Use of local carbohydrate sources and a protein supplement by pig farmers in a Colombian village in the Andean Hills

Antonio Solarte, Frands Dolberg* and Elcy Corrales**

Abstract

On-farm trials were carried out in two data collection periods to evaluate the performance of growing-fattening pigs fed on local sources of carbohydrates supplemented with 200 g/day of protein from soya bean grain or meal, in both cases enriched with vitamins and minerals.

In the first period, four farmers with a total of 33 pigs using the traditional system based on concentrates provided base line data. In addition, the use of sugar cane juice (SCJ) and soya bean cooked grains on a single farm including 29 animals was evaluated. The growth rate was calculated by linear regression from data of the live weight of the animals, which was recorded every 14 days, and used
as a response variable in a model that included the effect of the farm as a variation factor. This effect was found to be significant (P<0.05). The means for daily gain (g/day) on the farms using the traditional system based on commercial concentrates ranged from 527 up to 623 g/day, while on the farm with SCJ daily gain was 427 g/day.

In the second period a revolving research fund was established and the experimental diets evaluated were based on sources of carbohydrates available on each farm and the use of 500 g of a protein supplement (40% protein) from soya bean meal. In this period, growth rate of the animals was calculated as described above and the effect of farm and diet were included as variation factors in the variance analysis. Both factors were found to be significant (P<0.05) for daily gain. The adjusted means for daily gain on the different diets were: commercial concentrate (baseline data, 20 animals in 4 farms) 567 g/day; SCJ (24 animals in 2 farms) 518 g/day; plantain and bananas (8 animals in a single farm) 367 g/day, and for farm and kitchen wastes and residues (24 animals in 4 farms) 512 g/day.

It was concluded that protein is the main limiting factor and it was recommended that work in this area be given the highest priority. The fact that the farmers were willing to repay 8.5 % above the value of the inputs borrowed indicates their willingness to participate in further research, and the constructive role that a revolving research fund can play to facilitate on-farm livestock research.

*Keywords: On-farm, pigs, revolving research fund, feeds, protein, fodder trees and shrubs.*

*Introduction*
The lack of progress in the animal production systems promoted by national and international organizations in the developing countries is due, at least in part, to the considerable emphasis given to the transfer of technologies developed in industrialized countries without first assessing the local constraints and the value of the available local feed resources (Preston and Murgueitio 1992). In this respect Dolberg (1995) pointed out the need to scientifically describe and understand the current farmer practices as a strategy to identify problems and weak points that require research, instead of promoting technologies.

In Colombia, the pig industry is characterized by a high dependence on the use of commercial concentrates. In the case of the small units run by small scale farmers the use of both concentrates and local sources of carbohydrates is a normal practice (CEGA 1988). The most promising alternatives to cereal grains for intensive feeding of pigs in the tropics (Perez 1997) are: sugar cane juice, enriched sugar cane molasses, crude palm oil, oil-rich fibre by-products, whole palm fruits and cassava root. By-products from tree, root and tuber crops, are included in tropical pig diets but mostly on an ad hoc basis, and not as the feeding system. All these feed resources are characterized by very low protein content in the dry matter, and as a consequence of this all the requirements for amino acids in the diet have to be supplied in a supplement (Preston 1995).

The use of restricted amounts of protein to supplement local sources of carbohydrates in growing - fattening pigs has been studied in Colombia with the following feeds: sugar cane juice (Sarria et al 1990), kitchen wastes from restaurants (Cuellar et al 1991), African palm oil-rich residues (Ocampo et al 1990), and plantains (Espinel and Ramos 1993). This technology is being
already applied in different parts of Colombia (Preston and Murgueitio 1992), Philippines (Valenzuela et al 1993), Cuba (Perez 1993) and Vietnam (Dolberg 1993). However the available information at small-holder level is still scarce and there are many interactions between the farm and the farm household which influence the performance of a given technology (Ostergaard 1994). A relevant aspect in the technology research and development process is the importance of early on-farm tests, as an iterative learning process, for scientists and planners to establish the strong and weak points of the technology, before promoting a wider application (Dolberg 1995). In this context the aims of the present study were:

- To understand the farmers' traditional pig production systems in "La Virgen" village.
- To evaluate the level of pig productivity obtained with local feed resources.

Materials and methods

The research site

The research was carried out in "La Virgen" village, Dagua Municipality, Department of Cauca Valley, Colombia. This village is located 1,450 m above sea level, in the foothills of the western chain of the Andean Hills 35 km from Cali city. The average rainfall in the area is 1,550 mm/year, the average temperature is 18 C, and the relative humidity is 86 % (CVC 1987).

The local participants

The village is inhabited by 120 families, second, third and fourth generation descendants of the peasant colonizers of the area, who came a hundred years ago from the south of Colombia. The main
agricultural activities include coffee, plantain and livestock production. The criteria taken into consideration for selecting the eight farmers in the on-farm trials, apart from willingness to participate, included:

- Importance of pig production as a source of income in the household.
- Previous experience in pig rearing.
- Availability of piglets and pig housing on the farm.
- Availability of farm grown carbohydrates or ability to obtain them in some other way.

One farmer had recently settled in the area, two were second generation and five were third generation colonizers.

**Data collection**

The data collection was undertaken in two periods. The aim of the first period, from February to July 1993 was to obtain information on the traditional pig rearing systems including baseline data on pig growth rates under traditional management. The local resources utilized as pig feeds were recorded on three farms using a 50 kg capacity portable scale. These records were collected every two weeks and the same day the pigs were weighed. Additional random checks were also made. During the first period cooked soya bean grain was evaluated in one farm. The basal diet was sugar cane juice and the system was growing and fattening. The second period was from August to December 1993. During this period a revolving research fund was established and managed by the first author and the farmers in order to develop participatory research projects on the use of local resources for animal production. The text of the research fund agreement is shown in Annex 1. The diets tested in the second period were a combination of the sources of carbohydrates available on each farm and a protein supplement.
(40% protein) based on soya bean meal, enriched with calcium carbonate, dicalcium phosphate, salt and a premix of vitamins and trace minerals. Two groups of pigs fed commercial concentrates acted as the control. A summary of the diets in both periods, including the number of animals per farm, is shown in Table 1.

Table 1: Distribution of the animals within the farms and diets during the two periods

<table>
<thead>
<tr>
<th>Period 1</th>
<th>Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diets</td>
<td>1 2 3 4 5 All</td>
</tr>
<tr>
<td>1</td>
<td>6 4 - 13 10 33</td>
</tr>
<tr>
<td>2</td>
<td>29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period 2</th>
<th>Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 3 - 9 - - 4 - 20</td>
</tr>
<tr>
<td>2</td>
<td>- - - - - - - - 0</td>
</tr>
<tr>
<td>3</td>
<td>- - 12 12 - - - - 24</td>
</tr>
<tr>
<td>4</td>
<td>- - - 8 - - - - 8</td>
</tr>
<tr>
<td>5</td>
<td>6 - - - - 6 6 6 24</td>
</tr>
</tbody>
</table>

Diet 1: Commercial concentrates  
Diet 2: Sugar cane juice + 200 g/day of protein from soya bean cooked grain  
Diet 3: SCJ + 200 g/day of protein from soya bean cake  
Diet 4: Bananas and plantains + 200 g/day of protein from soya bean meal  
Diet 5: Kitchen and farm residues + 200 g/day of protein from soya bean meal

In order to identify the resources used on each farm a participatory rural appraisal exercise of matrix and scoring (Chambers, 1992a,b)
was conducted towards the end of the trials. Chemical analysis (including dry matter, ash, crude protein and neutral detergent fibre) of the local resources used as animal feed in the village were performed according to the standard procedures of AOAC (1985).

Animals and management

The pigs were commercial Landrace - Yorkshire crossbreeds belonging to the farmers. The farmers also provided their normal management, drugs and vaccines. The traditional feeding regime (Period I) included commercial concentrates fed twice a day and variable amounts of plantain and bananas (*Musa* Sp.), squash, kitchen waste and farm residues (including poultry slaughter residues). The growing - fattening pigs on the experimental diet were fed 200 g/day of protein from cooked soya bean grain during the first period and soya bean meal in the second period. The carbohydrates (whatever the type) were offered twice daily. During the first period the soya bean grain was weighed and soaked overnight. The next morning it was boiled for 30 minutes, using fuelwood, in order to remove the anti-nutritional factors, before being offered to the animals.

Measurements and statistical analysis

In both periods the animals were fasted overnight and weighed in the early morning every 14 days using a pig harness and a 100 kg capacity portable scale with an accuracy of 0.5 kg. The daily gain of each pig was calculated by linear regression and used as response parameter. The periods were analysed separately. In period I the farm factor was included in the model and the initial weight of the pigs was used as a covariate. In the case of period II the diet factor was included in addition to the ones included in period I. The
interactions between the factors were not calculated as the model was unbalanced. The statistical analysis required the use of the general Linear Model procedures included in the MINITAB software version 8.2 (1991).

Other activities undertaken during the field period

In addition to the research activities, two workshops on the use of local resources were held including visits, by a small group of the farmers involved in the on-farm trials, to another village in the North of the Cauca Valley and the South of Colombia. The aim was to share experiences with other small scale farmers involved in similar animal production projects. As support to an initiative of the farmer community of the village, one workshop was held with the aim of sharing methodologies of Participatory Rural Appraisal with them as they wanted to do a diagnosis of the watershed area.

Results

In addition to the traditions and experiences of the inhabitants of "La Virgen" village in pig rearing, the following factors were identified as relevant:

Demand for pork in the area

The village is located only 3 km from the main road between the cities of Cali and Buenaventura and there is demand generated from these cities and also from neighbouring villages which contain many holiday homes belonging to people from Cali. There are two market places near the main road in which people from the neighbouring villages meet twice weekly and also several restaurants for travellers between the two main cities.
Access to transport

The farmers in the village have easy access to transportation as there are two small trucks in the area carrying products several times a week between the village and the city. This also gives farmers access to kitchen wastes from restaurants in Cali. Availability of transport in the region also facilitates marketing of animals and purchase of inputs.

Strong links between the families

The villagers maintain strong family relations as all of them are descendants of the same families that have inhabited the area for more than one hundred years. This creates solidarity and trust, which in many ways facilitates access to resources and joint marketing of the animals.

Characteristics of the local pig rearing system

All the farms visited had a pig shed with a capacity of from four up to 80 animals, the average being 15 pigs. The oldest families had bigger farms and better pig sheds built of bricks with cement floors and including feeder and automatic drinkers. The materials used for the roof are tiles, and there were a few pig sheds with iron or cardboard sheets or without any roof.

Gender considerations

There are no special gender considerations in relation to rearing of pigs in this community. Both men and women from the new and older generations were involved. However, in some of the older families it was observed that the men and the women raised their batches of pigs separately and they also had access to different
resources within the same farm. In the case of hired labour the men are in control, which in some cases gives them access to resources that need to be harvested or transported from the fields to the house. Other animal production activity such as cattle production is mainly a male activity which is also undertaken in female-headed households.

**Pig rearing systems**

Three basic pig rearing systems were identified:

- Farmers working with their own pigs. This system is applied by those farmers who have enough economic resources to buy the piglets and the concentrates.
- Farmers working with their own pigs, but with a partner supplying the commercial concentrates. This system is applied by farmers who have access to piglets through their own sows, but have insufficient resources to buy concentrates. In this case a "rich" partner supplies the concentrates and after selling the pigs the cost of the piglets and concentrate is deducted and the profit is split between the partners.
- Farmers that raise pigs for somebody else. In this system the "rich" partner supplies the piglets and the concentrates and the farmer manages the animals. The partners split the profit after deducting the costs.

In all cases the "rich" partners were relatives who were no longer living in the village but had moved to the town or the nearest village across the main road. There is a convention in the area which equates 6 bags of concentrate (a total of 240 kg) for each piglet to be raised, while the farmer (the pig raiser) supplies any balance from his/her own resources.

The fattening of pigs with a partner using commercial concentrate is a very common practice, as both partners are normally of the same family or close relatives. This system has advantages in comparison with the use of protein supplements, because there is no access locally to protein supplements which must be bought in Cali.
addition, the "rich" partner has local access to credit and transport in
the case of commercial concentrates. The only possible way to have
access to the ingredients to prepare protein supplements by the
local people is through credit with organized groups.

Local resources used as animal feed

During period 1 the local resources utilized were identified on three
farms, representative of each of the three different pig raising
arrangements as explained above. The data are included in Figure
1.

Figure 1: Local resources used as supplements
to commercial concentrates (period I). The
fattening period was 788, 95 and 102 days
respectively for farms 1, 2 and 5.

The results of the matrix and scoring exercise undertaken to identify
the feeds used during the second period are shown in Table 2.

Table 2: Matrix and scoring exercise identifying the local resources used during the
second period in the on-farm trials

<table>
<thead>
<tr>
<th>Farm</th>
<th>1</th>
<th>3</th>
<th>4</th>
<th>4</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

**Resource**

- Sugar cane juice: * *** *** *
- Sidra fruits: ** * * * *
- Kitchen wastes: *** ** *** **
- Plantain and bananas: * * * *** *
- Squash: * * *
- Whey: ***
- Poultry slaughter residues: ** ** ***
- Trichanthera leaves: * * **
- Bore leaves and roots: * * *

* Used occasionally.

*** Used as basal diet.

The chemical analysis of some resources used in the area as pig feed are shown in Table 3.

**Table 3:** Chemical analysis of some resources used as animal feed.
<table>
<thead>
<tr>
<th>Protein supplements</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Soya bean meal</td>
<td>88.5</td>
<td>5.7</td>
<td>46.3</td>
</tr>
<tr>
<td>Soya bean meal supplement</td>
<td>88.4</td>
<td>9.0</td>
<td>43.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fruits</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chayota sp.</em></td>
<td>4.5</td>
<td>9.3</td>
<td>49.3</td>
</tr>
<tr>
<td><em>Cucurbita sp.</em></td>
<td>8.5</td>
<td>13.8</td>
<td>34.0</td>
</tr>
<tr>
<td><em>Musa sp. ripe</em></td>
<td>5.5</td>
<td>5.3</td>
<td>10.1*</td>
</tr>
<tr>
<td><em>Musa sp. green</em></td>
<td>5.9</td>
<td>5.4</td>
<td>14.1*</td>
</tr>
<tr>
<td><em>Xanthosoma sp. roots</em></td>
<td>10.8</td>
<td>9.9</td>
<td>20.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Foliages</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Erythrina edulis (L)</em></td>
<td>20.0</td>
<td>12.0</td>
<td>24.3</td>
</tr>
<tr>
<td><em>Erythrina glauca (L)</em></td>
<td>21.6</td>
<td>7.9</td>
<td>24.9</td>
</tr>
<tr>
<td><em>Erythrina glauca (LS)</em></td>
<td>17.8</td>
<td>7.5</td>
<td>20.2</td>
</tr>
<tr>
<td><em>Erythrina poepigiana (L)</em></td>
<td>22.2</td>
<td>9.8</td>
<td>25.7</td>
</tr>
<tr>
<td><em>Erythrina poepigiana (LS)</em></td>
<td>18.8</td>
<td>9.2</td>
<td>22.1</td>
</tr>
<tr>
<td><em>Leucaena leucocephala (L)</em></td>
<td>28.5</td>
<td>5.7</td>
<td>19.2</td>
</tr>
<tr>
<td><em>Tithonia diversifolia (L)</em></td>
<td>13.8</td>
<td>18.9</td>
<td>18.9</td>
</tr>
<tr>
<td><em>Tithonia diversifolia (LS)</em></td>
<td>13.5</td>
<td>12.9</td>
<td>17.4</td>
</tr>
<tr>
<td><em>Trichantera gigantea (L)</em></td>
<td>26.9</td>
<td>17.1</td>
<td>22.5</td>
</tr>
</tbody>
</table>
Trichantera gigantea (L) 19.1 22.0 22.3 44.0
Xanthosoma sp (L) 9.5 10.9 14.5 25.2

* With amylase treatment to remove the starch. DM Dry matter; N*6.25 Crude Protein.; NDF Neutral Detergent Fibre
(L) Leaves only; (LS) Leaves + young stems

Pig growth

According to the analysis of variance the growth of the pigs was influenced significantly (P<0.05) by the farm factors in period 1; and by farm and diet in period 2. The adjusted means for farms and diet are in Table 4. The model used did not permit calculation of farm and diet interaction.

Table 4: Adjusted means for the daily gain of the pigs according to the analysis of variance performed for each period, independently.

<table>
<thead>
<tr>
<th>Period I</th>
<th>Farm *</th>
<th>Diets1</th>
<th>n</th>
<th>Mean (kg/day)±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concentrate + Residues</td>
<td>6</td>
<td>0.527±0.022</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Concentrate + Residues</td>
<td>4</td>
<td>0.588±0.025</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SCJ + SB</td>
<td>29</td>
<td>0.427±0.012</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Concentrate + Residues</td>
<td>13</td>
<td>0.624±0.014</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Concentrate + Residues</td>
<td>10</td>
<td>0.572±0.020</td>
<td></td>
</tr>
</tbody>
</table>

Period II
Comparison among farms

<table>
<thead>
<tr>
<th>Farm</th>
<th>Diet Description</th>
<th>n</th>
<th>Mean (kg/day) ±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concentrate + Residues* + Kitchen waste + SBM</td>
<td>10</td>
<td>0.466±0.027</td>
</tr>
<tr>
<td>2</td>
<td>Concentrate + Residues</td>
<td>3</td>
<td>0.525±0.042</td>
</tr>
<tr>
<td>3</td>
<td>SCJ + SBM</td>
<td>12</td>
<td>0.438±0.030</td>
</tr>
<tr>
<td>4</td>
<td>Concentrate + Residues, SCJ + SBM, Plantains / bananas + SBM</td>
<td>29</td>
<td>0.529±0.016</td>
</tr>
<tr>
<td>5</td>
<td>Kitchen waste + Residues* + SBM</td>
<td>6</td>
<td>0.484±0.038</td>
</tr>
<tr>
<td>6</td>
<td>Concentrate + Residues* + Kitchen waste + SBM</td>
<td>24</td>
<td>0.511±0.031</td>
</tr>
<tr>
<td>7</td>
<td>Kitchen waste + Residues* + SBM</td>
<td>6</td>
<td>0.487±0.038</td>
</tr>
</tbody>
</table>

Period II,
Comparison among diets

<table>
<thead>
<tr>
<th>Diet No</th>
<th>Diet Description</th>
<th>n</th>
<th>Mean (kg/day) ±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concentrate + Residues,</td>
<td>20</td>
<td>0.568±0.021</td>
</tr>
<tr>
<td>3</td>
<td>SCJ + SBM</td>
<td>24</td>
<td>0.518±0.029</td>
</tr>
<tr>
<td>4</td>
<td>Plantains / bananas + SBM</td>
<td>8</td>
<td>0.368±0.033</td>
</tr>
<tr>
<td>5</td>
<td>Kitchen waste + Residues* + SBM</td>
<td>24</td>
<td>0.512±0.022</td>
</tr>
</tbody>
</table>

SCJ Sugar cane juice; SB boiled soya beans; SBM Soya bean meal; *
Discussion

In "La Virgen" village, in the traditional management system, commercial concentrates are the main source of energy and protein. This is therefore a system highly dependent on outside village inputs. However, it is seen as convenient for raising pigs jointly with a "rich" partner in the case of young farmers (of the third generation) who usually have a shortage of labour, cash or local resources, as well as by old female farmers who had limited access to labour to harvest local resources.

According to CEGA (1988) in Colombia the dependence on the use of commercial concentrates on pig raising farms increases with the number of animals and scale of operation. In this same study it was found that in farms with 1 to 25 animals, the prevalent feeding system was the use of different combinations of energy-rich products and by-products, including kitchen wastes, plantains, wheat bran, potatoes, maize, maize bran, vegetables, whey, cassava, sidra fruits (Chayota sp), molasses, sugar cane, and rice bran.

The materials identified as pig feed in "La Virgen" village in periods 1 and 2, are in accordance with those reported by CEGA (1988) and Preston (1995). During period 1, in addition to the commercial concentrates the most common local resources used were squash (Cucurbita sp.), plantain and bananas and kitchen and farm residues. During period 2, however, only small quantities of squash were used by the farmers as prices had increased. This fact clearly indicates how fluctuations in the market price change the availability of marketable products used as animal feed. In period 2, four farmers used a diet based on kitchen waste and farm residues (see...
The adjusted mean for daily gain on this diet was 512 g/day. This result is in accordance with an on-farm trial reported by Cuellar et al (1991), aimed at evaluating commercial concentrate and protein supplements as methods to improve pig performance on basal diets of organic wastes from restaurants. In this trial there were better responses for daily liveweight gain, when 400 g/day of a 40% protein supplement was given to the animals in comparison with 750 g of a commercial concentrate (14 % protein); the means for those treatments were 0.567 kg/day and 0.510 g/day, respectively.

It is important to note (see Table 2) that the main resources included in this category were kitchen wastes from restaurants in Cali city, poultry slaughter residues, and whey. Two of the farmers included in this group had units of 1,000 chickens, and on these farms the poultry slaughter residues were fed fresh without any treatment, the same day that the chickens were slaughtered. Sometimes there was even more residue than the pigs could eat. An answer to this surplus could be to make silage with these residues, as has been described for fish-residues by Dominguez (1988) and Gohl (1992).

The pigs in farm 4 had the highest average growth rates in period 2. However, it is of interest to note that on this farm, three batches of pigs were raised in this particular period: one on sugar cane juice, one on commercial concentrates and one on plantain and bananas. The diet which resulted in the lowest daily gain (table 3) was based on plantain and bananas which implies some nutritional limitations in these feed resources other than protein as the pigs also received soya bean meal.

In an on-farm trial conducted by Espinel and Ramos (1993), on the feeding of pigs on a basal diet of plantain (Musa sp.) supplemented
with protein from soya bean meal, the growth rate was 434 g/day with 180 g of protein from soyabean meal versus 362 g/day with 140 g/day of the same protein source (on this latter treatment the pigs also received 16 g/day of protein from leaves of *Trichanthera gigantea* in the growing period and 42 g/day in the fattening period). The control pigs fed commercial concentrates were consuming an average of 290 g/day of protein and had a mean daily gain of 741 g/day.

Dominguez (1988) reported that plantain and bananas (*Musa sp.*) have very low protein contents, and therefore require an adequate protein supplementation. The pigs tend to decrease their feed intake when the plantain or bananas are offered green, due possibly to a high tannin content. This fact could explain the low daily gains obtained in the farm where these feeds were used (Farm 4). However, it is important to consider that only one farm used this particular diet. In period 2 the growth rates of pigs fed diets based on sugar cane juice, kitchen waste and farm residues, supplemented with 200 g of protein from soyabean meal, were only 50 g/day lower in comparison with the commercial concentrates, indicating that it is possible to establish feeding systems for pigs based on locally available energy sources in "La Virgen" village provided they are appropriately supplemented.

All the locally available feed resources used in the trials, such as sugar cane juice, plantains and bananas, fruits of *Cucurbita sp.* (Squash) and *Chayota sp.* and roots of *Xanthosoma sp.*, have low contents of protein in the dry matter basi. In contrast, all the leaves of the tree and shrub species growing in the region had levels of crude protein ranging from 14 to 25 % of DM (Table 3). The feeding of leaves of *Trichanthera gigantea* and *Xanthosoma sp.* (see Figure 1 and Table 2) was observed on three farms and on one farm
small amounts of *Tithonia diversifilia* were given as pig feed. Although the level of crude protein in the dry matter of most of the fodder tree species is relatively high, D'Mello (1992) suggested that their potential as protein sources is limited primarily by the: low digestibility of the protein; the low proportion of the sulphur amino acids; and by the bulkiness of these products. Thus the value of leaf meals as replacement for soya bean meal and fish meal is relatively low. The experience of Sarria et al (1991) on the use of *Trichanthera gigantea* as a partial replacement of the soya bean protein in pig fed on a sugar cane juice diet are in accordance with this statement, indicating that more work must be undertaken to identify alternative sources of protein as a supplement in pig diets based on unconventional sources of energy such as those available in the present study.

The use of a research fund as a mechanism to carry out on-farm research has been demonstrated to be an efficient way to develop alternative feeding systems under the farmer conditions. A similar experience in the use of a revolving experimental fund to develope on-farm livestock trials has been reported in Vietnam by Dolberg (1993). In this case the fund was managed by the Women's Union, who selected the participant women farmers and supervised the trials. The fact that the farmers were willing to repay 8.5 % more over the value of the inputs borrowed in order to do further research indicates that the experience undertaken was positive according to their criteria.

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References


Chambers R 1992a Participatory Rural Appraisals; Past, Present and Future. Forest, Trees and People. Newsletter No. 15/16:4-9


CVC 1987 Histogramas de distribución mensual y multianual de la precipitación según estaciones meteorológicas en cuencas hidrográficas del alto Cauca, Anchicaya, Dagua y Calima. Anexo Informe CVC No.66-6 Buga - Colombia


Valenzuela F, Moog F, Samiano A, Raymundo R, Fementira E and Galaraga A
1993 Use of the sugarcane juice as feed for pigs in the Philippines. In: FAO
International Workshop "Increasing Livestock Production through Utilization of
15-23.

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