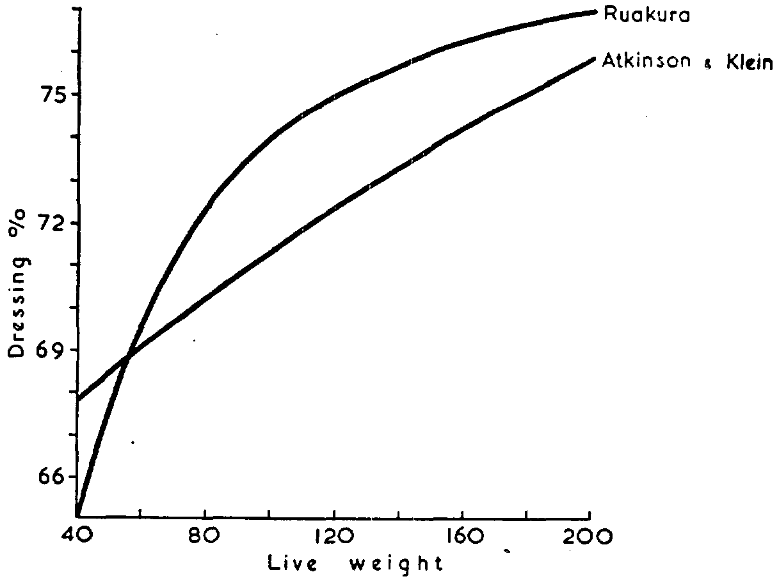

FIGURE 7.
Calculated dressing percentage from data shown in Figure 6. Included also are data presented by Atkinson and Klein (1946).

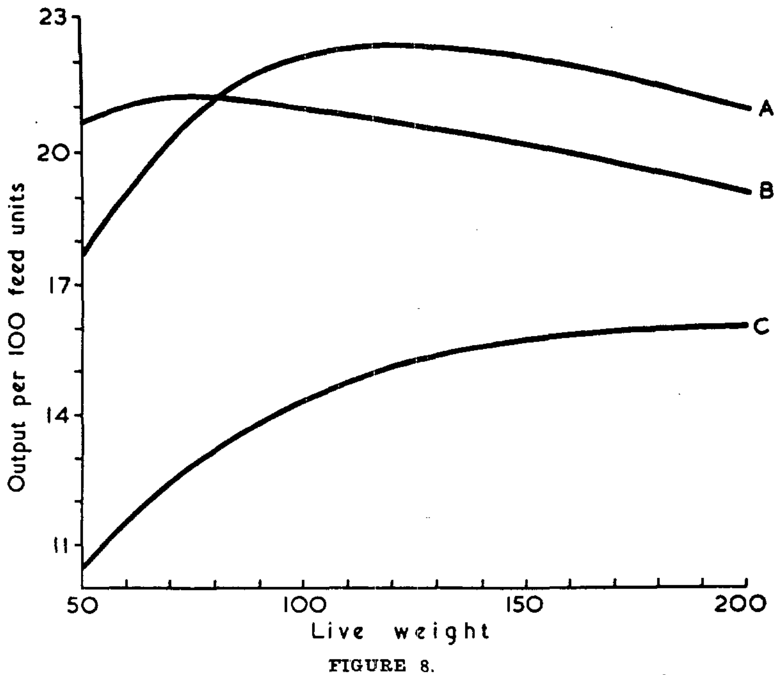

FIGURE 8.
A comparison of efficiency of production as among three feeding methods. A: Sow overhead 167 feed units, Ruakura fattening data. B: sow overhead 136 units, Hansson fattening data. C: sow overhead 290 feed units, Hansson fattening data. Dressing percentage according to Ruakura data.

However, the progressive fattening requirement per pound of live-weight involves the total weight of the pig and the total fattening cost to that weight. This is a curvilinear relationship, and is shown in Fig. 2. Included in this figure is a graph based upon data collected on Swedish farms. (Hansson and Bengtsson, 1924-26).

The two curves are used to represent two levels of efficiency of conversion. When Fig. 1 and Fig. 2 are combined as in Fig. 3, the total food cost per pound of live-weight at successive live-weights for a herd of pigs with a mean litter size of 6 pigs weaned is obtained.

This figure demonstrates the interaction between sow overhead and live-weight and fattening requirement and live-weight, the important principle being that the weight at which decrease in sow overhead per pound of live-weight equals the increase in fattening cost, is the weight in the pig's life at which maximum efficiency is reached. (For convenience sake, this weight will be referred to in future as the "critical weight.")

Changes in sow overhead will affect both total efficiency and critical weight.

In Fig. 4, total sow overhead is reduced, for purposes of illustration, by 430 units—the total cost of gestation. This may be considered drastic but many New Zealand farmers do in fact allow their dry sows nothing but pasture.

The net result is to lower the critical weight from 110 pounds to about 45 pounds and to increase total efficiency in terms of skim-milk and meal actually fed to bring a pig to market wieght.

Note:—In all these graphs, litter size is held constant at 6 pigs per litter.

It may be argued that the lowering of sow overhead would result in lower sow efficiency which would find expression in smaller litter size and lower weaning weights. Ballinger's work at Ruakura demonstrated that sows fed on pasture alone were difficult to get in pig, but those that did hold to the boar farrowed as large litters as those fed at the rate of 5 units per day during pregnancy.

I suggest that feeding a ration of this nature for the first 4 weeks after weaning should definitely be recommended, since consistent breeding will mean more effective use of pasture. Even if smaller litter size did result, however, it would be necessary to reduce the number weaned per sow to 3 pigs per litter to offset the saving in milk and meal resulting from pasture feeding alone during gestation.

Changes in fattening cost will also affect both total efficiency and critical weight.

Raising the total fattening requirement to that obtained by Hansson, while keeping sow overhead at Ruakura levels, has the effect shown in Fig. 5.

The net effect is to lower the overall efficiency and lower the critical weight.

It is of interest here to compare these results with those from similar studies overseas. Davidson (1948) in presenting data recorded at the Duthie Experimental Stock Farm, shows that the food consumption per pound of increasing live-weight falls till a live-weight of 125 lb. is reached and then rises. Considering the higher sow overhead usual under English conditions, this conclusion is similar to our own.

Davidson points out, however, that the monetary return from the light-weight pig is no greater than the return from bacon production because (a) the labour costs are greater per pound of gain made in the early stages of growth and (b) the cost per pound of food from 100 lb. on, is less because of the lower protein content of the ration. He also points out that the heavier pig is more efficient at storing calories than the light pig. (Menzies-Kitchen, 1942). This latter point becomes especially important in time of war.

The above qualifications do not apply in New Zealand—in fact our conditions demand the opposite approach. Our pig industry is dependent upon the skim-milk and whey left over after the manufacture of butter and cheese. Skim-milk is responsible for the larger part of our total meat output. This feedstuff is high in protein (35% on dry matter basis) and its use as a pig feed, while inherently wasteful, should aim at converting the largest possible proportion of this protein into meat.

Woodman and others (1937) in the course of protein metabolism experiments, have demonstrated (a) that a higher than normal protein intake does not increase nitrogen retention in the pig and (b) that the rate of nitrogen retention was roughly constant from weaning to 200 lb. The protein retained daily was about 90 grams. On this basis, pigs consuming 200 gallons of milk and taking 56 days from weaning to reach 110 lb. live-weight would retain 15.3% of the protein in the milk fed, while a pig consuming 620 gallons and taking 132 days from weaning to reach 210 lb. would utilise only 11%. The light weight pig is therefore nearly 30% more efficient in converting protein than the heavy pig.

Atkinson and Klein (1945 and 1946) have made a very critical study of the relationship between marketing weight and efficiency for pigs in the American corn belt. Their results show that maximum efficiency is reached at 175 lb. live-weight. This is reasonable when compared with the results quoted here when it is realised that the sow overhead per pig marketed was 290 feed units as compared with 160 in this study for litters of similar size.

Both Atkinson and Davidson, however, state that the efficiency based on live-weight differs markedly from efficiency based on carcase weight. The reason given is that the heavier the pig the greater the carcase percentage and this factor outweighs the rising food requirements per pound of live weight. Ruakura slaughter data support this in principle but on the basis of these data, the trend is not nearly as great as that shown by the English and American results.

The regression of carcase weight on live-weight for 213 Ruakura pigs is shown in Fig. 6. These pigs were kept under standard conditions in a Danish-style fattening house from weaning to slaughter. They were weighed twice weekly and all treated in a similar manner prior to and at slaughter.

They received their last feed at 4.30 p.m. on the day before being killed, were weighed at 5.30 a.m. the following morning after being given the opportunity to dung and urinate, and killed between the hours of 10 a.m. and 12 noon of that day. The carcase weights shown are hot carcase weight less 6%. The rations fed were meal and skim milk up to 90 lb. live-weight and skim-milk thereafter.

From this regression, dressing percentages have been calculated as shown in Fig. 7.

Included also in this figure is the graph of the dressing percentage upon which Atkinson and Klein's results were based. (Dressing percentage = 65.2 plus 7.0 L — $0.8L^2$ where L = live-weight/100).

It is apparent (a) that the Ruakura percentages are higher than the American and (b) that the Ruakura percentage increases more rapidly in between 40 and 120 lb. live-weight and less rapidly from 120-200 lb.

It is apparent from these data that the slower rising dressing percentage will not offset the rising food costs of carcase gain to the extent shown by Atkinson and Klein.

A further factor operates when carcase weight is related to feed consumption. From the Ruakura data (Fig. 6) the ratio, live-weight increase/dead-weight increase is 20/16. Therefore a pound of carcase gain results from 1.25 lb. of live-weight gain. The food requirements per pound of carcase are then 1.25 times as great as those for a pound live-weight, and more important, increases in requirements with increasing weight are also 1.25 times as great. As a result the rise and fall in the feed/grain ratio about the weight at which maximum efficiency is reached will be accentuated. This fact is demonstrated in Fig. 8.

The data from which these graphs were constructed are as follows:—

Graph A:—Sows fed 430 units during gestation. At the rate of 4 per sow and 2/3 units per piglet for a 6-pig litter suckled during lactation. Creep intake 20 units per pig. Postweaning fattening requirements based on Fig. 2 (high efficiency). Ruakura carcase yield as in Fig. 4.

Graph B:—Sows fed 215 units during gestation. Lactation litter size and ration as in A. Fattening requirements as in Fig. 2—(Hansson data). Carcase yield as in A.

Graph C:—Sow overhead 290 per pig weaned (Atkinson and Klein). Fattening requirements—as in graph B. Carcase yield as in A and B.

These graphs illustrate the important differences existing between New Zealand pig-keeping economy and that of the cornbelt. The difference between graphs A and B is two-fold. Sow overhead is lower in B and fattening requirements higher—both factors lower the weight at which maximum efficiency is reached. Maximum output per 100 feed units is reached at 70 lb. live-weight in B and 120 in A.

Low fattening efficiency has lowered the absolute efficiency of B. The only difference between the data upon which B and C are based lies in sow overhead. The values shown in Graph C are similar to those obtained by Atkinson and Klein and show the same rising tendency at 200 lb. live-weight. It is of interest to note that the meat output per 100 feed units shown in Graph B when converted to meat per 100 lb. of butterfat produced on a skim-milk farm gives values of between 35 and 40. Riddet and McMeekan (1934) concluded from data collected on dairy farms in the Manawatu that 40 lb. of pig meat per 100 lb. of butterfat produced was a reasonable level of efficiency under New Zealand conditions.

It would appear therefore that Graph B could represent the general situation on New Zealand farms.

The reason for the above difference between New Zealand and overseas values is simply that, by the use of pasture as a large part of the pregnant sow requirement the overall efficiency of production in terms of skim-milk and meal is held at a relatively high level, and as shown in this paper the economic marketing weight is lowered.

It is interesting in the light of the above conclusions to examine the recent National policy of encouraging the production of porker carcases of 60-80 lb., by paying a premium of 2d per pound for pigs in this weight class.

Such policy could have as its aim the production of carcases preferred on our English market, or directing the efforts of producers toward a method of increasing their general efficiency by reducing normal marketing weight. Meat board representatives have dispelled any doubt on the first point.

It is apparent from the findings shown in this paper, that any policy which encourages the production of pork weight pigs will tend to improve the national efficiency of food utilisation.

SUMMARY.

(1) The total food used to produce a marketable pig carcase is the sum of that classed as sow overhead per pig, and that consumed post-weaning, during fattening.

(2) The effects upon overall efficiency of changes in the milk and meal requirements during these two phases are illustrated.

(3) The general conclusions are that low sow overhead and low fattening efficiency lower the weight at which maximum efficiency is reached by the fattening pig. The reverse situation also holds true.

(4) Under New Zealand farm conditions, low sow overhead in terms of meal and skim-milk is achieved by the extensive use of pasture for the pregnant sow, and as a result the marketing of light-weight pigs is a more efficient method of feed utilisation than the marketing of heavy-weight pigs.

(5) Pigs marketed at light weights, use the high protein of skim-milk more efficiently than does the heavy pig.

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Discussion

Dr. WALLACE: Grazing is not considered in assessing sow overhead. Where sow overhead is reduced so that sows are ill-fed, are pigs likely to be smaller at birth, have lower weaning weights or to have higher feed costs per pound of live-weight gain?

Mr. SMITH: If poor sow feeding reduces weaning weight, the effect may be that of reducing sow efficiency. It is possible to have such poor sow efficiency that the overhead per pound of live-weight at weaning is high. The effect of this is to lower overall efficiency and raise the critical weight. On the other hand, the total food needed to raise the poorly weaned pig to market weight is increased—that is, fattening efficiency is reduced. The effect of this is to lower the critical weight. These two effects, therefore have the common result of lowering total efficiency but may cancel each other in respect to critical weight.

Dr. STEWART: How important a factor is litter size?

Mr. SMITH: Litter size is very important, but above a litter size of 5 or 6 pigs the law of diminishing returns operates effectively. Further, the immediate practical possibility of increasing sow fertility is less than that of increasing feeding efficiency.

Dr. FILMER: More sows are required to produce lighter pigs. What increase in labour would be necessary?

Mr. SMITH: At present approximately two baconers are produced to one porker. Since the pig industry is dependent upon a seasonal skim-milk supply, the aim should be to raise 1 to 1½ porkers for each baconer. This would have two effects: (a) The greater number of pigs would enable more efficient use of the available milk; and (b) the increase in the total pigs marketed would in fact be pork-weight pigs, which would, in the light of the findings of this paper, make for more efficient utilisation than a similar increase in meat from bacon-weight pigs. To achieve this extra production would require an increase of about 25 per cent in the sow population. The average New Zealand farmer invests little labour in his sows and litters, but even if labour and accommodation costs did increase the present 2d per pound pork premium would cover these.

Mr. LONGWILL: The sow overhead is at present about as low as it can go with safety.

Mr. SMITH: At Ruakura, we allowed 430 feed units to sows during gestation and they are still fat. In fact, we now run 8 ewes per acre to eat the grass the sows do not eat. The aim of our present research work is to reduce the milk and meal fed to the pregnant sow and increase the use of pasture. How far we can go in this respect remains to be seen. At the present stage, I prefer to take comfort in the fact that the New Zealand farmer is probably more efficient than Ruakura in respect to sow feeding.