A physical and financial appraisal of a feeding system using combinations of low nutrient-dense and concentrated feeds for growing pigs in the Solomon Islands

Peter J. Thorne*

Livestock Feeds Project, Ministry of Agriculture and Lands, PO Box G13, Honiara, Solomon Islands

Received June 1991; revised May 1992

A concentrated protein supplement based on locally available fish meal and wheat mill run was evaluated as a means of improving the efficiency and profitability of smallholder pig production in the Solomon Islands. In comparison with a low nutrient-dense diet based on cassava and coconut alone, supplementation with small amounts of concentrate [20% of dry matter (DM) intake] resulted in a much improved growth rate ($P < 0.001$), total DM intake ($P < 0.001$), and feed conversion ratio ($P < 0.001$) of growing pigs between 6 kg and 55 kg live weight. Restricting DM intake of pigs fed low nutrient-dense feeds and concentrate had little adverse effect on growth rate ($P = 0.380$) as the animals compensated for reduced feed intake with improved feed conversion ratio ($P = 0.050$). A financial appraisal of these data suggested that the improvements in production parameters observed with the use of concentrate would translate into an enhanced financial performance for the smallholder pig keeper albeit at an increased risk. Returns to labour for this system were greater than for other forms of land use currently practised in the Solomon Islands.

Keywords: Pig feeds; Solomon Islands; Cassava; Low nutrient-dense pig diets; Concentrated supplement

Rural markets in the Solomon Islands exhibit a considerable demand for pigs because of the importance of pork in fulfilling the social obligations of the customary feast. However, poor productivity from smallholder livestock enterprises, due mainly to poor nutrition, means that it may be difficult to meet this demand locally.

Distribution of complete compound pig feeds from a central manufacturer could improve standards of nutrition considerably but shipping is complicated within the scattered archipelago. Furthermore, the use of a complete compound feed does not allow for optimizing the use of those feed resources such as household wastes and crop residues which may be available as a result of the other activities of the smallholder farmer.

The use of concentrated feeds formulated specifically to complement available, low nutrient-dense raw materials is a possible alternative. Transport difficulties are reduced as the volume of concentrate required to support a given level of production can be as little as one fifth of the equivalent amount of compound feed. Using concentrates, a reasonably balanced diet could be supplied to the village pig despite less than optimum conditions of production. A concentrate is required principally to make up the shortfall of protein usually occurring in the diets of pigs kept by smallholders. It can also be of value in ensuring a reliable supply of essential minerals and vitamins and for the application of anti-parasitic medications.

Previous studies have shown that feeding of concentrates with low nutrient-dense feeds can produce growth rates similar to those observed with compound feeds under commercial conditions (Calder, 1960; Gomez, 1977; Watt, 1973; Thorne, 1992). However, little attention has been paid to the interacting socioeconomic factors which are ultimately likely to be most important in determining adoption of this type of feeding system by farmers.

The feeding trial described here was designed to generate physical data that could be used in a financial appraisal of the use of concentrates to supplement the low nutrient-dense feeds (cassava and coconut) that are widely available in the villages of the Solomon Islands.

Materials and methods

Dietary treatments

Three dietary treatments based on low nutrient-dense raw materials were tested in the experiment:
Treatment A — fresh chopped cassava offered *ad libitum* with a daily allowance of fresh coconut. This treatment was designed to simulate the tra-

*Present address: Natural Resources Institute, Central Avenue, Chatham Maritime, Kent ME4 4TB, U.K.

Table 1 Raw material composition of feeds

Composition	Concentrate %	Coconut %	Cassava %
Components			
Mill run*	28.55		
Fish meal	67.73		
Salt	0.57		
Lysine-HCl	0.15		
Premix	2.00		
Mecadox growth promotor	1.00		
Analysis			
Dry matter	91.0	56.0	32.0
Crude protein	41.8	3.7	0.8
Ether extract	7.9	31.7	0.4
Crude fibre	2.6	1.5	1.3
Ash	15.8	1.0	0.9
Nitrogen-free extract	31.7	18.1	28.5
Calcium	4.00	0.01	0.06
Phosphorous	2.36	0.03	0.07
Lysine	3.15	0.10	0.03
Methionine + cystine	1.19	0.05	0.01

*Mixed wheat-bran fraction

ditional extensive system practised currently by the village pig farmer which uses feeds available on-farm. The most significant characteristic of this system from a nutritional point of view is the serious limitation on protein supply.

Treatment B — fresh chopped cassava offered *ad libitum* with daily allowances of fresh coconut and concentrate. This may be described as a semi-intensive system as the basic feeds used are the same as for treatment A, but a concentrated supplement which would in practice be brought in from off-farm is used to counteract the limitations imposed by an inadequate protein supply.

Treatment C — fresh chopped cassava offered restricted with daily allowances of fresh coconut and concentrate (semi-intensive system). This treatment may also be described as semi-intensive, but it was designed to simulate the restriction on feed intake which is likely to occur under practical conditions because of limited labour availability for feeding or misconceptions on the part of the farmer as to the amount of feed that pigs are capable of consuming when their diets are properly balanced for essential nutrients. The degree of restriction of cassava in this treatment was calculated to impose a limitation of approximately 20% on total dry matter (DM) intake.

The ingredient composition of the concentrate and chemical analyses of all feeds are shown in Table 1.

Experimental design and statistical analysis

The experiment was designed so that each of the three dietary treatments was replicated by three pens of four (two male and two female) pigs. A two-way analysis of variance to isolate pen and treatment effects was applied to all data. Student's *t*-test for paired samples was used, where appropriate, to assess statistically the differences between treatments B and C.

Animals and procedure

At the start of the trial, a total of 18 male and 18 female cross-bred pigs of between 6 and 10 kg live weight (one to two weeks post-weaning) were allocated randomly to treatment. The exact genetic constitution of the animals was uncertain as they did not result from a carefully controlled breeding programme. They would have contained genes in varying proportions from Large White, Tamworth, Berkshire, and native pigs. A weight-based daily allowance (Table 2) for the concentrate and coconuts was calculated using the asymptotic model of voluntary feed intake (ARC, 1981). Cassava was fed *ad libitum* to the animals on treatment B and to a restricted scale (also calculated using the asymptotic equation) to those on treatment C. All feed intakes were recorded daily throughout the experimental period. Animals were weighed weekly and, on reaching a live weight in excess of 55 kg, were fasted for 24 hours before slaughter. The final starved live weight and the weight of the eviscerated and trimmed carcass with the head attached were used in the calculation of dressing percentage.

Chemical analyses

Full proximate analyses of the feed samples were undertaken according to the methods of AOAC (1984). Amino acids were estimated using an auto-analyzer method based on that of Spackman *et al.* (1958).

Results and discussion

No effects of pen were evident in any of the parameters measured.

Physical performance

The physical performance data are summarized in Table 3.

Pigs fed treatment A were characterized by their slow growth rates and low voluntary intakes of a feed which was inefficiently converted into live weight. This dietary treatment was designed to simulate, as

Table 2 Amount of concentrate, cassava, and coconut fed to animals

Weight of pig (kg)	Concentrate (g pig^{-1} day^{-1})	Coconut (kg pig^{-1} day	Cassava* (kg pig^{-1} day^{-1})
< 15	160	1.0	1.1
15 - 20	230	1.0	1.6
20 - 25	290	2.0	2.0
25 - 30	350	2.0	2.4
30 - 35	400	3.0	2.8
35 - 40	450	3.0	3.1
40 - 45	490	4.0	3.4
45 - 50	530	4.0	3.6
50 - 55	560	4.0	3.8

*Treatment C only

Table 3 Physical performance of pigs under the three treatments

Treatment	Weight gain (g pig^{-1} day^{-1})	Feed consumed (g DM pig^{-1} day^{-1})	Feed conversion ratio	Dressing percentage
A	26[a]	379[a]	13.85[a]	
B	424[b]	1432[b]	3.38[b]	81.7[a]
C	409[b]	1131[c]	2.76[c]	80.8[a]
d.f.	11	2	2	
SE	9.1	50	0.11	1.5
P	<0.001	<0.001	<0.001	0.590

Means for each parameter associated with the same superscript did not differ significantly

closely as practicable under the conditions of the experiment, the nutritional status of village pigs fed in the traditional manner. In practice, the village diet would probably be slightly more diverse in its composition which would also vary from day to day depending on the availability of particular feeds (de Fredrick, 1971). However, the growth rates observed in animals fed treatment A were of the same order of magnitude as a mean figure of 56 g day^{-1} calculated from survey data for village pigs at three locations in the Solomon Islands (P.J. Thorne, unpublished data), and this treatment was therefore felt to represent an appropriate control for the experiment.

Use of the concentrate with the same low nutrient-dense ingredients resulted in disproportionate improvements in all of the physical parameters measured, clearly illustrating the effects of improving overall dietary nutrient balance on voluntary feed intake and gross efficiency of feed utilization. In treatment B, the provision by the concentrate of the nutrients which were in short supply in treatment A resulted in a twofold (when corrected for unequal live weight) increase in the *ad libitum* consumption of cassava.

The degree of restriction of cassava intake imposed in treatment C reduced its consumption by 33% in comparison with the pigs fed cassava *ad libitum*

Table 4 Dry matter feed intake

Treatment	Concentrate (g pig^{-1} day^{-1})	Coconut (g pig^{-1} day^{-1})	Cassava (g pig^{-1} day^{-1})
		161[a]	218[a]
B	265[a]	300[b]	867[b]
	262[a]	288[b]	581[c]
d.f.	2	2	2
SE		25	36
P		0.027	<0.001

Means for each parameter associated with the same superscript did not differ significantly

on treatment B (Table 4). However, the feed conversion ratio of the animals fed treatment C was improved (P = 0.05) such that there was little difference (P = 0.38) between the two treatments in growth rates observed. These results suggest that, up to the observed 20% restriction on total DM intake, the effects of restrictions on cassava intake which might occur, in practice, could be beneficial rather than detrimental to overall productive efficiency.

The poor growth rates of the pigs on treatment A prevented them reaching slaughter weight during the experiment. Dressing percentages observed with the other two treatments were similar (P = 0.59).

Financial appraisal

The two principal variables affecting the appraisal of the data from this experiment were identified as:

1 Price of pigs, affected chiefly by location. At the time of the experiment, the normal range in pig price was between \$2.50 kg^{-1} live weight [Solomon Island dollars; £1.00 = \$3.74 (March, 1990)] where pigs are sold intermittently to neighbouring villagers and a maximum of \$6.50 kg^{-1} live weight in areas of concentrated demand [towns, industrial sites (in these situations there is a waged population with no land rights in the vicinty to allow them to pursue their own agricultural activities)].

2. Opportunity cost of cassava, affected by similar factors to pig price. Cost ranges effectively from zero to around \$2.30 kg^{-1} DM where formal markets are established (Anon., 1989).

The price of copra (\$0.40) is controlled country-wide by the Commodities Export and Marketing Authority and may vary in either direction with time depending on world market prices. The price of concentrate could be expected to rise over time with increases in raw material prices. At the time of the experiment these had been stable for more than 12 months. Effects of exchange rate fluctuations

would be minimal as imported ingredients formed only a small part of the concentrate's formulation. Returns from the semi-intensive feeding system will also vary with yields of cassava and coconut. For the purposes of this appraisal yields were fixed at levels (cassava, 6.11 t DM ha^{-1} yr^{-1}; coconut, 0.9 t DM ha^{-1} yr^{-1}) reasonable for smallholders in the Solomon Islands (Patten and Fleming, 1988).

In Figure 1, margins over feed costs are compared for the extensive and semi-intensive systems. In both cases, margins were responsive to changes in pig price and, particularly, in cassava price. The effects of varying opportunity cost of cassava were less pronounced in the pigs fed treatment C suggesting that, in practical terms, the inherent stability of returns under the semi-intensive system would be improved considerably in comparison with the traditional system. This must, however, be assessed in relation to the fact that with treatment A, operating with negative margins represents lost opportunity whereas with treatment C, it is more likely to represent an actual loss of money. Risk, therefore, is greater when the semi-intensive system is employed. The two factors most important in avoiding this risk are likely to be adequate management skills to maintain pig performance and the reliability of the market for pigs.

Figure 2 illustrates that with the semi-intensive system, high pig prices are necessary to sustain positive returns $man\text{-}day^{-1}$ when the opportunity cost of cassava is high. In areas where pig prices are lower, the possibility of negative returns arises. However, as both pig meat and cassava are food staples, market demand and consequently prices for each are unlikely to be entirely independent. Where there is little demand for pig meat and therefore a low market price, there is also likely to be a relatively small market and low price offered for cassava. In practice, this situation would operate to reduce the risk in pig production below the levels suggested by casual perusal of Figure 2 and assist in sustaining positive returns from the enterprise.

In Table 5, the returns from both pig feeding systems are compared with those for other smallholder activities commonly undertaken in the Solomon Islands. This table also serves to illustrate the importance of considering the appropriate socioeconomic parameters when evaluating production systems. On the basis of gross margin ha^{-1}, extensive pig keeping appears to represent a drain on the farmer's resources whereas a positive, though, small return to labour is observed. In most rural areas of the Solomon Islands, pressure on land is not great and it is not generally possible to assign costs to labour, since it is family or co-operative labour. In this situation, returns to labour are generally more reliable in the financial appraisal of a system than returns $unit\text{-}area^{-1}$.

Pig raising using the semi-intensive system described has potential as an effective land use system for the smallholder which is capable of adding significantly to cash income. In comparison with other enterprises, the relative benefits of engaging in it would appear sufficient to stimulate widespread involvement. Widespread adoption of semi-intensive feeding practices might also stimulate an increased

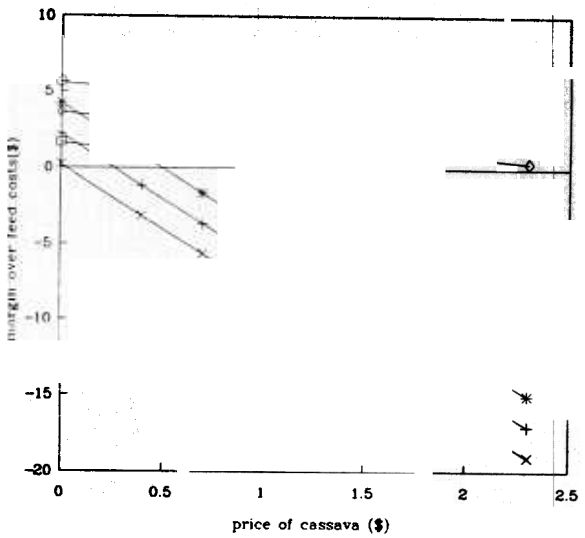

Figure 1 Effect of price of pigs and cassava on margins over feed costs for extensive and semi-intensive pig feeding. Selling price of pigs (live weight) and dietary treatment are (✳) \$2.50 kg^{-1} (A); (⊟) \$2.50 kg^{-1} (C); (+) \$4.50 kg^{-1} (A); (◇) \$4.50 kg^{-1} (C); (✱) \$6.50 kg^{-1} (A); (⊖) \$6.50 kg^{-1} (C)

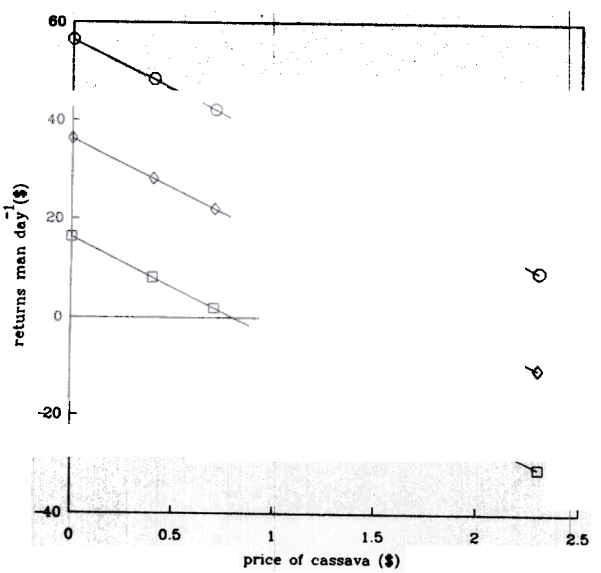

Figure 2 Effect of price of pigs and cassava on returns $man\text{-}day^{-1}$ from semi-intensive pig feeding. Selling price of pigs live weight are (⊟) \$2.50 kg^{-1}; (◇) \$4.50 kg^{-1}; (⊖) \$6.50 kg^{-1}

influx into the capital of pigs from the provinces although these would have to compete with increasing numbers of animals which are being reared by larger producers using cheap compound feeds based on locally available feeds. However, the concept of growing a crop, not for direct consumption or sale but as a raw material in another agricultural undertaking, is probably alien to many Solomon Islanders who are perhaps more concerned with short-term returns and risk minimization. Adoption of semi-intensive feeding systems for pigs will also depend on a reliable distribution network for concentrate

Table 5 Comparison of gross margins and returns man-day^{-1} from cash-generating smallholder enterprises

	*Gross margin ha^{-1} ($)	Return man-day^{-1} ha^{-1} ($)
Extensive pigs	-235.42	2.58
Semi-intensive pigs	4175.80	58.54
Copra	235.00	5.00
Cocoa	527.60	5.11
Sweet potato	800.00	8.88
Chillies	2132.70	3.47
Peanuts	990.00	13.07
String bean	670.00	3.57

Based on information from DBSI (1983); Patten and Fleming (1988); P.S. Mullard, (personal communication)

* It was calculated that 1 ha of land planted to cassava and coconuts in the appropriate proportions could be used to support 13 pigs under the extensive system or 6 pigs under the semi-intensive

feeds. This might be accomplished using the existing network of copra-buying points operated by the Solomon Islands Commodities Export and Marketing Authority.

Semi-intensive feeding systems for pigs are perhaps best seen as part of an overall strategy for improving the productivity of smallholder pig production enterprises, reducing reliance on expensive imported compound feeds for pig feeding, and ultimately generating a supply of locally produced meat that is cheap and sufficiently reliable to substitute for imported meat and meat products.

Acknowledgements

The author thanks Mrs P.M. Carlaw of the Natural Resources Institute for chemical analyses of the experimental diets. The financial support of the Technical Co-operation Programme of the British Government's Overseas Development Administration is gratefully acknowledged as is the co-operation of staff of the Solomon Islands Government, Ministry of Agriculture and Lands.

References

Agricultural Research Council (1981) *The Nutrient Requirements of Pigs*, London, Commonwealth Agricultural Bureau

Anon. (1989) *Socio-economic Survey of Small-holder Farming Systems in Solomon Islands*, Honiara, Solomon Islands, Ministry of Agriculture and Lands

Association of Official Analytical Chemists (1984) *Official Methods of Analysis of the Association of Official Analytical Chemists*, Washington, AOAC

Calder, A. (1960) Sweet potatoes for pigs, *Rhodesian Agric. J.* **57** 293–298

de Fredrick, D.F. (1971) *Pig Raising in the British Solomon Islands Protectorate*, Hong Kong, Cathay Press

Development Bank of the Solomon Islands (1983) *Field Base Manual (2nd edition)*, Honiara, Solomon Islands, DBSI, Agricultural Promotions Division

Gomez, G. (1977) Life cycle swine feeding systems with cassava, in: *Cassava as Animal Feed*, Proceedings of a Workshop held at the University of Guelph, Canada, 19–20 April 1977, Ottawa, Canada, IDRC-095e, pp. 65–71

Patten, L.H. and Fleming, E.M. (1988) *Farm Management Handbook for Solomon Islands*, South Pacific Smallholder Project, University of New England

Spackman, G.W., Stein, W.H. and Moore, S. (1958) Automatic recording apparatus for use in the chromatography of amino acids, *Analy. Chem.* **30** 1190–1206

Thorne, P.J. (1992) Alternatives to imported compound feeds for growing pigs in Solomon Islands, *Trop. Agric. (Trinidad)*, **69** 141–144

Watt, I.R. (1973) Feeding sweet potatoes to pigs, *Harvest* **2** 138–141