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

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ABSTRACT

In Thailand, cassava (Manihot esculenta Crantz) is considered as one of the most important economic crops. Thailand has demonstrated the importance of cassava as more than a subsistence crop, and has developed a large and complex industrial system for processing and marketing of the crop. Production of cassava has steadily increased during the 1970s and 80s through expansion of the planted area, but has decreased again since the early 1990s. Despite the total planted area remained unchangeable, the production of cassava has increased by improving the national average yield which is approximately 20-25 tons/ha. Major production problems are declining soil productivity, soil erosion and long drought period. Since 1959, the products derived from cassava have been a major export commodity for Thailand, assisted by relatively easy market access to the EU and recently to China.

Cassava roots are utilized for making dry chips, pellets, native starch, modified starch, MSG (monosodium glutamate), glucose, fructose, sorbitol, pearls, citric acid which are used in the food, beverage, feed, paper, textile, and plywood industries. In addition, they are used as the major raw materials for the production of bioethanol, an alternative biofuel to be blended with petroleum gasoline.

1. Cassava is a cash crop of Thai farmers.

Cassava (Manihot esculenta Crantz) or tapioca is the third most important crop in Thailand. It was first introduced into the southern part of Thailand from Malaysia during 17th-18th century. The crop has excellent drought tolerance and can be planted, with a low input requirement, in almost all soil types where other crops cannot be cultivated economically, making the rapid expansion of cassava plantation throughout the country especially in the Northeastern part of Thailand. Currently, the total acreage of 1.1 million ha is devoted for cassava planting by a large number of farmers, generating greater than 25 million tons of roots annually. During the past decade, the root productivity in Thailand has been significantly improved by 60% (from 14.27 in 1997 to 22.93 tons/ha in 2007) with the implementation of improved varieties and cultivation practices, operated under the collaboration of government agencies (Department of Agriculture, Ministry of Agriculture and Cooperatives and Kasetsart University) and private sectors, led by the Thai Tapioca Development Institute (TTDI). According to its excellent agronomic traits, improved varieties and cost-effective farm practices, cassava is recognized as the farmer’s cash crop.

2. Beyond the farmer’s cash crop, cassava is an industrial crop.
In some regions, cassava is mostly used as a staple food. Nevertheless, Thailand has demonstrated the importance of cassava as more than a subsistence crop, and has developed a large and complex industrial system for processing and marketing of the crop. The major industries include chips, pellets (soft and hard), starches and starch-derived products (pearls, modified starches, sweeteners, acids and sugar alcohols) and bioethanol, for locally used and export markets. The structure of the cassava market in Thailand is depicted in Figures 1.

3. With market-oriented technology development for cassava processing, Thai cassava industry has greatly expanded.

3.1 Cassava chip industry

Cassava chip factories are small-scale enterprises which belong to farmers or small business men and are located in close proximity to the growing area. The chipping factories are installed with simple equipment, consisting mainly of a chopper. Roots are loaded into the hopper of the chopping machine by a tractor; after chopping into small pieces, the chips are sun-dried on a cement floor. The final moisture content of chips should be below 14% and the sand content should not exceed 3%. Normally it takes 2.00-2.50 kg of fresh roots (with 25% starch content) to produce 1 kg of chips (14% moisture content).

Chips are sold to pelletizing manufacturers who either directly export the chips/pellets or sell to traders. In most cases, the small chip factories sell their products to large factories that in turn sell a consolidated consignment to pellet manufacturers. Some portions of cassava chips are used locally for animal feed as well as the feedstock for citric acid production. For feed application, a meal of 0.8 kg cassava mixed with 0.2 kg soybean meal has an equivalent nutrition value as 1 kg corn. Recently, the demand of cassava chips for local use has increased dramatically as a result of the national policy of bioethanol production for fuel uses.

To produce ethanol from cassava, the starch is initially converted to fermentable sugars, mainly glucose by enzyme or acid process. The sugars are then fermented to ethanol by yeast. To produce 1 liter of anhydrous ethanol, around 2.5 kg of dried chips (65% starch content, wb) are required; the conversion ratio, however, varies depending on processing efficiency; the most widely used process is Simultaneous Saccharification and Fermentation (SSF; Figure 2).

Since 1981, Thailand has exported to the EU mainly hard pellets rather than chips. In this form, less dust is created, lowering the impact of environmental pollution during the loading and unloading of ships at the port. Recently, due to the national program on biofuel established in many countries, an export of cassava chips to non-EU countries, especially to China increases. The high carbohydrate content of cassava chips is of value for biotechnological conversion; this utilization will secure a continued future for the cassava chip industry. In China, cassava chips are used as the feedstock for ethanol production as well as the substitute of corn in animal feed. This generates an increase demand from 1.96 to 2.56 million tons (equal to 6.25 million tons of fresh roots) in 2003 to 2004. The trend still progressively increases.
3.2 Cassava pellet industry

The pellet industry began a few years after the start of cassava exports to the EU (around 1967). Development of this product was stimulated by a need to improve the uniformity in shape and size of cassava chips required by the compound feed producers/users. In addition, during transportation, loading and unloading of chips dust generation caused serious air pollution, placing pressure on the importers in Europe to improve the nature of cassava products handled by the ports. Production of pellets involves pressing chips, and extrusion through a large die. The heat and moisture in the chips helps in the formation of a pellet-like shaped product, known as a soft pellet. Later process developments involved grinding of chips followed by steam extrusion; this created strong pellets upon cooling, known as hard pellets. Exports of hard pellets began in 1981; by 1987 hard pellets dominated pellet production in Thailand and by 1989 these were virtually the only pellets exported to Europe. The raw material (cassava chips) for pellet manufacturers is purchased from chip drying yards; pellet factories do not produce chips. The purchase price is directly dependent on the export price of pellets in Bangkok.

3.3 Cassava starch and starch-based industries

At the time that cassava was introduced into the southern part of Thailand (1786-1840), a cottage-scale industry for production of cassava meal or cassava flour was adopted from neighboring countries, Malaysia and Singapore. Conversion of fresh cassava roots, by grating, mixing with water followed by sedimentation and sun-drying (or conductive heating) produces a product traditionally called “cassava flour” but now called “cassava starch”. Cassava starch may be further processed to make sago pearls, later was named as tapioca pearls, which is a traditional dessert for the people in the southern part of Thailand.

Demand for cassava starch increased dramatically and this led to the development of the modern starch manufacturing process in the 1970s. Currently, there are 73 modern starch factories, operating with modern separation and drying processes. The processing time (from the grating of fresh root to dried starch) is estimated to be less than 30 minutes. Presently, factories using the sedimentation process do no longer exist in Thailand. The process for production of cassava starch manufacturing is essentially the same for all factories, and is shown in Figure 3. About 4.75 kg of fresh roots produce one kg of dry starch. About 50% of cassava starch produced is used domestically and the rest is for export markets as in native, modified and hydrolyzed forms. Distribution from factories is by three outlets; 1) direct sale for general consumption and local factories, 2) sale to intermediary dealers for domestic retail and export, and 3) direct export.

Domestic market – cassava starch is currently used in many industries. As a very pure carbohydrate source, the starch is an excellent raw material for producing monosodium glutamate (MSG) and lysine, of which the native starch is consumed the most, by fermentation process and sweeteners, including glucose, fructose and its sugar alcohols, i.e. sorbitol by enzyme process. The native starch is also used to produce sago pearls. In addition, the functionality of cassava starch can be significantly improved by modification process. Accordingly, the diversified types of modified cassava starches are produced and used in the food industry, especially for canned products and seasoning sauces as a thickening agent. Moreover, cassava starch has the film forming ability and, therefore, it is...
widely used in the paper industry for surface treatment (sizing). In the textile industry it is used for yarn treatment and in the plywood industry for its binding properties.

**Export/International Market**—Of the various cassava-based products mainly cassava starch and pellets are exported (Table 1). The export of cassava starch becomes more significant in both value and volume. Thailand exports not only native cassava starch but also the modified products, for example, chemically and physically modified starch, sago pearls, seasoning powder, sorbitol and liquid glucose. Future exports of cassava starch are expected to increase due to the growth of global industrial sectors and starch market expansion. The export of cassava starch and its derivatives, however, has to comply with the AFTA (Asian Free Trade Area) and FTA (Free Trade Area) agreements with other countries.

### 3.4 Bioethanol industry

Ethanol, an alternative biofuel used to blend with gasoline to make gasohol, can be produced from sugar and starch crops by yeast fermentation. In Thailand, besides molasses, cassava is considered as one of the most promising feedstock for bioethanol production. The great benefit of cassava is the feedstock procurement as it can be processed in form of fresh roots during the harvest season or dried chip when fresh roots are out of season. Currently, there are 45 factories possessing licenses to produce fuel ethanol from molasses and cassava of which 24 factories (7.73 million liters of anhydrous ethanol /day) plan to use only cassava, another 8 factories (1.22 million liters of anhydrous ethanol /day) plan to use cassava and molasses and the rest (1.22 million liters of anhydrous ethanol /day) processes with molasses only. In case, 32 factories use cassava as feedstock for the production of 8.95 million liters of ethanol/day, approximately 16 million tons of fresh roots are need annually.

### 4. Conclusion: The important 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.

The Thai cassava industry has long been developed by various mechanisms as the collaborative networking among all stakeholders; important are the government agencies including Ministry of Agriculture and Cooperatives, Ministry of Commerce, Ministry of Science and Technology with the cooperation of private and industrial organizations which are the Thai Tapioca Development Institute (TTDI), the Thai Tapioca Trade Association (TTTA), the Thai Tapioca Flour Industries Trade Associations, the Thai Tapioca Starch Association (TTSA) and North Eastern Tapioca Trade Association. The crop is recognized as an important industrial crop that serves as the raw material for various industries including chips, pellets, starch & starch derivatives and bioethanol (Figure 1). With great industrial competence driven by the need of global markets, the cassava cluster chaired by the government agency has to establish the plans for compromising root supply and demand. This also leads to the establishment of the nation roadmap to strengthen the industry’s competitiveness. The core of cassava roadmap contains important strategies including improvement of root productivity (tons of roots/area), development of value added cassava-based products, cassava market expansion and support of researches for cassava industry.
Figure 1 Marketing structure of cassava in Thailand.
Figure 2 Mass Balance of Ethanol Production from Cassava Chip by SSF (Simultaneous Saccharification and Fermentation) process

T/D = Tons/Day, TS = Total Solid, L/D = Liter/day
(Fermentation efficiency 90%, Distillation efficiency 98.5%)
Figure 3 Mass Balances of the cassava starch manufacturing process in Thailand.
(Unit : tons/day)