Digestion and N metabolism in Mong Cai and Large White pigs having free access to sugar cane juice or ensiled cassava root supplemented with duckweed or ensiled cassava leaves

Nguyen Van Lai and Lylian Rodriguez

Abstract

It is envisaged that traits which facilitate more efficient use of by-product and vegetative feeds will become increasingly important as the role of livestock in farming system changes from that of a specialized producer of animal protein to a more synergistic one of optimizing total resource utilization. The following experiment, which measured digestibility and N retention parameters in Mong Cai and Large White pigs given diets based on local feed resources, is part of a long term study to define more precisely the role of livestock as components of the overall farming system.

Four male piglets of Mong Cai breed (mean weight±SD = 8.65±2.3 kg) and four Large White piglets (8.03±1.49 kg) were housed in metabolism cages made of bamboo for four consecutive periods of
10 days during which they received, according to a Latin Square arrangement, dietary combinations of: sugar cane juice or ensiled cassava root in each case with either fresh duckweed or ensiled cassava leaves as the protein supplement. In each 10 day period the first five days were for adaptation to the diet and the last five for determination of digestibility and nitrogen retention. There were no significant interactions among dietary treatments. Apparent digestibility of the nitrogenous fraction was higher (67%) when duckweed, rather than ensiled cassava leaves (59%), was the protein source (P=0.001). Nitrogen retention as a percent of nitrogen intake was high for both protein sources with higher values (P = 0.004) for the duckweed diets (52%) than for diets with ensiled cassava leaves (44%). The efficient use of the dietary nitrogen on all diets implies that both duckweed and ensiled cassava leaves have a good array of the essential amino acids needed for growth, with the advantage slightly in favour of the duckweed because of its superior digestibility.

*Key words: Pigs, digestibility, N retention, sugar cane juice, ensiled cassava roots, duckweed, ensiled cassava leaves.*

**Introduction**

In the search for high yielding feed resources which are suitable for monogastric animals, and which are not in direct competition with human needs, two promising alternatives as sources of energy are sugar cane juice (Sarria et al 1990) and cassava roots (Gomez 1979). In Latin America, sugar cane has been called "ensilaje vivo" (living silage) because, provided it is left in the ground and is not harvested, it maintains its nutritive value for as long as 12 months after reaching maturity. It can then be harvested as needed and the
juice extracted from the stalk on a daily basis. In the case of
cassava, ensiling of the roots is an appropriate way of storing this
plant product which in the fresh state has a high moisture content
(60%).
Soya beans are the main source of protein for monogastric animal
diets in temperate latitudes but in the tropics there are other protein-
rich plant products which are both high yielding and perennial. In the
case of pigs, the ensiled leaves of cassava and fresh duckweed
(*Lemna spp.*) are two of the most promising alternatives in terms of
acceptability and nutritive value (Rodriguez and Preston 1996; Du
Thanh Hang et al 1997). Ensiling is an appropriate method for
storing cassava roots and cassava leaves; this process also
reduces the level of cyanogenic glycosides to a concentration not
harmful to monogastric animals such as pigs (Nguyen Thi Loc et al
1997). Duckweed is characterized by a very high moisture content
(94-95%) which precludes both drying and ensiling as methods of
conservation. Experience also indicates that pigs prefer the freshly
harvested product (Rodriguez Lylian, unpublished observations).
Traditionally in the rural areas of Vietnam, the farmers use Mong Cai
females for reproduction, crossing them with exotic breeds such as
the Large White and Landrace to produce progeny for fattening. The
reasons for keeping the local breed are that they are "easy to
manage" and are accustomed to eat low-cost, voluminous, natural
feed resources such as vegetable wastes, grasses, weeds and
water plants. In contrast, it has been observed that the exotic breeds
only perform adequately when they are given feeds of high
nutritional density such as those derived from cereal grains and
oilseeds and edible animal offal such as fish meal.
It is envisaged that traits which facilitate more efficient use of by-
product and vegetative feeds will become increasingly important as
the role of livestock in farming systems changes from that of a specialized producer of animal protein to a more synergistic one of optimizing total resource utilization (Preston 1998). In this context it is relevant to document the responses of local and exotic pigs in a nutritional environment that emphasizes the utilization of resources matched with the environment rather than feeds that satisfy the theoretical needs of the animals. The following experiment, which measured digestibility and N retention parameters in Mong Cai and Large White pigs given diets based on local feed resources, is part of a long term study to define more precisely the role of livestock as components of the overall farming system.

Materials and Methods

Location

The experiment was carried out at the Finca Ecologica situated on the campus of the College of Agriculture and Forestry in Thu Duc District, some 15 km from Ho Chi Minh City. The site is close to sea level with a range of temperature from 22 to 39 °C, and relative humidity in the range of 60 to 100%.

Animals

These were four Mong Cai male piglets (mean weight±SD = 8.65±2.3 kg), born and raised in the Finca Ecologica, and four Large White piglets (8.03±1.49 kg), from the pig farm of the College of Agriculture and Forestry.

Experimental design and treatments
The treatments were:

*Energy source*: Sugar cane juice or ensiled cassava root

*Protein source*: Duckweed or ensiled cassava leaves

The treatments were arranged in a double 4*4 Latin Square. Breeds occupied adjacent squares and the dietary combinations were arranged within the squares according to the following order:

<table>
<thead>
<tr>
<th>Period\Animal</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ECR-DW</td>
<td>ECR-ECL</td>
<td>SCJ-DW</td>
<td>SCJ-ECL</td>
<td>ECR-DW</td>
<td>ECR-ECL</td>
<td>SCJ-DW</td>
<td>SCJ-ECL</td>
</tr>
<tr>
<td>2</td>
<td>ECR-ECL</td>
<td>SCJ-DW</td>
<td>SCJ-ECL</td>
<td>ECR-DW</td>
<td>ECR-ECL</td>
<td>SCJ-DW</td>
<td>SCJ-ECL</td>
<td>ECR-DW</td>
</tr>
<tr>
<td>3</td>
<td>SCJ-DW</td>
<td>SCJ-ECL</td>
<td>ECR-DW</td>
<td>ECR-ECL</td>
<td>SCJ-DW</td>
<td>SCJ-ECL</td>
<td>ECR-DW</td>
<td>ECR-ECL</td>
</tr>
<tr>
<td>4</td>
<td>SCJ-ECL</td>
<td>ECR-DW</td>
<td>ECR-ECL</td>
<td>SCJ-DW</td>
<td>SCJ-ECL</td>
<td>ECR-DW</td>
<td>ECR-ECL</td>
<td>SCJ-DW</td>
</tr>
</tbody>
</table>

where:

ECR-DW = Ensiled cassava root and duckweed; ECR-ECL = Ensiled cassava root and ensiled cassava leaves

SCJ-DW = Sugar cane juice and duckweed; SCJ-ECL = Sugar cane juice and ensiled cassava leaves

Each experimental period lasted 10 days: the first 5 days were for adaptation to the change of diet and the last 5 for collection of faeces and urine.

**Metabolism cages**

These were made from split bamboo poles fixed to a wooden frame in a composite unit (2.8 m length and 0.9 m wide) holding 4 animals in separate compartments (Rodriguez and Preston 1996). The floors were composed of lengths of bamboo round poles of 1-2 cm.
diameter with 1 cm spacing to facilitate passing of the faeces. The area per pig was (70*70cm) and the divisions of half bamboo sections were 50cm high. The faeces collector, suspended 5cm below the floor, was a rigid sheet of plastic net used traditionally for sealing windows against entrance of insects. Urine fell through the net and was collected over a sheet of polyethylene suspended in the form of a shallow "V" with the lowest point emptying into a filter placed in a funnel suspended over a plastic bucket. The cages were fitted with automatic water drinkers and the feeds were offered in ceramic dishes. Two cage units were used: one for the Mong Cai and the other for the Large White piglets.

**Diets and feeding system**

Sugar cane stalks, cassava roots and cassava leaves (leaf lamina plus petiole) were purchased from local farmers. The sugar cane stalks were crushed each morning using a 3-roll mill and a local Vietnamese (Chinese yellow breed) lactating cow to provide traction. The cassava roots were chopped into small pieces (approximately 1*1cm in section), mixed with salt (0.5% by weight) and ensiled in sealed plastic bags (1,000 litre capacity) for 8 weeks before being fed. The cassava leaves were mixed with molasses (5 parts by weight of molasses: 100 parts by weight cassava leaves), packed tightly in plastic bags (1,000 litre capacity) and ensiled for 8 weeks before being fed. The duckweed was harvested each morning from ponds in Finca Ecologica which were fertilized with biodigester effluent at the rate of 10 litres/day per 10 m² of pond area, which it was estimated would maintain nitrogen levels at about 20-30 mg/litre. The daily quantities of sugar cane juice, ensiled cassava root, ensiled cassava leaves and duckweed were weighed each morning.
and fed in small amounts in separate dishes 6-8 times per day in order to avoid wastage. The pigs had free access to water from automatic drinkers strategically located outside the cages to avoid leaks into the faeces and urine containers.

**Measurements**

During the experimental period intakes of individual feed ingredients were determined daily (by weighing amounts offered and refused). Samples of sugar cane juice offered and residues were collected daily and the Brix measured (% total soluble solids) with a hand refractometer. The juice residues were what remained in the bucket used to dispense this feed. In contrast, the residues of ensiled cassava root were mainly what was recovered from the ceramic dish in which the supplement was offered. Samples of ensiled cassava leaves, duckweed and ensiled cassava root were analysed for dry matter and nitrogen. Dry matter was determined by microwave radiation until constant weight as recommended by Undersander et al (1993). Nitrogen was determined by the standard Kjeldahl method.

Urine was collected and weighed daily. 4N H₂SO₄ was used to keep the pH below 4 in order to preserve the N. An aliquot of 10% of the total daily quantities per piglet were stored in one plastic container per animal until the end of the period when a representative sample was taken to analyze for N. Faeces were collected and weighed daily. The total daily amounts of faeces/piglet was stored in a freezer (-18°C) and at the end of the period were mixed carefully by hand and representative samples taken for analysis of N (on the fresh faeces) and for dry matter. Cassava leaves and cassava roots were stored anaerobically in 1 litre capacity polyethylene bags and samples removed at weekly intervals for measurement of pH (glass
electrode with digital readout) and hydrocyanic acid (by titration with silver nitrate following boiling in chloroform and reaction with potassium hydroxide).

**Statistical analysis**

The data set comprising results for the two Latin squares was analysed using the General Linear Model of the Minitab statistical package (version 10.2). Sources of variation included in ANOVA were treatment (diet), period, animal and error.

**Results and Discussion**

**Composition of the dietary ingredients**

<table>
<thead>
<tr>
<th></th>
<th>Dry matter, %</th>
<th>N in dry matter, %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ensiled cassava leaves</strong></td>
<td>46</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>Duckweed</strong></td>
<td>4.8</td>
<td>5.4</td>
</tr>
<tr>
<td><strong>Ensiled cassava root</strong></td>
<td>40</td>
<td>0.35</td>
</tr>
<tr>
<td><strong>Sugar cane juice</strong></td>
<td>14</td>
<td>0.072</td>
</tr>
</tbody>
</table>

The mean values for the composition of the dietary ingredients (Table 1) highlight the low N content of both energy sources, the low dry matter content of the duckweed and the slightly higher N content
of the duckweed compared with the ensiled cassava leaves. The rather low value for dry matter (dissolved solids) in the sugar cane juice can be explained by the fact that the trial was done in the rainy season which is when sugar cane is in an active growth stage rather than in the process of accumulating sucrose which takes place in the dry season. The trends with time of ensiling for pH and HCN content of the ensiled cassava roots and ensiled cassava leaves (Figures 1 and 2) indicate that at least 8 weeks should elapse before the ensiled products are fed to pigs.

**Figure 1:** Decrease in pH of cassava leaves and roots with time of ensiling  
**Figure 2:** Decrease in concentration of HCN in cassava leaves and roots with time of ensiling

**Feed intake, digestibility and N retention**

Mean values for individual treatments are shown in Table 2. In the study of Rodriguez and Preston (1996) with sugar cane juice and duckweed, fed to Mong Cai and Large White*Mong Cai crosses of a similar live weight, apparent digestibilities of dry matter and nitrogen were similar (90 and 67%, respectively) to those in the present experiment (87.6 and 67.3); their values for nitrogen retention were 3.5 g/day, 33% and 46% for daily retention and retention as percentage of intake and of nitrogen digested, compared with 2.44,
51.2 and 74.4, respectively were lower. An unexplainable result was the significantly higher proportion of the diet dry matter represented by ensiled cassava leaves when the energy source was ensiled cassava root. Apart from this, the main source of difference was in the comparison between protein sources; duckweed versus ensiled cassava leaves.

*Effect of the protein source*

The main effects (duckweed versus ensiled cassava leaf; and sugar cane juice versus ensiled cassava root) are compared in Table 3. There were no significant interactions among dietary treatments therefore the discussion is centered on the main effects. The most important finding was the significantly higher apparent digestibility of the nitrogenous fraction of the diet when duckweed was the protein source (67.3%) as compared with ensiled cassava leaves (58.9%). The choice of energy sources with negligible nitrogen content (0.072% and 0.35% in dry matter of sugar cane juice and ensiled cassava roots, respectively; Table 1) meant that the values for digestibility of the nitrogenous fraction of the diet were essentially those for the protein sources. The higher digestibility of duckweed compared with ensiled cassava leaves almost certainly reflects differences in the concentration of cell wall material as the small floating water plant has much less need of built-in structural support. This difference was shown clearly by Du Thanh Hang (1998) who reported that the crude fibre concentration in the dry matter of ensiled cassava leaves was twice as high as in duckweed (15.3 versus 8.3%).

The higher digestibility when duckweed was the supplement resulted in a significantly higher retention of nitrogen (52.4 versus
43.7%) when this was expressed as a percentage of nitrogen intake. There was no significant difference in the nitrogen retained when this was expressed as a percentage of the nitrogen digested. The fact that nitrogen retention as a percentage of nitrogen digested did not differ between protein sources implies that the profile of essential amino acids was similar. This is in accordance with the literature which indicates that both protein sources are well balanced in essential amino acids with the sulphur amino acids being the first limiting in both cases (Rusoff et al 1980; Ravindran 1992). The relatively high values for nitrogen retention, expressed as percentage of intake (42-54%) or percentage of nitrogen digested (72-84%), merit comment. Du Thanh Hang (1998) reported similar high values (54-60% and 72-84%, respectively) in diets of ensiled cassava root supplemented with different proportions of fish meal and ensiled cassava leaves. The salient feature of diets based on sugar cane juice and ensiled cassava roots is the negligible content of protein in the energy source. Thus the entire supply of amino acids has to be provided from the protein supplement. Fish meal, ensiled cassava leaves and duckweed have a balance of amino acids close to that of the "ideal protein" for pig growth (Cole 1978; Fuller and Chamberlain 1983; Wang and Fuller 1989). It is therefore to be expected that in these diets the wastage of nitrogen in the urine will be minimized and as a result the efficiency of utilization of dietary nitrogen will be high, which in turn permits a substantial reduction (at least 30-40%) of dietary protein levels (Sarria et al 1990), as compared with diets traditionally fed to pigs based on cereals with high content of "unwanted" amino acids derived from "imbalanced" proteins (Speer 1990).

Effect of the energy source
Despite the contrasting sources of energy -- soluble sugars (mainly sucrose with smaller amounts of glucose and fructose) in sugar cane juice and starch in the ensiled cassava root -- there were no apparent differences in any of the measured criteria. Sugar cane juice contains no fibre and there is less than 1% in the dry matter of ensiled cassava root. Therefore high apparent digestibility of the dry matter was to be expected on both diets.

**Table 2:** Mean values for intake of DM and N, apparent digestibility of DM and N, N retained per day and as percent of intake and of digested N, for piglets fed duckweed or ensiled cassava leaves as protein sources and sugar cane juice or ensiled cassava root as sources of energy

<table>
<thead>
<tr>
<th></th>
<th>ECL-SCJ</th>
<th>DW-SCJ</th>
<th>ECL-ECR</th>
<th>DW-ECR</th>
<th>SEmean</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Apparent digestibility, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>57.3</td>
<td>68.3</td>
<td>60.6</td>
<td>66.2</td>
<td>2.0</td>
<td>0.004</td>
</tr>
<tr>
<td>Dry matter</td>
<td>84.2</td>
<td>87.6</td>
<td>89.8</td>
<td>84.4</td>
<td>1.6</td>
<td>0.066</td>
</tr>
<tr>
<td><strong>N retention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g/day</td>
<td>2.08</td>
<td>2.44</td>
<td>2.18</td>
<td>2.30</td>
<td>0.22</td>
<td>0.661</td>
</tr>
<tr>
<td>% of N intake</td>
<td>42.1</td>
<td>51.2</td>
<td>45.4</td>
<td>53.6</td>
<td>2.6</td>
<td>0.02</td>
</tr>
<tr>
<td>% of N digested</td>
<td>72.4</td>
<td>74.4</td>
<td>74.6</td>
<td>80.3</td>
<td>2.4</td>
<td>0.15</td>
</tr>
<tr>
<td>N*6.25, % in DM</td>
<td>12.2</td>
<td>11.2</td>
<td>9.2</td>
<td>13.2</td>
<td>1.0</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Intake, g/day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter</td>
<td>248</td>
<td>262</td>
<td>321</td>
<td>232</td>
<td>23</td>
<td>0.068</td>
</tr>
</tbody>
</table>
### Table 3: Mean values for main effects (duckweed vs ensiled cassava leaf; sugar cane juice vs ensiled cassava root) on intake of DM and N, apparent digestibility of DM and N, N retained per day and as percent of intake and of digested N, for piglets fed duckweed or ensiled cassava leaves as protein sources and sugar cane juice or ensiled cassava root as sources of energy

<table>
<thead>
<tr>
<th>Protein source</th>
<th>Energy source</th>
<th>ECL</th>
<th>DW</th>
<th>ECR</th>
<th>SCJ</th>
<th>SEmean</th>
<th>Prob. (DW vs ECL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Apparent digestibility, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td></td>
<td>58.9</td>
<td>67.3</td>
<td>64.1</td>
<td>62.2</td>
<td>1.66</td>
<td>0.001</td>
</tr>
<tr>
<td>Dry matter</td>
<td></td>
<td>87.0</td>
<td>86.0</td>
<td>88.0</td>
<td>84.9</td>
<td>1.60</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>N retention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g/day</td>
<td></td>
<td>2.12</td>
<td>2.38</td>
<td>2.42</td>
<td>2.08</td>
<td>0.18</td>
<td>0.24</td>
</tr>
<tr>
<td>% of N intake</td>
<td></td>
<td>43.7</td>
<td>52.4</td>
<td>47.9</td>
<td>48.3</td>
<td>2.1</td>
<td>0.004</td>
</tr>
<tr>
<td>% of N digested</td>
<td></td>
<td>73.5</td>
<td>77.3</td>
<td>74.4</td>
<td>76.4</td>
<td>1.9</td>
<td>0.13</td>
</tr>
<tr>
<td>N*6.25, % in DM</td>
<td></td>
<td>10.7</td>
<td>12.2</td>
<td>10.9</td>
<td>12.0</td>
<td>0.80</td>
<td>0.19</td>
</tr>
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</table>
### Intake, g/day

<table>
<thead>
<tr>
<th></th>
<th>244</th>
<th>247</th>
<th>242</th>
<th>249</th>
<th>19.8</th>
<th>0.16</th>
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<tbody>
<tr>
<td>Dry matter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>4.66</td>
<td>4.50</td>
<td>4.98</td>
<td>4.18</td>
<td>0.28</td>
<td>0.64</td>
</tr>
<tr>
<td>Foliage, % of DM</td>
<td>36.0</td>
<td>29.0</td>
<td>31.0</td>
<td>34.0</td>
<td>2.6</td>
<td>0.07</td>
</tr>
<tr>
<td>DM intake, % of LW</td>
<td>3.59</td>
<td>3.08</td>
<td>3.52</td>
<td>3.14</td>
<td>0.31</td>
<td>0.13</td>
</tr>
</tbody>
</table>

### Conclusions

The results of this study confirm the high digestibility of all the dietary ingredients. The apparent digestibility of the nitrogenous fraction was significantly greater for diets containing duckweed than for those in which the protein was provided by ensiled cassava leaves. The efficient use of the dietary nitrogen implies that both duckweed and ensiled cassava leaves have a good array of the essential amino acids needed for growth, with the advantage slightly in favour of the duckweed because of its superior digestibility.

### Acknowledgements

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