Chapter 4

Production analyses

According to pig farmers' beliefs, pig-raising activities are an important component of their farming system because they provide a means of saving or storing money in the pig, which can be converted to supplementary cash income when appropriate. The next question to ask is how efficient backyard pig-raising is, at the "low profit-oriented" scale, and at the semi-commercial scale. Efficiency in animal husbandry has two main components: biological efficiency which measures the ability of the pig to convert physical input (feed) into physical output (weight gain), and economic efficiency, which measures the farmers' success at converting economic input (capital investment) into output (income from pig sales). In this chapter production efficiency will be discussed; economic aspects will be addressed in the following chapter.

In order to measure production efficiency, the 33 pig farmers from the study area who were willing to do so kept detailed daily household and pig production records. Collectively they raised a total of 133 pigs from post-weaning stage to saleable size. Every day for four months, they recorded types and precise weights of feed provided to

their pigs. To assess physical output, the author weighed each pig at monthly intervals, four times over three months.

Feed efficiency is widely measured by collecting data on daily feed intake, average daily weight gain (ADG), and then calculating feed conversion ratios (FCR). FCR is the amount of food input required to produce a unit of live-weight gain; usually daily averages are used. Low FCRs reflect high efficiency, since relatively less feed intake is required to produce that unit of weight gain. Feed conversion efficiency varies with the developmental stage of each pig. As illustrated by McMeekan's classical sigmoid growth curve for swine, growth rate is most rapid in pigs in their early life stage, that is, from after weaning to puberty (Figure 30, McMeekan 1940). This is the period in which most biological and economic gain is made, in terms of feed input and cost. This period can also be described as the period of growth up to 70 kilograms of live-weight; after pigs reach 80 kilograms, they tend to grow more slowly per unit of feed intake (Eusebio 69).

Furthermore, feed intake after puberty results in pigs storing more fat and caloric density, which decreases the quality of the pork. Thus it has been recommended in the Philippines, for example, that pigs be sold when they

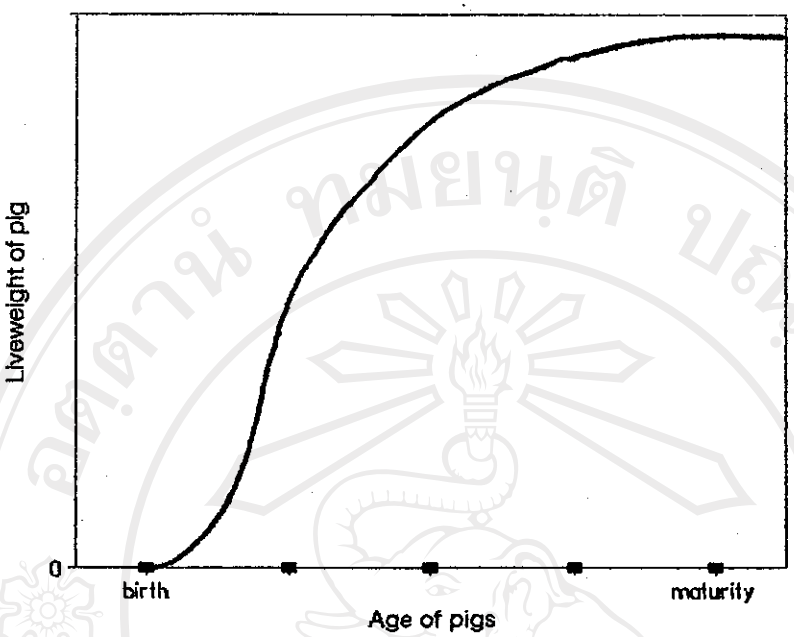

Figure 30. Growth curve for swine (McMeekan, 1940).

reach a weight of 70 or 75 kilogram (Eusebio 1969). The reason is not only to avoid loss of quality from high-fat content pork, but also because feed conversion ratios rise significantly as pigs grow past this point (Figure 31). High FCRs will require more feed and feed cost with less returns. In the case of Mae Taeng backyard pig production, pigs are sold live by overall appearance and size. Although carcass quality is not exactly determined at this point, sellers can differentiate between lean and fatty pigs by the appearance of the pig, so it is still important to backyard pig farmers to manage the quality of their pigs' meat.

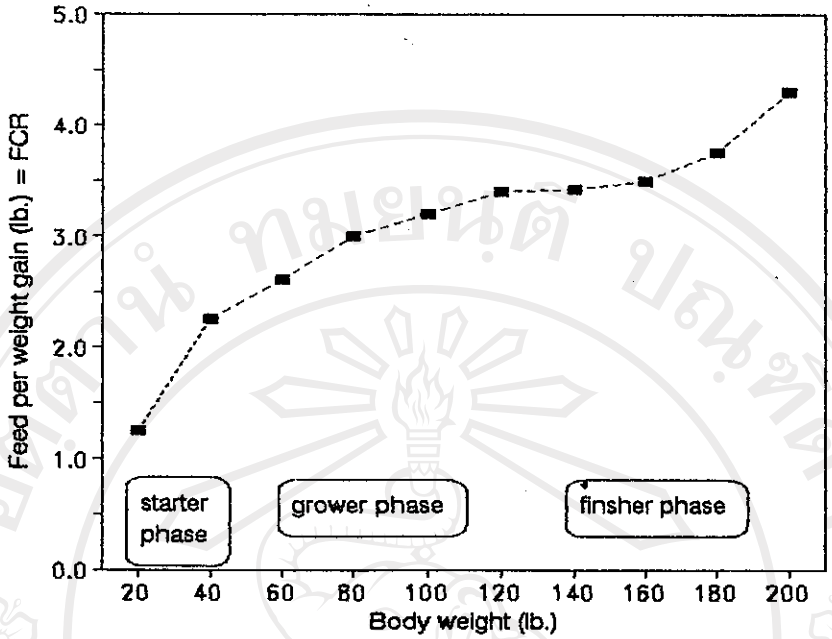

Figure 31. Relation of feed efficiency to body weight (Eusebio, 1969).

Several factors in addition to the pigs' natural development affect feed conversion efficiency. These factors may be more easily manipulated by farmers. Quality of pig breed can be said to set the upper limit to pig growth and final size (Goodwin 1974). But in terms of rate of growth, which is important to cost efficiency, and size at maturity, which again affects sale price, the important factors include nutrition, environment, management, and disease. In fact, as observed by the former chief of Animal Production Branch of the F.A.O., the latter factors are probably more important than breed to the small-scale pig producer, because improved breeds have often failed under

the reality of backyard conditions, whereas health, nutrition and management can and should be targeted for more effective improvement of pig performance (Malynicz 1978). In Thailand, rice forms the basis of most backyard pig diets. Since rice by-products are so widely used among small-scale farmers, the rice fraction of the diet is critical in contributing various nutrients and sources of energy. The quality of various diets can be compared by calculating feed conversion ratios.

Another important measure of feed efficiency for farmers to consider is figured as the feed cost required to produce one unit of liveweight gain (Buckett, 1981). In the following pages, these various measures of efficiency will be presented: feed conversion ratios, derived from average daily feed intake and average daily weight gain, as well as feed cost per unit weight gain. Furthermore, these parameters will be compared between pigs fed different diets, in order to determine the influence of feed components on pig growth. At times it will be useful to compare results between pigs with different initial weights at the start of the weight measurement survey, since the size of the pig may also influence feed conversion efficiency. Where relevant, statistical analyses such as analysis of variance and the nonparametric Kruskall-Wallis

one-way analysis by ranks are employed to test differences between feed diets.

In order to understand and visualize the actual conditions of backyard pig production in the study area, the general management practices in use will first be described. In the proper context, then, the parameters used to measure and assess production efficiency can be explained.

4.1 General management

4.1.1 Management practices

The range of management practices and scale of backyard pig production was assessed for study participants through surveys and regular house visits. Farmers' responses indicate that their background economic standing, as reflected by paddy landholding and verified by household budgeting presented in Chapter 2, again plays a role in their choice of management practices.

One basic difference between farmers from different farm sizes is in the number of pigs raised per household, that is, herd size. Just as small-scale farmers have the

least area of cultivable land, especially paddy, they raise on average the fewest number of pigs (2.7 per household). Medium-scale farmers raise 3.9 pigs, while large-scale farmers raise an average of 9 pigs per household. The scale of pig-raising activities and other management practices is presented in Table 15 and Appendix H.

Regarding area which farmers make available to their pig herds, pigsties are all generally small, from 5 to 7 square meters in area. However, since large-scale farmers raise many pigs, especially piglets, the sty area per head of pig is somewhat less in those households, never exceeding 2 square meters per head. For the smaller herds of the small and medium scale farmers, area per animal is similar size but can range up to four (Appendix H).

The pig breed purchased by study participants was most often reported as a single cross breed, which is supposed to represent the cross of a pure-bred individual with another mixed breed. A minority of farmers reported using a double cross breed, which they determine by the physical characteristics which would seem to represent more than two varieties, perhaps without a purebred as a parent.

Table 15. Basic management practices.

	Farm size Small	Medium	Large
a. Scale of pig-raising activities			(averages)
No. pigs/house	2.74	3.88	9.00
Pigsty size (m2)	5.80	6.58	6.60
Sty area/head (m2)	2.53	2.32	1.20
b. Pig breed used			(percents)
Purebred	0.0	3.0	0.0
Single cross	85.7	80.6	100.0
Double cross	14.3	16.4	0.0
c. Source of piglet			(percents)
Piglet vendor	71.5	65.6	20.0
Village pig producer	17.4	17.9	60.0
Small piglet farm	6.3	3.0	0.0
Pig R & D Station	0.0	0.0	0.0
Own sow	4.8	13.4	20.0
d. Health care of pig			(percents)
Yes	46.0	41.8	60.0
No	54.0	58.2	40.0
e. Frequency of cleaning pigs and sties			(percents)
Less than once a day	11.1	13.4	0.0
Once per day	44.4	56.7	80.0
More than once a day	44.4	29.9	20.0
f. Feed additives			(percents)
Yes	6.3	0.0	20.0
No	93.7	100.0	80.0

Source: Formal survey,1990.

However it should be realized that most of the farmers acknowledge that they do not know the actual parentage of their pigs in terms of genetic breeding, and only comment on the general physical appearance of their pigs. As pig breed has been known to affect pig performance, more precise information would be helpful.

Small and medium-scale farmers most often purchase their piglets from a piglet vendor. This vendor first buys piglets from small-scale farmers in the same and nearby districts. The vendor then fattens the piglets for one or two weeks, until the piglets weigh between 12 to 15 kilograms, and then sells them to farmers in the villages, at usually over 500 Baht per pig. In each village, two or three farmers also produce surplus piglets, which they tend to sell at a young age, immediately after weaning. These piglets are usually less than 12 kilograms, and cost less, perhaps 400 Baht per piglet. But they require special compound feed, which is expensive, and must be purchased in large 30 kilogram sacks. Large-scale farmers, who buy more pigs, tend to buy their piglets from this latter source. They can save on piglet costs, and since they buy many, the purchase of the large 30 kilogram sacks of special feed is efficient. Small and medium-scale farmers who raise few pigs cannot afford to buy such a large amount of expensive

compound feed, and thus must pay slightly more for the older piglets from the vendor.

Health care of pigs is another critical management practice. As evident in Table 15, less than half of small and medium-scale farmers reported having their pigs vaccinated against disease. In the backyard system, vaccinations are given only once in the pig's life, during the weaning stage. Piglet vendors are considered responsible for this job, so when farmers buy older piglets they assume that it has been done. Since many large-scale farmers buy piglets from the village producer who is not responsible for vaccinations, these farmers are slightly more likely to vaccinate their pigs.

Farmers in the study reported cleaning the pigsties on a regular basis, generally once per day, with fair numbers cleaning more than once. More frequent cleaning may be associated with those farmers raising several pigs in one sty. Both small and medium scale farmers had a minority of 11 to 13 percent who cleaned less than once per day; the pigs in those situations would be more likely to be exposed to unsanitary conditions.

4.1.2 Feed quality

Farmers provide their pigs with a range of food components, provided in different proportions. The combination of food components, or "diet", is likely to have different effects on pig growth because of the different amounts of proteins, minerals, vitamins, fibers, and carbohydrates provided. In addition, the type of feed combination used will affect the economics of pig raising, since individual items have widely varying costs. The majority of farmers from all groups did not provide special feed additives such as extra vitamin supplements or other products that are prepared by feed companies.

Table 16 lists nine different combinations of feed components with the proportion of farmers from each farm size that chose those foods for their pigs (see also Figure 32). The most common item is rice bran, which, with the exception of one group of farmers, is always included in the diet. The five farmers who do not include bran give their pigs only commercial complete feed, which was described in Chapter 3 as a ready-made feed with full nutritional requirements. Despite the instructions of the feed company, many small and medium scale farmers still add rice bran to the complete feed (32 and 28 percent respectively). This

allows them to reduce the proportion of complete feed, which costs more, and make up the bulk with cheaper but less nutritious rice bran. The diet would be expected to be inferior to the diet of full compound feed.

Table 16. Farmers' use of feed diets.

Feed diet[1]	Percent of farmers using feed (by farm size) Small	Medium	Larger
1 (conc+bran+BR+veg+left)	1.6	0.0	0.0
2 (conc+bran+BR+veg)	14.3	9.0	0.0
3 (conc+bran+BR)	4.8	14.3	20.0
4 (conc+bran)	19.1	34.3	0.0
5 (comp+bran+BR+veg+left)	4.8	0.0	0.0
6 (comp+bran+BR+veg)	15.9	4.5	0.0
7 (comp+bran+BR)	4.8	10.5	60.0
8 (comp+bran)	31.8	28.4	0.0
9 (comp)	3.2	1.5	20.0

[1] Description of feed components:
Conc= hog feed concentrate;
comp= complete feed;
bran= rice bran;
BR= broken rice;
veg= vegetables;
left= household leftovers

Source: Formal survey, 1990.

The next most popular diet for small and medium scale farmers is combining concentrate feed with bran (19 and 34 percent). As explained earlier, the more expensive concentrate feed requires the addition of other ingredients such as rice by-products, vegetables, et cetera. However,

as described in Chapter 3, all farmers preferred mixing concentrated feed not in accordance with the recommended formula, mainly because not all additional ingredients required were easily available. The nutritional content of the diet finally achieved would not be what the feed companies expect.

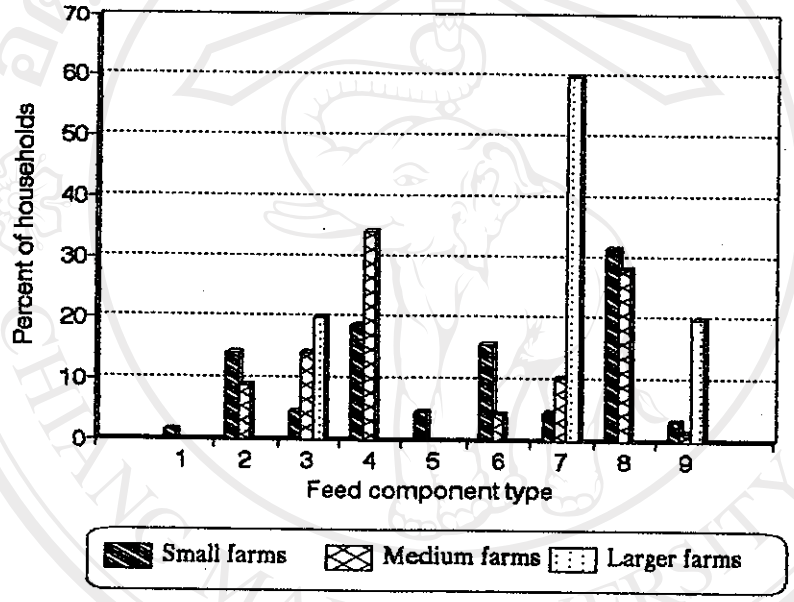

Figure 32 Farmers' use of feed components.

Nearly a quarter of medium-scale farmers and 20 percent of small-scale farmers also add broken rice to bran and concentrate (23.3 percent), while a fair proportion took the time to boil and add vegetables to the diet (30 percent of small-scale and 13 percent of medium-scale farmers). It is

expected that adding vegetables should improve nutrient content.

The most common feed combination for large scale farmers is complete feed with bran and broken rice added (60 percent). Since these farmers have large rice fields they can produce plenty of rice by-products, which are easily added to their pigs' feed. The two farmers who are also rice millers will obviously have a surplus of by-products to feed to their own pigs, as well as to sell back to the other farmers. None of these farmers took the trouble to add vegetables. Twenty percent used complete only, and the remaining mixed concentrate with bran and broken rice.

When comparing the proportion of home-supplied feed used to commercial ("bought") feed, the trend emerges in which the small scale farmers use less homefeed and the larger scale farmers use more homefeed (Table 17, Figure 33). In fact, 60 percent of the larger scale farmers use at least 70 percent home feed, whereas the reverse is true for small-scale farmers, three-quarters of whom combine less than 30 percent home products into their pigs' diets.

Table 17. Comparison of farmers' use of homefeed and bought feed.

Proportion of homefeed[1]	Percent of farmers by farm size		
	Small	Medium	Larger
At/over 90%	1.6	9.0	20.0
70 to 89%	0.0	10.5	40.0
50 to 69%	9.5	26.9	40.0
30 to 49%	12.7	37.3	0.0
10 to 29%	47.6	16.4	0.0
Less than 10%	28.6	0.0	0.0

[1]The remainder would be bought feed

Source: Formal survey,1990.

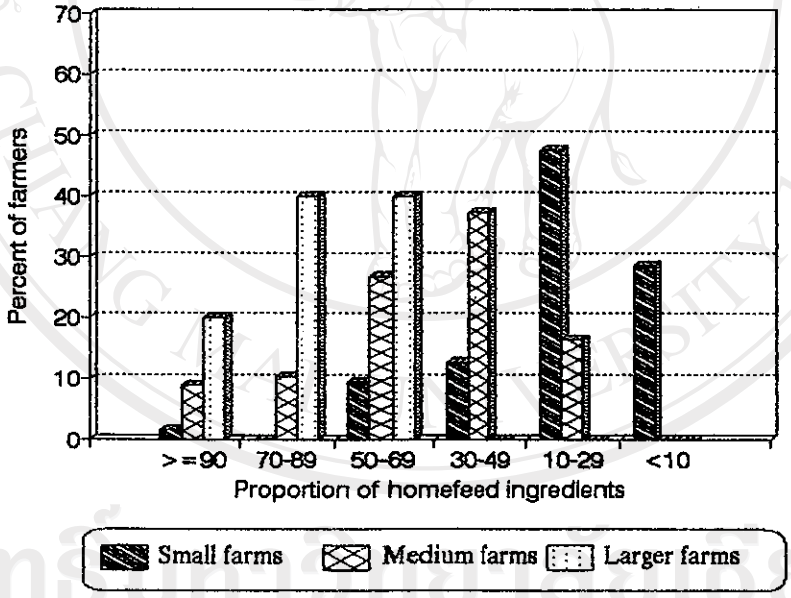

Figure 33. Farmers' use of homefeed in proportion to bought feed.

The traditional backyard system includes the use of vegetables, along with rice by-products. However, with the availability of and promotion of commercial feed products such as complete feed and concentrate, many farmers have abandoned their practices of preparing and adding cooked vegetables to their pigs' food. However, until pig growth and feed conversions are compared between pigs fed with vegetables, and fed without vegetables, it may not be known whether vegetables contribute to the pig-raising enterprise. The contribution may have both a nutritional aspect and an economic aspect, because the vegetables should not increase the feed costs, while possibly promoting healthy growth.

Because the decision to use complete feed or concentrate, and whether or not to add vegetables affects the nutritional quality of the food and the pigs' growth, the following analyses of feed conversion efficiency will include comparison of these four feed "diets": concentrate with vegetables ("diet 1" or D1), complete feed with vegetables ("diet 2" or D2), concentrate without vegetables ("diet 3" or D3), and complete without vegetables ("diet 4" or D4).

These four diets are listed below in Table 18, and include the various feed combinations described earlier in

Table 16. It is understood that in all cases bran is provided anyway, and on occasion, broken rice as well, for extra bulk. Results from Diets 1 and 2 can be averaged to provide the result of using vegetables versus not using vegetables (Diets 3 and 4). A fifth diet, which is the one with complete feed only, will be evaluated separately, and in comparison to the averaged results of the other four. Since a full diet of complete feed is supposed to provide all nutritional needs, it is expected that growth should be fast and feed conversion efficient, as is the case in semi-commercial pig production, which relies mostly on complete feed only.

Table 18. Five main pig diet types used by farmers in household record-keeping survey.

Diet	Description	Feed combinations from Table 15	No. farmers
1	Vegetable-concentrate	1:(conc+bran+BR+veg+left) 2:(conc+bran+BR+veg)	3 (9.1)
2	Vegetable-complete	5:(comp+bran+BR+veg+left) 6:(comp+bran+BR+veg)	8 (24.2)
3	Non-vegetable-concentrate	3:(conc+bran+BR) 4:(conc+bran)	8 (24.2)
4	Non-vegetable-complete	7:(comp+bran+BR) 8:(comp+bran)	9 (27.3)
5	Complete only	9:(comp)	5 (15.2)

Note: Numbers in parentheses are percentages.
Source: HHRK, 1990.

4.2 Production efficiency

4.2.1 Feed efficiency

Daily feed intake was recorded for each of the 133 pigs belonging to 33 farmers in the study. Average daily feed intake was calculated by month, and for the overall period of three months. Results are presented in Table 19 and Figure 34. Dry commercial feeds such as concentrate and complete feeds were not oven-dried; it is expected that their weights include not more than ten percent moisture. Fresh foods, however, because of their high water content, were converted to dry weights as noted in Table 19.

Apparently feed intake quantities differ for pigs fed on different diets. The average daily feed intake per pig was 2.43 kilograms of dry weight for pigs on the diets with vegetables, and 3.15 kilograms for pigs fed without vegetables. Probably the farmers adding vegetables prepared what appears to be a large amount, but with high water content, which is not included in the dry weight measurement. The average feed intake for the Diets 1 through 4 was 2.97 kilograms, compared to only 2.16 kilograms for pigs fed Diet 5 (complete feed only). When feed intake is compared from month to month, the amount

naturally increases with time, as the pigs grow and need to consume more. Average daily feed intake in the first month for Diets 1 to 4 was 2.19, but by the third month it was 3.42.

Table 19. Feed intake[1] (FI) (avg. kg per head per day).

	Veget D1	D2	Avg D1&D2	Non-veg D3	D4	Avg D3&D4	Avg D1-D4	D5
FI1 (1st mon)	2.55 (1.01)	1.7 (0.73)	2.13 (0.84)	2.14 (0.54)	2.34 (0.70)	2.24 (0.61)	2.19 (0.77)	1.59 (0.23)
FI2 (2nd mon)	3.5 (1.16)	2.31 (0.85)	2.9 (0.96)	3.20 (0.99)	3.35 (1.20)	3.28 (1.07)	3.09 (1.11)	2.07 (0.28)
FI3 (3rd mon)	4.33 (1.46)	2.68 (0.73)	3.51 (0.95)	4.01 (0.79)	3.77 (0.80)	3.89 (0.80)	3.42 (1.08)	2.55 (0.68)
Avg. FI (3 mons.)	3.32 (1.31)	2.23 (0.76)	2.43 (0.91)	3.15 (0.78)	3.15 (0.79)	3.15 (0.79)	2.97 (0.96)	2.16 (0.47)

[1] Feed intake includes dry matter of vegetables where relevant and calculated as fresh weight x percent dry matter, Tropical Products Institute, Proc. of the Conferences on Animal Feeds of Tropical and Subtropical Origin, 1985.

Plant	Dry matter wt.
Sweet potato root	.30
Vegetable cuttings	.40
Banana trunk	.20
Cucumber	.16
Weeds	.15

Note: Numbers in parentheses are standard deviations (std).
Data used in calculations are from a 90 day period.

Source: HHRK, 1990.

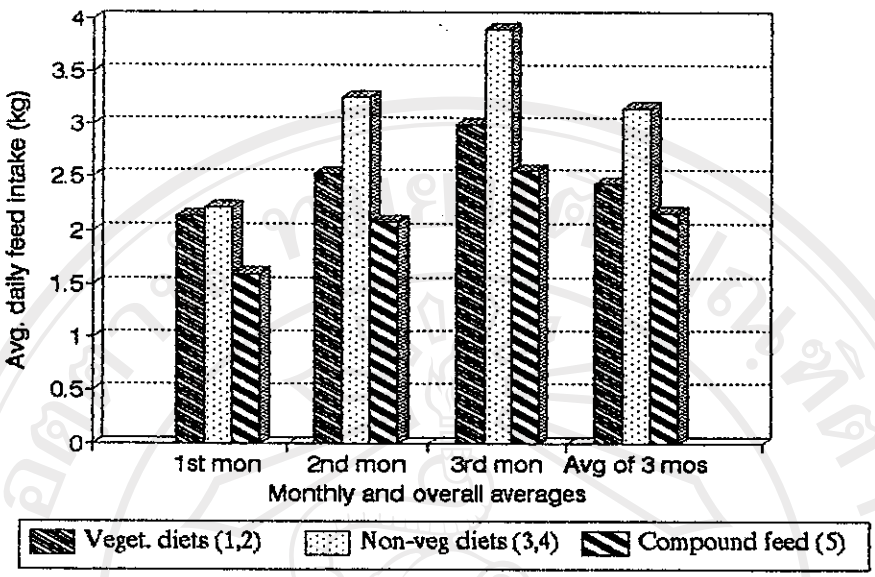

Figure 34. Daily feed intake (kg DM) averaged by month and over 3 months.

During the same three-month period, pigs were weighed individually four times: at the start of the record-keeping study, and subsequently at monthly intervals. Average daily gain (ADG) was calculated again by month and for the entire period. Table 20 and Figure 35 indicate an ADG of 0.48 kilos per day for pigs fed diets 1 to 4. Pigs on complete feed only, however, gained more weight: 0.65 kilos daily. This was predicted, considering the high quality of complete feed. With variation between pigs from different herds, differences in ADG between pigs fed vegetables or not fed vegetables is hard to detect (0.47 versus 0.50 kilograms respectively).

For most diets, it appears that the ADG generally increased from the first to the second month, and dropped off again in the third month as pigs approached maturity, with weights ranging between roughly 60 to 80 kilograms, as predicted by growth curves. Pigs fed complete feed, however, were gaining as much as 0.8 kilos per day in the second month, but this dropped back to 0.53 kilos by the third month.

Table 20. Weight change and weight gain (avg. kg per head per day).

	Veget D1	D2	Avg D1&D2	Non-veg D3	D4	Avg D3&D4	Avg D1-D4	D5
Ttl weight change	40.12 (5.31)	42.89 (6.99)	41.51	46.06 (5.92)	43.00 (6.93)	44.53	43.02	58.67 (4.43)
Avg monthly gain	12.97 (1.82)	14.28 (2.30)	13.63	15.05 (2.15)	13.63 (2.52)	14.34	13.99	19.81 (2.47)
ADG1 (1st month)	0.39 (.11)	0.44 (.13)	0.42	0.50 (.12)	0.52 (.14)	0.51	0.47	0.61 (.10)
ADG2 (2nd month)	0.44 (.08)	0.5 (.13)	0.47	0.59 (.09)	0.44 (.19)	0.52	0.50	0.8 (.25)
ADG3 (3rd month)	0.51 (.06)	0.48 (.11)	0.50	0.43 (.09)	0.42 (.12)	0.43	0.47	0.53 (.11)
Avg ADG (3 months)	0.45 (.06)	0.48 (.08)	0.47	0.51 (.06)	0.48 (.08)	0.50	0.48	0.65 (.08)

Note: Numbers in parentheses are standard deviations.
Data used in calculations are from a 90 day period.

Source: HHRK, 1990.

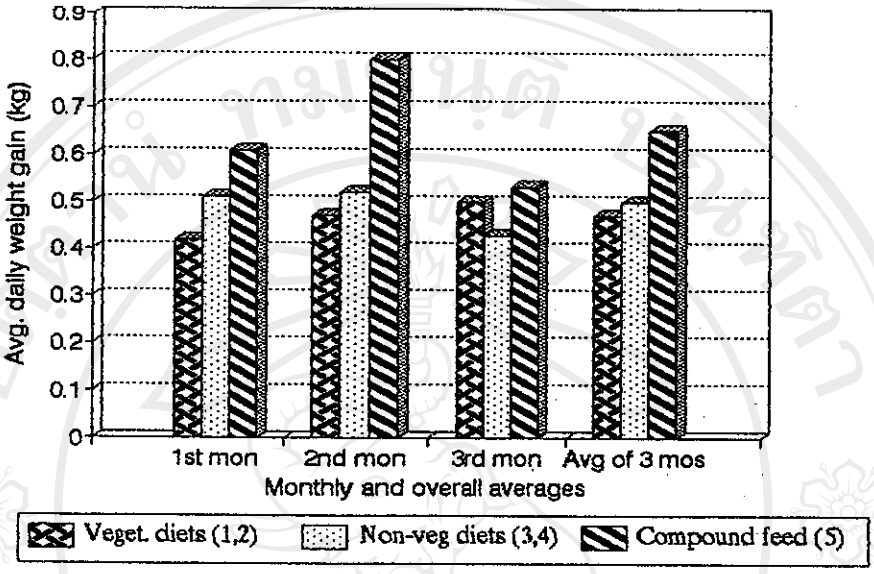

Figure 35. Daily weight gain (kg. per head) averaged by month and over 3 months.

Figure 36 illustrates the actual growth curve of backyard pigs raised in this study. It is similar to the middle stage of McMeekan's generalized growth curve. The growth rate of pigs fed complete feed (Diet 5) is seen to be faster than the rest.

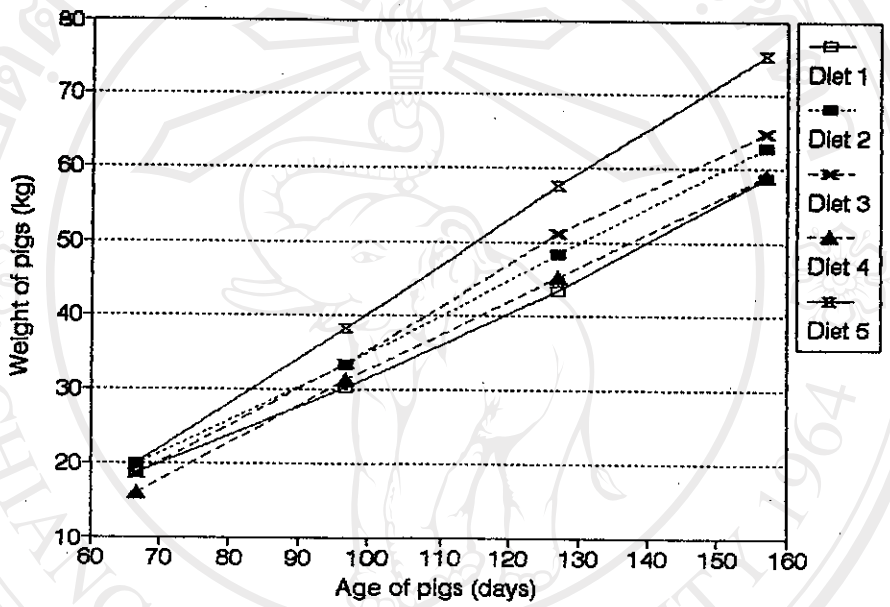

Figure 36. Growth curve of pigs raised in backyard system in Mae Taeng.

Feed conversion ratios (FCR) were calculated from the data on feed intake and weight gain (Table 21 and Figure 37). This is an important measure of feed conversion efficiency. Apparently the FCR averaged for all pigs in the study, excepting those fed complete feed only, is 5.94. As expected from general studies on pig development, FCRs were

lower in the first month of the study (4.97), and steadily rose during the second (5.93) and third months (7.37), by which time feed conversion efficiency can be said to be rather poor. In contrast, pigs fed complete feed only had the much lower overall FCR of 3.5. After the first month it was only 2.8, then slightly rose to 3.08 after the second month, and reached its highest of 4.4 by the third and last month. This demonstrates the better efficiency of pigs at converting feed into liveweight gain, when their feed is the high quality nutritious complete feed.

Table 21. Feed conversion ratios (FCR) (kg. feed to produce one kg. liveweight gain).

	Veget		Avg	Non-veg		Avg	Avg	D5
	D1	D2	D1&D2	D3	D4	D3&D4	D1-D4	
FCR1	6.62	3.99	5.31	4.70	4.55	4.63	4.97	2.80
(1st mon)	(1.87)	(1.64)	(1.75)	(1.67)	(1.94)	(1.78)	(1.88)	(0.90)
FCR2	7.88	4.68	6.28	5.56	5.60	5.58	5.93	3.08
(2nd mon)	(1.85)	(1.47)	(1.66)	(2.14)	(1.74)	(1.94)	(1.78)	(1.01)
FCR3	8.35	5.76	7.06	8.96	7.26	8.11	7.59	4.40
(3rd mon)	(2.3)	(1.61)	(2.0)	(1.87)	(1.4)	(1.74)	(1.8)	(1.69)
Avg FCR	7.27	4.63	5.95	6.26	5.60	5.93	5.94	3.50
(3 mons)	(2.11)	(1.04)	(1.62)	(1.79)	(1.15)	(1.59)	(1.73)	(1.16)

Note: Numbers in parentheses are standard deviations.
Data used in calculations are from a 90 day period.

Source: HHRK, 1990.

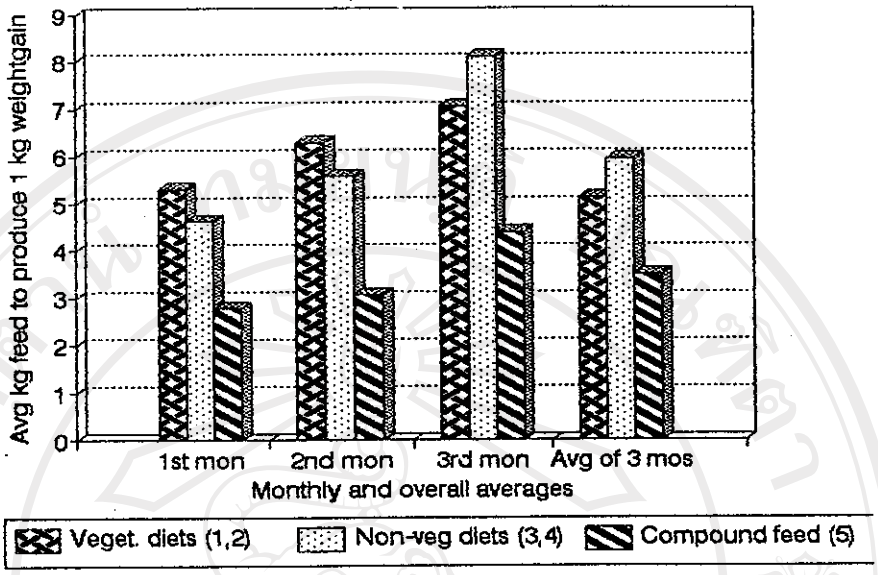

Figure 37. Feed conversion ratios averaged by month and over 3 months.

When the FCRs for pigs fed other diets were compared, the results averaged over the entire three-month study period showed that Diet 2 (complete with vegetables) was most efficient (4.63), followed by Diet 4 (complete without vegetables) and Diet 3 (concentrate with vegetables). The least efficient was Diet 1 (concentrate with vegetables), with an FCR of 7.27. This order of efficiency continued fairly consistently in the individual month averages. It indicates that diets including complete feed rather than concentrate produced better feed conversion efficiency, and that the addition of vegetables to complete feed created the most biologically efficient feed conversion.

The relationship between FCR and body weight is illustrated in Figure 38. It shows that FCR increases and feed efficiency decreases as the pigs grow larger (older), as suggested earlier by Eusebio (Figure 32). In the figure, pigs fed Diet 5 (complete feed only) consistently performed better, in terms of feed conversion efficiency, over all growth stages. Diet 2 (vegetables with complete feed) was consistently second best, proving much more biologically efficient than the other diets. The FCRs from Diets 3 and 4 (non-vegetable diets) did not rise until the later stage, as in Eusebio's study, while Diet 1 (vegetables with concentrate) was the poorest in the early growth stages.

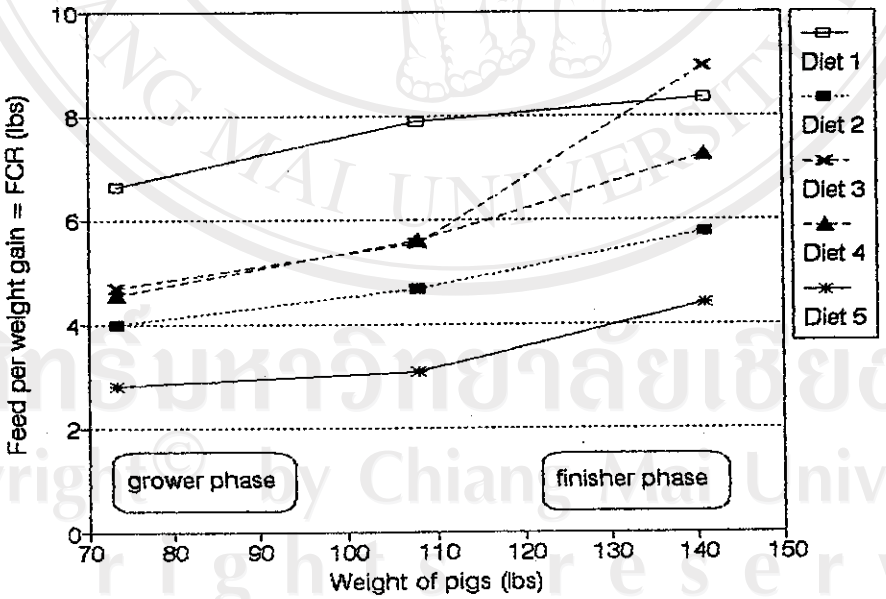

Figure 38. Relation of feed efficiency to body weight in Mae Taeng swine.

Caution is needed in ranking these diets on the basis of FCR because the feed efficiency shown here is also a result of farmers' use of different proportions of feed components. For example, the FCR for Diet 1 might be improved if farmers had used relatively more concentrate and less bran. This requires further tests.

In order to determine whether or not these perceived differences in mean feed conversion ratios indicate statistically significant differences due to diet, one-way analyses of variance were performed on the data. The study pigs were considered to be representative of the population of backyard-raised pigs in Mae Taeng. In accordance with assumptions, the data followed normal distributions. In some cases where the mean and variance of the feed conversion ratios for each feed diet ("treatment") were found to be related, or sample variances could not be shown to be independent, a square root transformation was used, of the form $\sqrt{x + .05}$. The transformed data fulfilled the assumptions of the analysis of variance for each of the monthly FCR averages which were compared. However, the FCRs averaged over the entire month period had widely different sample variances between the diets. This is mainly because the FCRs for Diet 1 had higher variance than for the other diets. For this case, the nonparametric Kruskall-Wallis

test was employed, which is the equivalent of a one-way analysis, but on ranks, and does not have the strict assumptions of parametric analysis. Anova and Kruskal-Wallis tables are provided in Appendix I.

When all five diets were included in the analysis of variance on transformed data, the between-treatment variance was statistically significantly greater than within-treatment variance, and it can be concluded that diet has an effect on feed conversion when measured for each month ($p=0.0000$). Similarly, the feed conversion measured over the total period was found to be significantly influenced by diet by the Kruskal-Wallis test, which used a chi-square ($p=0.0000$, K-W statistic = 58.19). Since the variance for Diet 5 (complete only) was quite low in the first month compared to the other diets, sample variances were not equal; in this case, the Kruskal-Wallis test again confirms the result of significant diet effect ($p=0.0000$, K-W statistic = 36.02).

The above analysis of variance may have shown a significant effect of diet mainly because Diet 5 had a much lower feed conversion ratio than the others. Therefore, to look for differences between the other four diets another analysis of variance was performed excluding Diet 5. Again,

the results were significant: for the first month p=0.0011, for the second month p=0.0000, and for the third month p=0.0000. The Kruskal-Wallis test on ranks for the FCRs averaged over the entire period also indicated significant effect of diet (p=0.0000, K-W statistic = 32.73), and was used only because the sample variances could not be proven to be equal. What these analyses show is that the differences between mean feed conversion ratios are greater for pigs fed different diets than they are for pigs fed on the same diet. It can therefore be concluded that first, a diet of only complete feed produces the highest feed efficiency, and secondly, that significant differences exist between the other diets, with notably complete feed plus vegetables showing the next best efficiency.

As discussed earlier, feed conversion ratios can also be influenced by the developmental stage of the pig. In this study, all of the 133 pigs were not of exactly the same age at the start of the weighing. Farmers could not provide precise ages of their piglets, but the developmental stage can be better estimated by the initial weight of the pig. In this way, the 133 pigs could be divided into three categories, according to initial weight. The first group included 30 pigs with initial weights between 12 and 15.9 kilograms; the second group had 40 pigs weighing between 16

and 20.9 kilograms; the third group had 29 pigs between 21 and 29 kilograms.

Feed conversion ratios were compared for pigs of differing initial weights, including pigs from all 5 diet groups. The result was obtained that in the first month of the survey, the FCRs were barely statistically different for pigs of different initial weights ($p = 0.054$, Appendix J). However, when only pigs from the first 4 diet groups were included, the FCRs from the first month are not statistically different according to initial weight ($p=0.579$). This suggests that at the earliest stage initial weight is not important.

However, by the second and third months, the feed conversion ratios are significantly different for pigs with different initial weights. This holds true when pigs from all 5 diets or only 4 diets are included in the analysis. The point is that pigs with low initial weights tend to have worse feed efficiency, as reflected in higher FCRs. For example, the lightest weight pigs had FCR of 7.342 (averaged for pigs fed all 5 diets in the 3rd month). This was less efficient than the pigs with heavier initial weights, who had FCR of 6.07 ($p=0.026$). Light weight pigs may be unavoidable in large herds, where competition means that

they continually lose out to their larger siblings, and their poor growth becomes more obvious with time, while their larger siblings are increasingly successful at getting the food first. Farmers can avoid this problem by separating their pigs or reducing the number per sty, so that small pigs can still have a good chance at getting enough food to improve their initial weights.

4.2.2 Feed cost per unit of liveweight gain

As explained before, the useful measure of production efficiency is to calculate the feed cost per unit of liveweight gain. Although analyses of feed conversion efficiency give important information on which feeds can produce more pig weight, the farmer needs to know how much those efficient diets are going to cost. Table 22 and Figure 39 presents this cost information for the five diets, by month and over the entire three month period.

Average feed cost per one kilogram of weight gain for pigs fed Diets 1 to 4 was 16.1 Baht. In the first month the cost was only 14.1 Baht, but as feed intake increased, the cost increased to 20.2 Baht in the third month. The higher quality complete feed composing Diet 5 was, as expected, rather more expensive. Overall cost was 20 Baht per kilo of

Table 22. Feed cost per one kilogram of liveweight gain (Baht).

	Veget D1	D2	Avg D1&D2	Non-veg D3	D4	Avg D3&D4	Avg D1-D4	D5
Cost1 (1st mon)	16.3 (6.98)	11.53 (4.93)	13.92	13.4 (4.90)	15.02 (5.44)	14.21	13.11	16.76 (3.20)
Cost2 (2nd mon)	14.79 (5.97)	13.44 (6.14)	14.12	13.62 (4.0)	21.12 (5.34)	17.37	15.75	18.42 (5.18)
Cost3 (3rd mon)	16.68 (5.55)	17.26 (6.52)	16.97	21.86 (3.72)	24.81 (8.05)	23.34	20.16	28.91 (12.18)
Avg cost (3 mons.)	15.75 (5.95)	13.54 (4.44)	14.65	15.95 (3.96)	19.31 (3.79)	17.63	16.14	20.01 (4.02)

Note: Numbers in parentheses are standard deviations.

Source: HHRK, 1990.

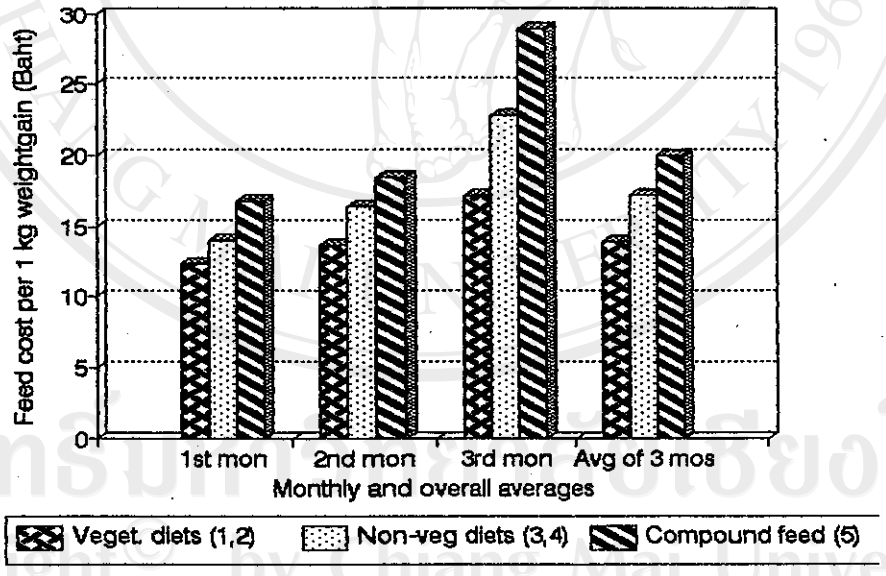

Figure 39. Feed cost averaged by month and over 3 months.

weight gain; in the first month the cost was 16.8 Baht, but rose to 28.9 Baht in the third month. So although the biological efficiency is greater for pigs fed complete feed, the farmer will have to have enough cash to pay for more expensive feed costs, before realizing any profit.

Regarding differences between the other 4 diets, apparently the diets which included vegetables had lower feed cost per kilo weight gain. The average of vegetable diets was 14.7 Baht, versus 17.6 Baht for non-vegetable diets. Considering both the lower cost of the vegetable diets, and the better feed efficiency (represented by lower average FCR), the traditional practice of adding vegetables would seem to be a good one. Interestingly, the vegetable diets which included complete feed instead of concentrate had the best feed efficiency and also the lowest feed cost per unit weight gain. On the other hand, when vegetables were not included, the feed efficiency of complete feed was better than for concentrate, but the complete feed diet cost more. Perhaps concentrate had been reduced to minimize costs (thereby also lowering feed efficiency). If a farmer cannot afford the pure complete feed diet, he or she might benefit by adding vegetables to some amount of complete feed. It will not cost so much, and the feed efficiency is relatively good, by backyard raising standards.

4.3 Correlation between rice by-products and herd size

In order to look for a relationship between the proportion of home (own) by-products used in pig feed and the herd size raised by the farmer, a simple correlation was performed on the data. The correlation was not significant, either when all 33 farmers were included, or when farmers using complete feed were excluded (R^2 = 0.006 and 0.284 respectively). It can be concluded that the use of by-products had no systematic relationship with herd size. The latter would be affected by other management considerations, as well as the feasible economic scale of production.