Cassava Starch Processing at Small-Scale in North Vietnam
Impact of technology on efficiency and effluent management.

Hoai Duc district, Ha Tay Province

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Cassava in Vietnam

From 45,000 to 70,000

Area of Cassava in 2002 (ha)

< 450,000

From 450,000 to 900,000

From 1,350,000 to 1,800,000

Cassava Production in 2002 (t)

< 450

From 450 to 900

From 900 to 1,350

Rate of Cassava High Yield Varieties in 2002 (% of cassava cultivated area), Pham et al. 2002

Cassava in Vietnam (cont.)

Introduction of CIAT varieties

Area harvested (x10^6 ha)

Yield (t/ha)

Production (x10^6 t)

(FAO stat, 2006)

Production (–), Area harvested (–), Yield (–x).
The Craft and Industrial villages (CIVs) in the Red River Delta (Northern Vietnam)

- **Vietnamese cluster** (Dao The Tuan, 2004):
  Production system concentrating in a specific geographical region where enterprises and households specialize in one of a group of activities and together create relationship, cooperation, competitiveness and innovation. Industrial cluster: a group of industrial villages in the same commune or in the neighboring communes.
  - 668 craft villages with 147 in Ha Tay province in 2002
  - Vietnam is willing to encourage the existing potential of the craft villages and create a further 1,000 by 2010
  - Numerous middlemen within the value chain (collectors, traders) and connecting different activities.

Cassava valorization

- Cassava valorization
- Fresh consumption
- Processing
- Separating out the constituents
- Rasping
- Fermentation
- Starch
- Fibers
- Animal feed
- Others
- Modified starch
- Textils et papers
- Recycle products
- Bioethanol
- Animal feed
- Others

Cassava starch production in Vietnam

- Rapid market growth (+ export) since the Doi Moi (opening) in the late 80’s
- Cassava production used in starch production: 24% (IFPRI, 1998) in 1998 (131,000 tons) versus 50% in 2004 (450,000 tons).
- Industry structure including different production scales:
  - Large scales: 42 factories in 2005 (imported equipment: Thailand, China)
  - 70% of the processing units at small scale (about 4,000 units producing up to 1 ton of starch/day) including the ‘craft villages’ (CIVs) from the Red River Delta => complex cassava value chain (ADB, 2005)

Issues

- Challenging future for the small firms producing Cassava starch (Goletti, 1998): is this scale can be competitive?
- Income benefits versus agriculture (SIUPA, 2001)
- CIVs: Territorialized system of production adapted to the specificity of rural industrialization in transition in Vietnam (Franchetta, 2006)
- Energy and environmental issues (Peters, 2003) at any scales
- High density of population: up to 3500 hab/km² in 2006

The Craft and Industrial villages (CIVs) in the Red River Delta (Northern Vietnam)
Objectives

- To propose a qualitative and quantitative diagnosis methodology at household’s scale to identify bottlenecks and strengths of cassava starch processing in the cluster.

- To make a typology of cassava starch processing units (Gottret et al. 1997) based on the different technologies currently used within the cluster.

- To quantify the efficiencies of starch extraction and water consumption during the cassava starch processing (Duc, 1994).

Materials and Methods (M&M)

- Information gathering: Key informal interviews with researchers, officials, institutions, projects, stakeholders.
- Participatory Rural Appraisal (Calub, 2003) in the selected communes (group of 12 people per commune):
  - PRA tools: timeline, seasonal calendar, processing flow diagram, SWOT analysis, trend analysis, …
Cassava wet starch processing diagram within the cluster

M&M: Diagnosis phase 2: technological

- Developing a methodology in a technological hall
- Dividing up roots deliveries (in bulk) among the different types (A, B, C) in the selected communes

M&M: Diagnosis phase 2

- Following-up the manufacturing process from one delivery of HYV in bulk and divided up into 3 types of processing systems A, B and C, and 3 replications

M&M: Diagnosis phase 2

- Water consumption follow-up for the 3 types of processing units
For each type of processing system (A, B and C):

- Calculation of mass balance during the manufacturing process for producing wet starch
- Follow-up of the production capacities and labor
- Estimation of the electrical consumption for rasping and extraction stages
- Noting down the daily prices and quantities of raw materials (roots), by-products (fibers, black starch) and final products (wet starch)
- Composition analysis of the samples (3 aliquots) during trials (dry matter content, starch content, ash)

The PRA has shown a diversity of activities within the three communes: Duong Lieu, Cat Que and Minh Khai (cluster)

A range of activities per household (ranking priorities)
A major constraint on the environment created from the discharge of the waste water from processing activities.

Solid wastes issue from processing during the peak season in the communes have been almost solved (market opportunities) for cassava but not for canna.

<table>
<thead>
<tr>
<th>No</th>
<th>Nature of waste</th>
<th>Unit</th>
<th>Cat Que</th>
<th>Duong Lieu</th>
<th>Minh Khai</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Canna waste</td>
<td>ton/day</td>
<td>4.44</td>
<td>21.46</td>
<td>27.38</td>
</tr>
<tr>
<td>2</td>
<td>Cassava peels</td>
<td>ton/day</td>
<td>9.0</td>
<td>12.56</td>
<td>3.6</td>
</tr>
<tr>
<td>3</td>
<td>Cassava residues</td>
<td>ton/day</td>
<td>32.4</td>
<td>45.00</td>
<td>12.9</td>
</tr>
<tr>
<td>4</td>
<td>Coal residues</td>
<td>ton/day</td>
<td>2.64</td>
<td>8.58</td>
<td>2.15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>ton/day</td>
<td>48.72</td>
<td>88.60</td>
<td>46.28</td>
</tr>
</tbody>
</table>

Source: Science and Technology department form Ha Tay province, 2002
Distribution of the 3 types A, B, C into the processing cluster of communes (2005)

<table>
<thead>
<tr>
<th></th>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>0.8 - 1</td>
<td>&lt;= 2</td>
<td>&lt;= 4</td>
</tr>
<tr>
<td></td>
<td>More than 1500 (with 733 HH)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Households among wet starch processors

- in Cat Que (%): 184 (58) 67 (36) 10 (5)
- in Duong Lieu (%): 514 (10) 384 (75) 120 (23)
- in Minh Khai (%): 35 (0) 25 (71) 10 (29)

Estimated quantity of roots processed (t/day)

- More than 1500 (with 733 HH)

R&D: diagnosis phase 1

Rapid evolution from type A to B and C depending on local constraints and specialized activities (noodle making, pig raising, maltose production...)

R&D: diagnosis phase 2: Equipment

- Type A and type B: Loading and Rasping stages

R&D: Development of the technology in Cat Que and Duong Lieu communes

<table>
<thead>
<tr>
<th>Date</th>
<th>Technique</th>
<th>Capacity (ton/h/HH)</th>
<th>Marketing in Duong Lieu commune</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>Starch</td>
<td>0.1 - 0.2</td>
<td>Starch sold to other commune</td>
</tr>
<tr>
<td>1986</td>
<td>Root cleaning machine appeared</td>
<td>0.5 - 0.6</td>
<td>Improved grating machine</td>
</tr>
<tr>
<td>1996</td>
<td>Separating machine (type C)</td>
<td>0.5 - 0.9</td>
<td>Root grating IH appeared</td>
</tr>
<tr>
<td>2006</td>
<td>Separating machine (type C)</td>
<td>0.8 ton/h/HH</td>
<td>Marketing in Duong Lieu commune</td>
</tr>
</tbody>
</table>

ⅡR&D: Diagnosis phase 1

- Development of the technology in Cat Que and Duong Lieu communes

- R&D: Diagnosis phase 2: Equipment

- Type A extractor: manual Stirring

- Type A and type B: Loading and Rasping stages

- Roots

- Cassava pulp

- Stirring machine

- Tile tanks
Type B extractor: Loading and Stirring stages

- Cassava pulp
- Water
- Starch milk

Type B extractor: Stirring stage

Type B extractor: Emptying the tank

Type C: Loading and Rasping stages

- Fibres
- Roots
Starch milk

Water

Type C: Stirring stage

Type C: Fibers emptying stage

Fibres

Wet starch (45% moisture w.b.)

Predrying

Selling and/or Storage

Filtration and settling

Types A, B, C...

R&D: diagnosis phase 2: raw materials

- Long distance (transport) between cassava production and starch processing: 2-5 days
- Cassava varieties with:
  - High dry matter content (40% ± 1.5 w.b.)
  - High starch content (27 to 33% w.b.)
- Processing depends STRONGLY on the delivering quantity and the type of the raw materials (cultivars)
- Competition with other cassava markets (cassava chips for China)
**R&D: diagnosis phase 2**

Production follow-up of a type A processor during the processing season in Cat Que commune

Cassava processing is a Seasonal activity (benefit) ⇒ diversity of activities

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**R&D: diagnosis phase 2**

Production capacities for the three systems (A, B, C) within Cat Que commune (2005)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Processing capacities (t roots/h/Household)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Washing</td>
<td>1.9</td>
</tr>
<tr>
<td>Grating</td>
<td>2.1</td>
</tr>
<tr>
<td>Extraction</td>
<td>0.3</td>
</tr>
<tr>
<td>Settling</td>
<td>0.1</td>
</tr>
</tbody>
</table>

⇒ Bottlenecks: Settling and extraction ⇒ optimization of washing and grating capacities

⇒ Type C is largely adopted to reduce labor and space constraints.

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**R&D: diagnosis phase 2**

**Extraction efficiencies**

<table>
<thead>
<tr>
<th></th>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of fresh processing roots (t)</td>
<td>1.13 ± 0.04</td>
<td>1.12 ± 0.03</td>
<td>2.26 ± 0.04</td>
</tr>
<tr>
<td>Conversion rate (%) kg of dry starch / kg roots</td>
<td>25.3 ± 1.5</td>
<td>24.3 ± 0.6</td>
<td>26.1 ± 1.0</td>
</tr>
<tr>
<td>Total water used in liter per kg of dry starch</td>
<td>16.8 ± 2.4</td>
<td>13.6 ± 2.3</td>
<td>21.9 ± 1.4</td>
</tr>
</tbody>
</table>

⇒ Type C requires higher water consumption than types A and B, but it is largely adopted for other reasons.
Comparison with other processing units

<table>
<thead>
<tr>
<th></th>
<th>Ivory Coast (Bietrix, 1996)</th>
<th>Brazil (Srivastava, 2001)</th>
<th>Colombia (Rivier, 2001)</th>
<th>Thailand (Sriroth, 2000)</th>
<th>Vietnam cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion rate (%)</td>
<td>17.2</td>
<td>24.0</td>
<td>17.2</td>
<td>18.3</td>
<td>25.2</td>
</tr>
<tr>
<td>kg of dry starch / kg roots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total water used per kg of dry starch (%)</td>
<td>29.1</td>
<td>18.8</td>
<td>43.6</td>
<td>12</td>
<td>17.4</td>
</tr>
<tr>
<td>Total solid in waste water per kg dry starch (%)</td>
<td>13</td>
<td>10</td>
<td>-</td>
<td>low</td>
<td>13</td>
</tr>
<tr>
<td>Starch content in Dry Starch (%)</td>
<td>98</td>
<td>97</td>
<td>95</td>
<td>&gt;= 98</td>
<td>89-97</td>
</tr>
</tbody>
</table>

Different solutions have been tested to reduce water consumption up to 50% with hydrocyclones technologies (Trim et al., 1996)
A waste water treatment device has been studied (Thuy, 2006) >= 30m³/day, 2days

=> Space shortage limits the adoption within the cluster (local constraints)

Cassava wet starch processing benefits?

<table>
<thead>
<tr>
<th></th>
<th>Amount (USD/day/MT)</th>
<th>A</th>
<th>B</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh roots</td>
<td>-39.1</td>
<td>-39.2</td>
<td>-36.1</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Electricity (SP)</td>
<td>-1.9</td>
<td>-3.5</td>
<td>-5.7</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>-11.3</td>
<td>9.5</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>Depulperation (mashing + extraction)</td>
<td>-9.1</td>
<td>-9.2</td>
<td>-9.7</td>
<td></td>
</tr>
<tr>
<td>Pigmentation (refining - mashing + rasping)</td>
<td>-1.8</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Equipment for processing</td>
<td>-164.8</td>
<td>-148.6</td>
<td>-150.8</td>
<td></td>
</tr>
<tr>
<td>Wet starch</td>
<td>69.8</td>
<td>50.3</td>
<td>119.8</td>
<td></td>
</tr>
<tr>
<td>Fract starch</td>
<td>2.2</td>
<td>1.4</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Fract fiber</td>
<td>2.5</td>
<td>1.7</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Gross benefit from processing</td>
<td>14.4</td>
<td>10.6</td>
<td>13.8</td>
<td></td>
</tr>
<tr>
<td>Net benefit from processing</td>
<td>-1.9</td>
<td>6.0</td>
<td>2.3</td>
<td></td>
</tr>
</tbody>
</table>

=> Based on our trials, processing looks not economical for type A and give a limited profitability for type B versus C (largely adopted)
=> Other costs/benefits must be considered (first investment + other activities)

Conclusion

The methodology of diagnosis at household level within a cassava processing cluster has allowed:

- To identify local constraints which mainly concern the space limitation and related environment issues (liquid waste management)
- To make a typology based on extraction systems:
  - Quantification of the differences between processors on stage capacities, water consumption and discharged water levels
  - Indicating a high efficiency of cassava starch extraction compared to other locations but lower quality level of the final product
- To roughly estimate the profitability of the different systems of extraction

Perspectives

- What principles do the rasping/extraction work on different aspects:
  - the available technology (Vietnam, other locations)
  - the raw materials (Cassava, Canna)
- Further research on quality levels of the final products depending on the applications (end-uses) and the local constraints (with or without storage)
- A complementary study at household scale on cost analysis by integrating the other activities (pig raising, labor renting, energy, by-products valorization...)
Acknowledgments

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Thank you for your attention