Lessons learned from the development of processing systems and markets for Thai cassava

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Lesson learned from Thai cassava industry

Thai cassava industry

- 3rd world root production after Nigeria and Brazil
- Total root production of 25-30 million tons annually (10% of world production)
- 1st producer and exporter of cassava-derived products
- Generate up to 1,400 million USD revenue of exported products
World Cassava Production

Total Production 228 million tons (2007)

Source: FAOSTAT
Cassava production in Thailand

- Total planting area = 7.4 Million Rai or 1.2 Million hectare
- Mostly grown in North eastern, eastern part
- Root productivity = 4.7 tons /Rai or 30 tons / hectare

(World average = 12 tons / hectare)
Cassava is a cash crop of Thai farmers

Excellent agronomic characteristics

- Drought tolerance
- Easy to grow with low inputs
- All year round planting/harvesting
- High yield-improved varieties
- High root productivity
- Roots with high quantity/quality of starch
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Improved varieties + Cost-effective cultivation practices = Good productivity

Increased farmer’s Income
Improvement of root productivity

1. Improvement of high-yielded varieties

- R & D of conventional breeding for improved varieties
  - high-yield
  - high starch content
  - good plant feature
  - good stake quality
  - disease resistance
- Release of new improved varieties to farmers & industries
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Cassava Varieties

Rayong5

Rayong90
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KU50

Huaybong 60

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Improvement of root productivity

2. Improvement of good cultivation practice

- Varieites: good varieties, good stake quality
- Period of planting & harvesting
- Soil preparation and conservation
- Cost-effective use of fertilizers
- Intercropping system
- Irrigation system
3. Supportive mechanisms / policies

- Efficient service of disseminating good stalks of developed varieties to farmers
- Training workshop of good cultivation practice to farmers
- Zoning of cassava planting area for yield improvement (MOA national agenda)
- Financial support
Beyond the farmer’s cash crop, cassava is an industrial crop
Cassava-derived products

- Chips
- pellets
- Native & modified starches
- Hydrolyzate and fermented products
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Marketing structure of cassava in Thailand

Growers

Cassava roots

Small scale entrepreneur

Cassava chips

- Local consumption
- Pellet companies (Pelletization)

- Pellets
  - Traders
    - Export market
    - Ethanol and feed

Starch factories

Cassava starch

- Modification
  - Modified starch
    - Local consumption
    - Export market
Export volume of Thai cassava products

- Cassava Starch (ton)
- Cassava Chip (tons)
- Cassava Pellet (tons)

Year:
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006

Volume (tons):
- 0
- 500,000
- 1,000,000
- 1,500,000
- 2,000,000
- 2,500,000
- 3,000,000
- 3,500,000
- 4,000,000
Export value of Thai cassava derived products

Value (million Baht)

Year

Cassava Starch (million Baht)
Cassava Chip (million Baht)
Cassava Pellet (million Baht)

(Note: 1 US dollar ≈ 35 Baht)
Currently, there are about 277 chip factories with the total production of 4 - 5 million tons.

- Conversion: 2.00-2.50 kg fresh roots / 1 kg chips
  (25% starch content)   (14% moisture content)
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1. Chopping into small pieces

2. Sun-drying on a cement floor

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Cassava pellets

- Produced from dried chips only
- Conversion: 1 kg chip : 1 kg pellet
- Soft pellets VS. Hard pellets
- Currently, there are 41 pellet manufacturers with the total production of 1.0 million tons
- Export market only for animal feed uses
Process of hard pellet production

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Chips from storage
- Removal of sand and impurities
- Grinding and sizing
  - Steaming and Extrusion
    - Extrusion
      - Cooling
        - Sieving
          - Hard pellets
            - Storage

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Steam

Grinding chips
Extrusion
Cooling
Storage of pellets

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Cassava starch

Conversion: 4.2 - 4.75 kg fresh roots / 1 kg starch
(25% starch content) (13% moisture content)
- Currently, there are 73 factories registered to Thai Tapioca Trade Association.
- The production capacity is about 3.0-3.5 million tons per year.
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Export volume and value of Thai cassava starch products

Volume (Million tons) - Value (Million Baht; 1 US dollars = 35 Baht)

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Technology development of cassava starch processing in Thailand

1\textsuperscript{st} generation - Tapioca flour
- Sedimentation process

2\textsuperscript{nd} generation - Tapioca starch
- Dewatering process with improved production efficiency and product quality

3\textsuperscript{rd} generation - Multi-product industry
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1st Generation - Tapioca flour production with sedimentation process

- Root Conveyor
- Rasper
- Filtration
- Sedimentation Pond
- Cassava Cake
- Drying

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2nd Generation: Current process of cassava starch production in Thailand

1. Cassava Root
2. Washing
3. Raspining
4. Extractor
5. Separation 1
6. Fine Extractor
7. Separation 2
8. Dewatering
9. Cassava Starch
10. Drying
Root Preparation

- Root Hopper
- Root Peeler
- Stem Cutting
- Root Chopper
- Root Washer
- Rasper
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**Starch Extraction**

*Process A*
- Starch Slurry
- Coarse Extractor
- Fine Extractor
- Separator

*Process B*
- Starch Slurry
- Horizontal Extractor
- Bent Screen
- Starch Hydrocyclone

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**Starch Drying & Packaging**

- Dewatering Centrifugal
- Flash Dryer
- Packaging of high quality starch

**Pulp Dewatering**

- Coarse Extractor
- Screw Press

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Thai cassava starch - the right choice for industry

- GMO-free
- No color
- No odor
- No taste
- High paste clarity
- High paste viscosity
- High freeze thaw stability
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3rd Generation: Multi-product industries

High Quality Starch
- Modification
  - Functional Starch

Low quality Starch
- Fermentation
  - Chemicals

Pulp
- Biomethylation
  - Energy

Wastewater

Animal Feed
Lesson learned from Thai cassava industry

**Starch Drying & Packaging**

- Thermo Oil Boiler
- Biogas Plant
- Power Generator
- Thermo Oil Boiler
- Dewatering Centrifugal
- Flash Dryer
- Packaging

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**Pulp Dewatering**

**Process A**
- Coarse Extractor
- Screw Press

**Process B**
- Horizontal Extractor
- Dewatering Centrifugal

Cassava pulp

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Modification, functionalities and uses of some commercial cassava products

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Tapioca starch

Native starch
- Household
- Bakery
- Noodle
- Snack
- Tapioca pearl

Modified starch
- Pregelatinized starch
- Acid thinned starch
- Dextrinized starch
- Oxidized starch
  - Starch ether
    - Hydroxyalkyl/Cationic starch
  - Starch ester
    - Acetylated starch
    - Phosphate monoester starch
  - Crosslinked starch
    - Di-starch phosphate
    - Di-starch adipate

Starch hydrolysate
- Maltodextrin
- Sweeteners
  - Glucose, Dextrose, Fructose
- Sorbitol/Mannitol
- MSG/Lysine
- Organic acid
  - Citric acid
  - Lactic acid
- Alcohols
  - Ethanol

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Starch hydrolysate:
- Maltodextrin
- Sweeteners (Glucose, Dextrose, Fructose)
- Sorbitol/Mannitol
- MSG/Lysine
- Organic acid (Citric acid, Lactic acid)
- Alcohols (Ethanol)
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Uses of modified cassava starches in food and non-food applications

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Starch hydrolysates and fermented products

- Maltodextrin
- Sweeteners & derivatives
  - glucose syrup
  - fructose syrup
  - sugar alcohol: sorbitol, mannitol
- MSG / Lysine – 6 Factories
- Acid: lactic acid
- Alcohols: ethanol

17 factories

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Starch hydrolysis → Fermentor → Purification/separation → Novel/Value-added products

**Novel / Value-added products**

- Feed & food additives: MSG, lysine
- Packaging: poly (lactic acid)
- Energy: Ethanol
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Lactic acid

Food & Feed
Cosmetic & Pharmaceutical
Chemicals, chemical feedstock
Production process of polylactic acid (PLA)

1. Fermentator
2. Purification
3. Lactic acid
4. Lactide
5. PLA

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Cassava ethanol

Conversion: 6 kg fresh roots / 1 liter of anhydrous ethanol
2.5 kg chips / 1 liter of anhydrous ethanol
Technology development for bioethanol production from cassava

- Energy and water saving process
- Waste utilization
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Cassava Chips

\( \alpha \)-Amylase \( \approx 85-105^\circ C \)

Glucoamylase \( \approx 55-60^\circ C \)

Yeast \( \approx 30-32^\circ C \)

Distillation & Dehydration

Conventional process

Milling

Cooking

Liquefaction

Saccharification

Fermentation

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Cassava Chips

Milling

α-Amylase
≈ 85-105°C

Cooking

glucoamylase
yeast
≈ 30-32°C

Distillation & Dehydration

Simultaneous Saccharification and Fermentation process - SSF

Liquefaction

SSF

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Mass Balance of Ethanol Production from Cassava Chip by SSF process

T/D = Ton/Day, TS = Total Solid , L/D = Liter/day

Fermentation efficiency 90%, Distillation efficiency 98.5%
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Simultaneous Liquefaction, Saccharification and Fermentation process - SLSF

UNCOOKED SINGLE-STEP

Cassava Chips

Granular starch hydrolyzing enzyme (GSHE)

Milling

yeast ≈ 30-32°C

Distillation & Dehydration

Fermentation
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**Continuous R &D**

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**Ethanol Fermentation**

**Very High Gravity (VHG) Technology Development**

**Fresh Root**

(moisture content = 60-70%)
100 Tons

**Cassava Chip**

(moisture content = 14%)
41 Tons

**Process water**

99 Tons

**Milling**

**Mixing**

(total solid = 25%)
140 Tons

**Water**

59 Tons

**Sun Drying**

**Process water saving**

**Ethanol Fermentation**
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Less by using fresh roots

Less by using SLSF process

Less by using VHG process

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Industrial use of cassava

Cassava roots
(26 million tons)

Native / modified starches
14.7 million tons
(3.5 million tons of starch)

Chips/Pellets
11.07 million tons
(5 million tons of chips/pellets)

Bioethanol
0.23 million tons
(39 million liters of ethanol)

Local use (37%)
5.44 million tons
(1.3 million tons of starch)

Export (63%)
9.26 million tons
(2.2 million tons of starch)

Local use (16%)
1.77 million tons
(0.8 million tons of chips/pellets)

Export (84%)
9.30 million tons
(4.2 million tons of chips/pellets)

Note: Conversion ratio

4.2 kg of fresh roots / 1 kg of starch
2.2 kg of fresh roots / 1 kg of chips & pellets
6 kg of fresh roots / 1 liter of bioethanol
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The lesson learnt from the development of processing systems and markets of Thai cassava industry is market-oriented technology development by “Cassava Cluster” – a collaborative group of all cassava stakeholders.
Lesson learned from Thai cassava industry

- **Raw material**
- **Technology**
- **Product**
- **Application**
- **Market-oriented**
- **Policy / Law / Environment**
- **R&D**

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New yield-improved varieties with GMO free

Well-developed production technology for starch / starch derivatives

Collaboration of stakeholders

Developed farm practices for high root productivity

Remarkable characteristics of starch / starch derivatives for food/non-food uses

Effective policy / Strategy

Strength of Thai cassava industry
Collaboration of stakeholders – “CASSAVA CLUSTER”

- Ministry of Agriculture and Cooperatives
- Ministry of Commerce
- Ministry of Industry
- Ministry of Science and Technology
- Non-profitable organization

  The Thai Tapioca Trade Association (TTTA)
  The Thai Tapioca Flour Industries Trade Associations
  The Thai Tapioca Starch Association (TTSA)
  North Eastern Tapioca Trade Association
  The Thai Tapioca Development Institute (TTDI)
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Strategy of Thai cassava industry

Strategy I: Improvement of root productivity
Strategy II: Value addition of cassava-based products
Strategy III: Market expansion
Strategy IV: Research and development (including infrastructure and human resource development)

Cassava – the winner crop of Thailand

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Thank you for your attention

http://www.cassava.org
Starch Update 2009
The 5th Conference on Starch Technology
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Queen Sirikit National Convention Center
Bangkok, THAILAND

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Activities

- Keynote lectures
- Oral and poster presentation
- Study tour to starch factory

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