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Thai Cassava Starch Industry: Current and Future Utilization

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Brief historical background

Initial stage of development

It is believed that cassava was introduced into the southern region of Thailand through Malaysia where cassava had been brought in from West Java. Cassava was grown and used as food in the initial stage of cassava planting in the south, then it was introduced to the eastern seaboard.

The cassava processing industry started around the 1920s or even earlier in Chonburi province where cassava starch was produced through a simple sedimentation process in small factories. The starch produced was mostly used for home consumption. After the Second World War modern starch milling technology was introduced and marked the start of the modern cassava starch industry in Thailand. Most of the cassava starch produced by the modern starch factories was exported, while some of its residuals (waste) was also exported to neighboring countries.

In the early 1950s cassava starch was the major export among cassava and its products. In 1955, for example, the total value of cassava products export was 69.1 million baht (or 54,122 thousand tons) in which cassava starch and waste accounted for 76.5% (or 54% of the total quantity) and 22.4% (or 44% of the total quantity) respectively. The US and Japan were the principal markets for cassava starch, while Malaysia and Singapore were the major markets for cassava waste. The export of cassava starch increased from 29 thousand tons in 1955 to 227 thousand tons in 1961, which was the highest during the period of 1955 to 1973.

There are no published data on domestic cassava starch utilization for this period. It is believed that domestic consumption was less than exports. In other words, the industry was very much an exported oriented industry which was developed in response to the export markets.

Introduction of cassava products for animal feed market

Although the value of cassava starch export increased to 220 and 223 million baht in 1960 and 1965 respectively, its percentage share of the total value of cassava products exported decreased over time from 76% in 1960 to 33% in 1965. This was due mainly to the rapid expansion of exports of cassava products for animal feed.

It is generally accepted that the Common Agriculture Policy (CAP) of the European

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Community (EC) triggered the rapid increase of imports of the so-called non-grain feed ingredients (NGFI), which included cassava or tapioca products, into the EC. In response to the strong demand for NGFI in the EC, the production of cassava products as animal feed was started in the late 1950s. The recorded quantity of cassava waste exported to West Germany and Netherlands was 7 and 1.4 thousand tons in 1957, respectively.

The use of cassava products for the animal feed industry started with the export of cassava waste in 1955. In fact, the development of this industry can be divided into three phases in accord with its product form development. The first phase was the initial phase during 1955-1968 in which the major product forms of exports were cassava waste, meal and chips. The second phase was the native or soft pellet during 1969-1982. The third phase was hard pellets and export limitation starting 1983 to now. The development of these product forms was induced by the minimization of the transportation cost and the pollution effects during loading and unloading of the products. This reflected the efficient marketing system of the industry through coordination and technological transfer from the importing countries to Thailand.

There are many impacts created by the cassava products animal feed industry such as increase in farm income, employment, and foreign exchange earning. However, there are at least two impacts that are of relevance to the development of the industry itself. First, the area planted and production of cassava increased tremendously from 38.4 thousand ha producing 0.42 thousand tons in 1957 to 171 thousand ha producing 2.6 million tons in 1968, of which 75% was produced by the eastern region. Then the expansion of area production moved into almost every region, especially into the northeastern region which produced more than 50% of the total production in 1977. Such an expansion was induced mainly by demand for cassava products for the feed industry. However, the starch industry also benefited from the expansion by the establishment of factories in the new areas. The second impact was the development of export facilities which enabled high speed of pellet loading as well as specialization of the exporting business. In addition, Thai exporters were able to adopt forward integration by setting up trading companies in the EC. Such outward expansion development opened up investment opportunities in the industry.

Nevertheless, the development of the industry was slowed down by the signing of a Cooperation Agreement between the European Economic Community and the Kingdom of Thailand on manioc production, marketing and trade in July 1982. This agreement set an annual maximum level of five million tons of exports of cassava products as animal feed to the EC market. The agreement, however, created more serious awareness of the need to explore new uses of cassava root and its products, especially cassava starch.

Modified starch

Modified starch is indeed a further value-added product of starch so that its application can be improved. In fact, some of the cassava starch (or native starch) exported from Thailand to countries such US and Japan was used as raw starch for further processing of modified starch. The earliest modified starch processing was glucose syrup monosodium glutamate processing initiated in 1960. However, in the late 1970s, the modified starch industry expanded by joint ventures between US and Thai companies for producing modified starch for exports. Then joint ventures in modified start production for export took place between Thai exporters and European firms as well as Japanese firms. It was observed that exporters of tapioca products for animal feed had integrated with the cassava starch processing and modified starch enterprises.

In the initial stage of modified starch development, the technologies of modified starch were treated as company secrets. At present, it is believed that some of simple physical modified starch technologies had already transferred to cassava starch producers. That means so-called physical modified starch could be produced by cassava starch factories in the cassava producing areas. Nevertheless, modified starch factories which produced the chemically modified starch and factories producing those modified starches requiring higher technology were mostly located in provinces near Bangkok. This was due to the fact that Bangkok is the largest terminal market for cassava/native starch. In addition, most of the

Editorial

Serving the target people of the CGPRT Centre

Seiji Shindo
Director
CGPRT Centre

As I am leaving the Centre after six years of service as its director, I would like to look at the Centre's programme from a general vantage point. In doing so, I position the Centre amidst the needs of its partners and the challenges facing agriculture, in Asia today.

The ultimate target group of the Centre's activities includes farmers, traders, processors and other people involved in CGPRT crop development. Small farmers relying on CGPRT crops for their livelihood constitute the core of the target population.

These small farmers have increasingly been exposed to market forces induced by differential growth among sectors in the economy. As a result, farmers have to increase their incomes by diversifying and intensifying their agricultural activities and by engaging in off-farm activities. Out-migration from agriculture and urban expansion can be considered as given but, also as a partly controllable phenomenon in this adjustment process. The advancing age and continuing outflow of labour from agriculture would be detrimental to agricultural production unless an increase in productivity compensates for the reduction of labour. On the other hand, expanded urban demand provides wide impetus to agriculture and creates new opportunities.

It is obvious that any research has to take into account a wide range of options in farming. The CGPRT Centre in its programmes has responded to this need. In doing so, and by systematically drawing on interdisciplinary methodology and approaches, the Centre has, we think, reduced the gap between the farming systems stream and economic sectoral approaches.

Recognizing the developments taking place in CGPRT-related agriculture, the Technical Advisory Committee of the Centre in its last session stated that the Centre's activities would have to cover a wide range of economic activities connected with farm activities. Farmers throughout Asia are changing and diversifying their farming by introducing other crops and production sequences involving labour-intensive, value-added and income-generating activities. Introduction of additional crops or livestock into the existing farming systems, semi-processing or processing of products, and commercial vegetable growing are typical choices of farmers.

The Centre has also responded to gradually emerging issues. The Centre's emphasis on sustainable agriculture, market development of products, and rural poverty alleviation in upland agriculture deserves mention. R & D has been pursued with the perception that upland agriculture entails CGPRT-related or dependent farmers, who are particularly vulnerable to the recent adjustment process.

As a research and development institution, the Centre can only achieve its objectives by carrying out collaborative projects with the Centre's partners, that is, national research institutes, planning agencies and other institutes and universities. They are regarded as the partners of the Centre. The Centre's programmes are thus identified, formulated, and structured to respond to the needs of the partner agencies, which addresses the above issues and challenges faced by the ultimate target population.

In leaving the Centre, I express my heartfelt thanks to our partner agencies and their staff for their support, advice and encouragement. I am confident that, thanks to our good relations and frequent encounters, the Centre can continue to contribute to our common goal of improving agriculture and income.

potential industries using modified starch are also located near Bangkok. In 1990, there were 17 modified starch factories with estimated capacity of 0.3 million tons per year and the actual production was about 0.25 million tons.

At least three reasons explain the development of modified starch in Thailand during the last decade. First, international trade of starch has been under different measures of import barriers which were imposed for protecting domestic starch industries. In most on the importing countries, however, there were no trade barriers on the import of modified starch. Secondly, the impressive economic growth of Thailand during 1980- 1990 induced investment in agro-industry with high technology processing. Third, there was a predictable over production or excess supply of cassava in Thailand due to the restriction of cassava pellet exports to the EC.

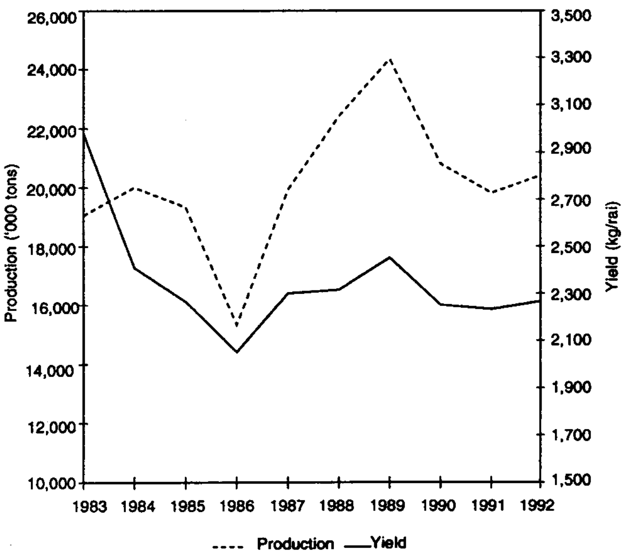
Production, marketing and price formation

Production of root and starch

During the past decade, data obtained from Ministry of Agriculture and Co-operatives (MOAC) showed that the total cassava root production increased from 19.0 million tons in 1983 to 20.4 million tons in 1992 at an annual growth rate of 0.7% (Figure 1). The yield per ha decreased from 18.66 tons in 1983 to 14.03 tons in 1992. This was due mainly to the lack of fertilizer application in most of the cassava growing areas, especially in the northeastern region. The north-eastern region produced about 60% of the total production, while the central plain region produced 30% of the total and the rest was produced by the northern region.

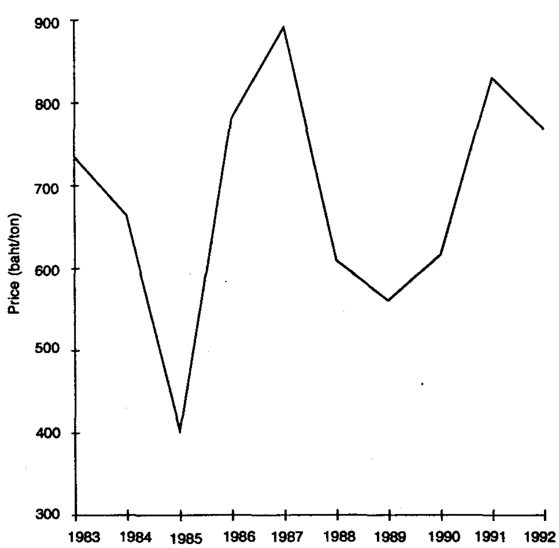
The national average production cost of cassava increased from 450 baht/ton in 1989/90 to 470 and 540 baht/ton in 1990/91 and 1991/92,

Figure 1 Production and yield of cassava.



respectively. During the same period, the national average farm-gate price per ton (price received by cassava growers) was at 620 baht in 1990, 830 baht in 1991, and 770 baht in 1992 (Figure 2). That means, on average, cassava farmers made a profit of 253 baht/ton. During 1990-1992, the average farm gate price increased by 24% which was about 4% more than that of the cost of production. However, if production cost increases at its current annual growth rate of 7%, the future competitiveness of Thai cassava products in the world market will be jeopardized.

Figure 2 Farm price of cassava.



By and large, annual root utilization can be divided into two major usages namely, animal feed products and cassava starch. During the past five years, roughly 14-15 million tons of root were processed into animal feed products (tapioca chips and tapioca pellets) which were mostly exported, while 5-6 million tons of roots were processed into cassava or tapioca starch.

Statistics on starch production are not readily available. It was estimated by the Thai Tapioca Flour Industries Trade Association (TTFITA) that total cassava or native starch production was about 1.265 and 1.353 million tons in 1989 and 1990, respectively. In 1992, it was estimated by the traders that the starch production was roughly 1.4 million tons.

As is the case for many agro-industries, data on the total number and capacity of cassava starch factories have not been updated by the official sources. This is due mainly to the fact that the official records, especially in the Ministry of Industry (M0I), are recorded when a factory is established, and there are limited industrial surveys for updating the statistics. For example, the total number of starch factories reported by the MOAC was 50 and 128 factories in 1970 and 1973 respectively. Then the MOI reported 146 factories in 1978 and 82 factories with estimated capacity of 1.58 million tons in 1987.

Table 1 Number of cassava starch factories and production by region, 1989 and 1990.

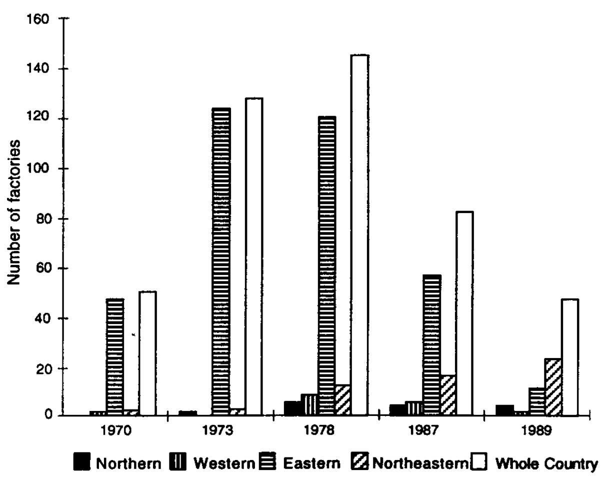
Region	1989		1990	
	Number of Factories	Production* ('000 tons)	Number of Factories	Production ('000 tons)
Northern	4	39	4	39
Western	2	27	2	27
Eastern	18	263	17	263
Northeastern	23	936	22	1,024
Total	47	1,265	45	1,353

Source: Thai Tapioca Flour Industries Trade Association (TTFITA).
*Production figures were estimated by the daily capacity multiplied by 240 days as an approximation of annual days of operation.

Information on the number of cassava starch factories shows that the actual number of starch factories in operation has been decreasing from 146 factories in 1978 to 82 factories in 1987, and it has further decreased to 45 factories in 1990 (Figure 3). However, the estimated capacity of

1.58 million tons of starch was not very much different from the annual production of 1.353 in 1990. This may imply that the starch industry has been suffering from over capacity since 1978. Even at its production level in 1990, the industry operated only 8 months per year. If the industry were to operate 10-11 months per year, then the potential production capacity of the industry would be 1.7-1.9 million tons of starch.

Figure 3 Number of starch factories by region.



Furthermore, the available information on the number of factories and annual production revealed that some of the factories' capacity might have been expanded, especially in the eastern and northeastern regions. During 1978-1990, the number of starch factories in the eastern region decreased drastically from 121 factories to 17 factories, in contrast to that of the northeastern region which increased from 12 factories to 22 factories. Such a phenomena reflected the shift of cassava producing region from eastern to the northeastern, which has been driven by expanded usage of tapioca products in the animal feed industry.

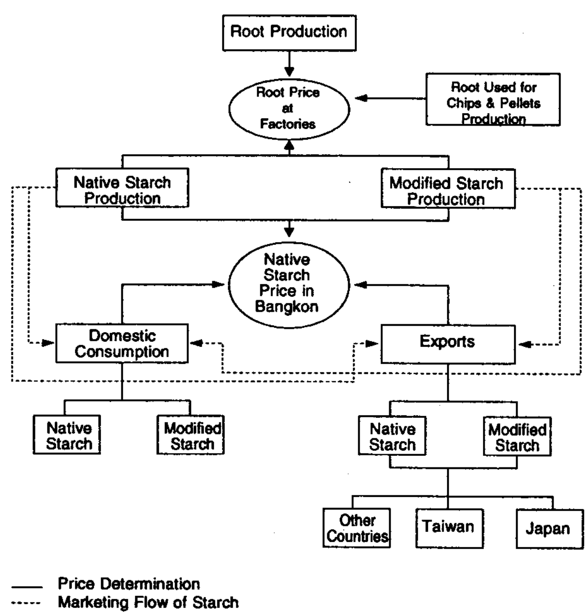
The decrease in number of factories was also due to the fact that many of the factories in 1978 were small and operated as family business. Some of these factories employed old technology or mixed technologies. It was also observed that as the starch industry developed with increasing competition between the starch industry and the animal feed product industry, the small starch factories were not able to compete with modern factories that had higher production efficiency.

It is worthwhile to note that most of the modern starch factories were constructed by local firms. More than 80% of the total materials and machinery used for constructing the starch factories were locally produced and assembled. In fact, some starch factories in Indonesia, China and Vietnam have been built by Thai firms.

Marketing and price formation

The marketing of root is simple, through local trucker to chip/pellet factories and starch factories. Since the government adopted measures of allocating the export quota to the EC based on the exporters accumulated stock in 1988, the root price has been determined by the price of chip/pellet when exporters were accumulating their stock, before the period of stock checking. Once the stock checking period was over, the root price was, more or less, determined by the native starch price. In years when the domestic price of starch is high following the high world price, only that root which could not meet the starch content requirement would - be sold to the chip/pellet factories. In other words, root will be sold to the starch factories first, until the quantity demand for root of the starch factories is satiated, then root will find its way into the chip/pellet factories (Figure 4).

Figure 4 Simplified system of price formation of cassava starch.



Native starch has at least two major outlets namely, domestic consumption and export. Domestic consumption includes food and human consumption and industrial usage which will be discussed further. However, native starch is also purchased by some domestic modified starch factories located in provinces near Bangkok. These modified starch factories' products are mostly for export. In some cases, native starch is also sold to the modified starch factories located in the cassava producing region in the form of wet starch for further processing.

In terms of market share, starch for export and starch for domestic consumption have been more or less equal during the last five years. However, the domestic native starch price is very much influenced by the export markets and therefore the world price. This is due to the fact that export markets for both native and modified starch have been playing a key role in the starch industry, and the prices of these products in the importing countries are competing with prices of other starch, especially corn starch. Therefore, the prices of Thai native and modified starch in these markets are following the competitive world market of starch. In the domestic market, native starch is the cheapest starch available for domestic consumption and most of the starch is consumed at a relatively small percentage of the value of its final products. This enables the domestic native starch consuming industries to absorb the price fluctuation of starch without serious effect on the price of the final product.

The price linkage among modified starch, native starch and root is depicted by the average prices, marketing and process costs in 1990 obtained from industry interviews in 1991 (Table 2).

The above price linkage shows the relationship between the native starch price in Bangkok and the native starch price as well as root price in Nakhon Ratchasima province. In normal situations, cassava starch factories will set their daily buying price of cassava root according the above derivation.

Table 2 Average prices, marketing and process costs in 1990.

Item	Cost US$/ton
Modified starch price c.i.f. Japan	405.0
Freight and insurance cost Thailand-Japan	45.0
Modified starch price f.o.b. Bangkok	360.0
Exporting cost	20.0
Modified starch price at factory in Bangkok	340.0
Processing cost of modified starch (including 5% weight loss)	117.8
Native starch price at Bangkok factor	222.2
Transportation cot Nakhon-Ratchasima and Bangkok	9.0
Native starch price at factory in Nakhon-Ratchasima	213.2
Processing cost of native starch (conversion rate starch to root 1:5)	52.0
Value of the root per ton of starch at factory	161.2
Value of waste (10% of the value of root)	16.1
Total value of root per ton of starch at factory	177.3
Price of root per ton (177.3/5) (root price at the factory in Nakhon-Ratchasima)	35.5
Production cost of roots in 1989/90 (published by MOAC)	17.6

Domestic utilization and export: current and future

Domestic utilization by food industries

In general, domestic utilization of cassava starch can be classified into two categories namely, food industries and non-food industries. There are no official records of total cassava starch consumption of both industries. Therefore, in 1991 an industrial survey was conducted by a team of researchers from the Thailand Development Research Institute Foundation (TDRI) to compile and estimate starch consumption in 1991 as well as to project the future utilization. The estimation was carried out by estimating the percentage of starch consumption per unit of the food or non-food final product. Then the total starch consumption of each final product was computed by multiplying the percentage use with the total annual production of each final product. In each case, the annual total cassava starch consumption for producing the final products was obtained from the survey in a discrete series, then the complete series was constructed using the growth rate between the periods.

Once the series on starch consumption was constructed, the future consumption of starch of each product was forecasted by a simple demand projection equation as follows:

$$D = R + NY \quad \text{(Equation 1)}$$

where D = growth rate of quantity demand for the final product

R = growth rate of population the annual population growth rate estimated by the TDRI at 1.33% for the period of 1991 to 2001 was used)

N = income elasticity of demand for starch of the final product (using the per capita income at the 1972 base year)

Y = growth rate of income per capita at the 1972 base year (using the TDRI projection of 6.45% for the period of 1991 to 2001)

The detailed estimation of each final product's starch consumption is discussed for food industries (monosodium glutamine, lysine, sweeteners excluding fructose, pearl, direct human consumption and other food industries) and non-food industries (paper industry, plywood industry, textile industry, other industries).

In 1991, there were three monosodium glutamate (MSG) factories, namely Ajinomoto, Raja and Thai Churos. Ajinomoto set up the first MSG factory in Thailand in 1960. This factory may be regarded as the first modern technology modified starch factory using cassava starch. Among these factories, only Ajinomoto used cassava starch as the major raw material for producing MSG with a conversion rate of 2.4 tons of starch per ton of MSG, while the other two factories used only molasses as raw material. In 1986, the Ajinomoto group set up a factory for producing lysine in Thailand which was the first and only such factory in southeast Asia. In producing lysine, the conversion rate of cassava starch was the same as that of the MSG.

It was found during the industrial survey that cassava starch consumption for producing MSG and lysine was 28,000 tons, 33,000 tons, and 87,000 tons in 1980, 1985, and 1990 respectively. In terms of growth rate, it was at 3.3% during 1980-85, and was at 21.4% during 1985-1990. Based on these growth rates, a series of starch consumed by MSG and lysine production during 1980-1990 was constructed. This series was used for estimating the income elasticity of demand for starch for producing MSG which was 1.75. The estimated equation, for which autocorrelation was corrected, is as follows:

$$\ln(ST1) = -16.043 + 1.749 \ln(GDP)$$
$$(-9.125) \quad (9.034)$$
$$R \text{ square} = 0.950$$
$$D.W. = 1.244$$

Where: In = natural logarithm

ST1 = per capita demand for starch for producing MSG/lysine

GDP = per capita income at 1972 base year

Then one can compute the approximate annual growth of demand for starch for producing MSG and lysine by equation 1. Thus, D is equal to 12.617% (or 1.33+1.75x6.45). Then the starch consumption for producing MSG and lysine in 1991 is equal to 97,977 tons (87,000x1.12617).

The domestic production of glucose syrup started in 1950, while the production of glucose powder started later in 1976, and the production of sorbital in 1980. The conversion ratios of each product and the estimated annual production obtained from the survey are as follows:

Product	Conversion ratio starch: product	Estimated annual Production (tons)
Glucose syrup	1 : 0.92	30,000
Sorbital	1 : 1.20	28,000

Glucose syrup producers estimated that sweetener production consumed 28,040 tons, 42,060, tons and 70,100 tons of cassava starch in 1980, 1985, and 1990. Based on this information, a series on cassava starch consumed by sweetener production was constructed and the income elasticity of demand for starch in producing sweeteners was estimated at 1.16. Hence, the annual growth rate of demand for sweetener was calculated at 8.812% which was used for projecting the demand for cassava starch for producing sweetener (excluding fructose) during 1991-2001.

Pearl or tapioca sago was produced by many small factories and a few large cassava starch factories. In 1990, the TTFIA listed 12 pearl factories, 5 of which were large factories and the rest were small. However, it is believed that there are many more small household pearl factories producing pearl from cassava starch. The production process is simply mixing starch with water and making it into pearl, then it is dried in the sun. The conversion rate of cassava starch to pearl is 1:0.9. Cassava starch used for producing pearl was about 23,000 tons and 30,000 tons in 1986 and 1990, respectively, which was equal to a rate of growth of 6.7% per year. The pearl producers expected that the same growth rate will be realized in the future, because both domestic and export markets are expanding. Therefore, the 6.7% growth rate was used in the projection of cassava starch used in pearl processing.

The quantity of cassava starch consumed annually for preparation of food and desserts at home was estimated by using a constant per capita consumption at 2.37 kg. This figure was approximated from the household survey conducted by the Office of Agricultural Economics, MOAC, during 1970/71. It was reported that total starch consumption was 7.12 kg per person per year. Generally, there are three kinds of starch consumed at home namely rice starch, sticky rice starch and cassava starch. Assuming equal proportions of starch consumption, then per capita cassava starch consumption would be 2.37 kg. The series on direct human starch consumption was constructed for 1991 to 2001 by assuming constant per capita consumption at 2.37 kg and using the population projection of TDRI.

Cassava starch is used as raw material or ingredient of many other food industries such as instant noodles, vermicelli, sauces, soup, sausage, candy and canning. The estimated annual cassava starch consumption of other food industries was 17,960 tons and 31,986 tons in 1980 and 1990, respectively. Based on these data, the income elasticity of demand for starch of other food industries was calculated at 0.64. Then equation 1 was used for the projection of future starch consumption of other food industries.

In 1989, the Thai Pulp and Paper Industries Association (TPPIA) reported that there were 38 paper mills, 12 of which received Board of Investment (B01) privileges. The annual total capacity was 870 thousand tons of paper of which 521, 193, 110, and 46 thousand tons was kraft paper, printing and writing paper, paper-board and sanitary paper, respectively. Thailand imported all its newsprint from abroad, but it is expected that by the end of 1993 there will be three operational factories with total annual capacity of 300 thousand tons newsprint paper.

Among these five type of paper, only kraft paper, printing and writing paper, and paper-board use cassava starch as a raw material in production. Industry participants indicated that the average starch application rate of these three kinds of paper was about 5% of the total weight, and production of these papers expanded at a rate of 13% per annum. From this information, cassava starch consumption in the paper industry was estimated at about 42 thousand tons in 1990, and projection of future cassava starch consumption was based on the 13% annual growth rate.

There were 35 plywood manufacturers in 1990. One sheet of plywood used 0.3726 kg of cassava starch. On average, one metric ton of plywood has 80 sheets. However, experts in the plywood industry indicated that the available information of total plywood production was not accurate. This is due to under reporting by some manufacturers in recent years when logs were imported from neighboring countries. It was suggested that more accurate plywood production could be estimated by the rather constant plywood market share of the Thai Plywood Company Limited, which is a state enterprise, at 10% during the last few years. The available data enabled estimates of 4,775, 6,924, and 6,700 tons of cassava starch consumption in the plywood industry in 1989, 1990, and 1991, respectively.

It is believed that 6,700 tons cassava starch consumption will be the maximum level for the next three years, based on at least four reasons. First, it will be difficult to import logs from the neighboring countries for the years to come, because these countries will establish their own plywood industries, and the price of logs will increase. Second, there is a strong tendency of using other board to substitute for plywood, such as hard board, medium board, medium density fiber board (MDF) and soft board. Some of these products are made from sugar cane fiber. Third, the comparative advantage in plywood production of Thailand will decrease in comparison to Indonesia and Malaysia in the future. Finally, cassava starch was replaced by a phenolic which provides a better adhesive quality in some plywood factories. Therefore, it is expected that the total cassava starch consumption in the plywood industry will decrease at 30-40% from the 1993 level and remain stable until the year 2000.

Cassava starch is applied to yarn in the warp prior to weaving. It was estimated that cassava starch was used at about one percent of the total weight of the warp. As a matter of fact, modified starch is used in dye processes which are not yet well developed in Thailand. Therefore, the estimated cassava starch in the textile industry based on the current major usage should be regarded as the minimum level of consumption. A series on cassava starch consumption in textile industry was constructed for the period of 1985 to 1990, then a simple trend regression based on this series was estimated and used for projecting the future consumption. The simple trend equation is as follows:

$$STH = 9657.5 + 816.5\ YR$$

t-value (26.699) (6.182)

R square = 0.9508 D.W. = 2.001

where STH = total annual cassava starch consumption

YR = year 1985 = 1

Other industries include those industries using cassava starch as raw material, such as the glue industry, paper product industry, and chemical industry. The estimated cassava starch consumption obtained from traders was about 15,000 and 60,000 tons in 1980 and 1990, respectively, indicating an annual growth rate of cassava starch consumption of 15% during this period. This growth rate was used for projecting the future consumption of cassava starch.

Estimated cassava starch consumption is presented in Table 3. In 1991, the total domestic cassava starch was estimated at 511,221 tons of which 73% was consumed by the food industries and direct home consumption. Direct home consumption has the highest percentage of total consumption at 26% followed by MSG and lysine, at 19%. The total non-food industries consumed 136,149 tons of starch or 27% of the total. The `other non-food industries' consumed the highest percentage at 13%.

Table 3 Projected consumption in tons of cassava starch in food and non-food industries.

Industry	1991	1996	2001
Food Industry	375,071 (73)*	516,463 (70)	772,819 (65)
MSG and lysine	97,977 (19)	170,456 (23)	322,194 (27)
Sweeteners (excluding fructose)	76,375 (15)	113,368 (15)	177,490 (15)
Pearl	32,060 (3)	44,690 (6)	62,295 (5)
Direct human consumption	134,908 (26)	144,582 (19)	153,645 (13)
Other food industries	33,751 (7)	43,367 (6)	57,195 (5)
Non-Food industry	136,151 (27)	226,357 (30)	411,634 (35)
Paper	47,098 (9)	86,776 (12)	159,879 (15)
Plywood	6,700 (1)	2,010	2,010
Textile	14,557 (3)	18,640 (3)	22,722 (2)
Other industries	67,796 (13)	118,931 (16)	227,023 (19)
Total	511,221 (100)	742,818 (100)	1,184,453 (100)

Source: TDRI "Cassava: A Scenario of the Next Decade" Jan. 1992.

* Figures in parenthesis are the percentage of the total.

The estimated total domestic starch consumption for 2001 is 1.18 million tons. Although the starch consumption of non-food industries will increase to 0.4 million tons (35% of the total), most of the domestic starch consumption will still be in the food industries. Among the industries, the starch consumption of the MSG/lysine industry will be the highest at 27% of the total.

It should be noted out that the fructose industry used about 9,000-15,000 tons of cassava starch during 1988-1990. However, fructose has not yet been used in the domestic soft drink industry due to existing food regulations. If fructose can penetrate into the soft drink industry, then it is expected that the demand for fructose will increase at about 20% per annum. That means an additional 17.6, 38.0, and 92.2 thousand tons of cassava starch will be consumed by the fructose industry in 1991, 1996, and, 2001, respectively.

Exports and major markets

As mentioned earlier, export markets for Thai cassava starch have a strong influence on domestic price formation. Therefore, the future prospects of export markets are very important for the development of the cassava starch industry and the cassava industry as a whole. By and large, cassava starch has been an export oriented industry since the 1940s. Although the quantity of exports of cassava starch has been fluctuating, a clear upward trend was observed, especially during the period of 1985-1990. Data obtained from TTFITA show that the total quantity of cassava starch (including native and modified starch) exports increased from 459,048 tons in 1985 to 656,291 tons in 1990, of which export to Japan and Taiwan increased from 143,619 tons and 124,926 tons to 204,572 tons and 248,434 tons, respectively. This implies that the export share of Japan and Taiwan increased from 58% to 69% of the total. It is expected that Japan and Taiwan will be the major export markets for the years to come.

Data from the Ministry of Agriculture of Japan show that total annual starch consumption increased every year from 2.4 million tons in 1986 to 2.7 million tons in 1990. However, experts in starch markets estimated that Japan consumed at least 3.5 million tons of starch annually, while the Japanese government allowed an annual import quota for starch of not more than 0.2 million tons. This measure was aimed at protecting the domestic starch industry which produced mainly sweet and white potato starch.

In 1990, in terms of percentage of starch consumption by Japanese industry, the dextrose syrup industry consumed 60%, followed by chemical or modified starch (13%), fibers, food and others (11%) and the paper industry (8%), while the rest was consumed by beverages (6%), fish paste products (3%) and monosodium glutamate (1%). The source of starch supply was mostly from corn starch (79%), white potato starch (10%), sweet potato (5%), imported starch (4%) and wheat starch/flour (2%).

It should be noted that all this starch consumption does not include modified starch. There are five groups of eligible starch importers which consist of syrup dextrose producers, modified starch processors, re-export processing industry, and others e.g. glutamate, medical, and adhesive. This implies that import starch is virtually all consumed by industries and processing.

In 1990, the available average wholesale price of starch in Japan clearly showed that native cassava starch was the cheapest of all starch. Therefore, if there were no import barrier, the import of cassava starch would increase tremendously.

Table 4 The average wholesale price of starch in Japan, 1990.

Starch	Price (yen/kg)
Domestic starch	
Sweet potato starch	65.0
White potato starch	140.0
Corn starch	62.0
Imported starch	
Native cassava starch	33.0
White potato starch	63.0

Source: TDRI "Cassava: A Scenario of the Next Decade" Jan. 1992, obtained from the Modified Starch Association of Japan.

The import of modified starch, which is under HS code 3505.10, is subject to 8% import duty if imported from developed countries, while that imported from the least developed countries largely received a preferential tariff (zero tariff). Nevertheless, the Japanese government has initiated the imposition of an import ceiling at a total value per year since 1989. During this early stage of implementation of the import ceiling measure, the Japanese government was still very flexible, and the actual value of imports of some groups of modified starch was very much higher than the ceiling set. As far as competition of imported modified starch is concerned, the domestic modified corn starch is the main competitor.

The competitive position of Thailand in the Japanese market can be divided into two markets. First, in the native starch market, Thailand still has a strong advantage of low price and continuous supply. Second, in the modified starch market, Thailand faces not only competition from the domestic modified starch, but also from modified starch from the EC which imports and processes cheap starch from Eastern European countries for export. Nevertheless, future prospects of cassava starch and modified starch exports to the Japanese market will very much depend upon the trade protectionist policy of Japan.

Taiwan is a newly developed industrialized country with a rapidly growing economy. Therefore, the agricultural sector in Taiwan has been restructured from basic raw material production to more high value products such as livestock, fisheries, and fruit. Consequently, more imports of agricultural products in both raw material form and as finished products are expected in the future. There is no non-tariff import barrier imposed on cassava starch by Taiwan. However, imports of cassava products are subjected to import duty (Table 5).

Table 5. Import duty imposed by Taiwan on cassava products.

HS Code	Tariff Rate
0714.10 Manioc (Cassava)	20%
1108.14 Manioc (Cassava) starch	17% or 1,200 NT/ton
1903.00 Tapioca and substitutes prepared from starch	17% or 1,306 NT/ton
3505.00 Dextrins and other modified starch	7.5 - 20%* 7.5 - 17%**

Source: TDRI "Cassava: A Scenario of the Next Decade" Jan. 1992.
* imposed for all countries
** applied for countries that have reciprocal arrangement, such as Thailand.

There are good prospects for Thai cassava starch exports to Taiwan. Thai exporters and concerned government agencies have been actively promoting tapioca product exports to the Taiwan market.

Projections of cassava starch exports to Japan, Taiwan and total starch exports were carried out using simple linear trends. The projected quantity of exports is shown in Table 6. It should be noted that projection of the total quantity of exports of cassava starch did not consider the possibility of new markets. It is expected that South Korea will be a possible new market for Thai cassava starch, especially cassava starch for use in the paper industry. At present, the import of cassava starch under HS code 1108.14 is under import control without specified import quantity. In addition, it was estimated that at least 10 thousand tons of cassava starch could be exported to Russian markets, if there were special export credits available to Thai exports through the establishment of on export-import bank.

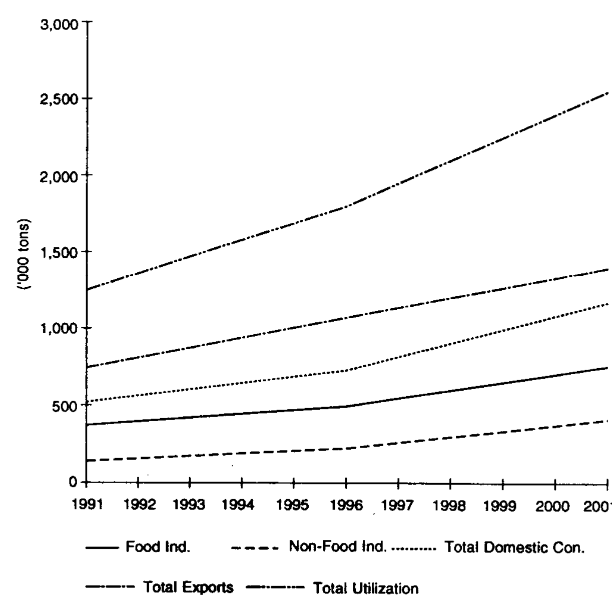
Table 6 Projected cassava starch exports in tons to Taiwan and Japan and total exports,

Year	Taiwan	Japan	Total Export
1993	355,673	259,837	872,614
1994	390,922	278,065	939,709
1995	426,171	296,293	1,006,805
1996	461,420	314,520	1,073,901
1997	496,668	332,748	1,140,997
1998	531,917	350,976	1,208,093
1999	567,166	369,204	1,275,189
2000	602,415	387,431	1,342,285
2001	637,664	405,659	1,409,381

Source: TDRI "Cassava: A Scenario of the Next Decade" Jan., 1992.

From the estimated total quantity demand for cassava starch in both domestic and export markets in 1996, domestic consumption will account for 41% of the total of about 1.82 million tons or 9.1 million tons of root. In 2001, the total cassava starch quantity demand will increase to 2.6 million tons or 13 million tons of root, of which domestic consumption will account for 46%. These figures indicate that the cassava starch industry will still be an export oriented industry in the future (Figure 5).

Figure 5 Projected total starch utilization (total domestic consumption and exports).



Scenario of future industrial adjustment

As mentioned earlier, that the Common Agriculture Policy (CAP) of the EC triggered the development of Thai cassava products for the animal feed industry. In addition, the EC has been the only principal market for these products, due to high cereal prices in the EC. Therefore, any changes to CAP will have a strong impact on the Thai cassava industry, and an analysis of CAP reforms will be imperative for the future prospects and development of the industry.

The CAP reforms

In general the CAP has well achieved the food self-sufficient objective of the EC, but the EC had to pay a high price for it by subsidizing the agricultural sector. There were many problems arising from the CAP such as over production of cereal, livestock products and dairy products that cost more than 79,299 million ECU for subsidizing all these agricultural products during 1986-88. One of the reasons for over production of cereal was the reduction of cereal use in the feed industry every year in the EC, in which high domestic priced cereal was substituted by the cheap import of NGFI. In fact, the EC has been trying to limit and decrease the import of NGFI by setting up quotas for import of cassava products for Thailand, Indonesia, Brazil, and China. However, there were many other NGFI which were imported without any restriction and tariff.

Having all these problems created by CAP, the EC has also faced pressure of trade liberalization from the Uruguay Round of trade negotiations under GATT. Therefore, it seemed that CAP reforms were inevitable. The major emphasis of the CAP reforms is to reduce the grain and meat surpluses through a decrease in agricultural supports. The strongest impact on the import of NGFI is the drastic decrease of intervention price of cereals which will cause a severe decrease in the domestic wholesale price of cereals. There are three major changes from the existing system as follows:

- agricultural supports are shifted from solely price supports to compensatory payments to producers;
- measures on increasing production for self-sufficiency are no longer emphasized; and
- there is a willingness to encourage free trade, while maintaining the basic principles and instruments of the CAP.

As far as the cereal prices are concerned, under CAP reforms, the buying-in and intervention prices are the same for all cereals. Table 7 shows intervention prices, target prices and threshold prices for all cereals from the July 1993/1994 season onwards. The international price is the price at which the EC is prepared to buy cereal if the market price falls below it. The target price is that which the EC wants producers to receive (and consumers to pay). The EC will intervene through import levies (taxes) or buying up surpluses to ensure that price does not fall below the target level. The threshold price is the price at which imports of cereals enter the EC or the world price plus the variable import levy.

Table 7 CAP intervention, target and threshold prices in ECU/ton.

Season	Intervention Price	Target Price	Threshold Price
1993/94	117	130	175
1994/95	108	120	165
1995/96	100	110	155

Impacts of CAP reforms on price of tapioca products and root price

It is expected that the CAP reforms will have strong impacts on imports of NGFI, especially energy source feed ingredients i.e. tapioca products. As cereals become a cheaper energy source, other energy substitutes for cereals will be used less. The EC study reported that a substitution effect would be a around 6 to 7 million tons.

Given the previous years price relationship between common feed wheat and tapioca products at 24 ECU/ton, it is expected that, for Thai tapioca products to be competitive in the EC market and be consumed by the animal feed industry at the current rate at around 5 million tons, the wholesale price of tapioca hard pellets (c.i.f. plus tax) in Rotterdam would have to decline (Table 8).

Table 8 Wholesale price of tapioca pellets and root farm gate price.

Season	Wholesale price of tapioca pellets in Rotterdam (Ecu/ton)	Farm gate price in Nakhon Ratchasima	
		(US$/ton)	(baht/ton)
1993/94	93	22.81	577.14
1994/95	84	18.78	475.26
1995/96	76	15.93	403.00

However, the price levels in Table 8 are regarded as the worst scenario. Given the exchange rate of 1 ECU = 1.19 US$ and 1 US$ = 25.30 baht, the farm gate price of cassava root in Nakhon Ratchasima province in Thailand would decline also.

Based on MOAC statistics, the national average production cost of cassava root in 1991/92 was at 540 baht/ton (US$ 21.34/ton), indicating the farmer would have only 37.14 baht/ton (US$ 1.47/ton) net profit in 1993/94. Then in 1994/95 and 1995/96, the farm gate price would be less than the production cost. Obviously, if the above price level became a reality, one would expect cassava farmers to produce other crops instead of cassava.

It is quite obvious that the above hard pellet prices in Rotterdam (76-93 ECU/ton) and the root prices in Nakhon Ratchasima (15.93-22.81 US$/ton) will not be attractive for Thai exporters to export to the EC. That means the quota rent for the export quota to the EC will vanish. Then it would be rather difficult for Thai exporters to export pellets to the non-EC markets at a low price to obtain an export quota to the EC which enables them to sell pellets at a high price. As a matter of fact, the present non-EC markets for Thai pellets are subsidized by the quota rent to the EC. These markets will not be potential markets for tapioca pellets, unless there is drastic shortage of cereals and the price of high protein feed ingredient (soybean meal) is very low in the world market.

Impacts of CAP reforms on Thai cassava starch industry

After implementation of the new CAP in July, 1993, it was observed that the factory buying price of root in Nakhon Ratchasima decreased from 740 baht/ton in July to 700 baht/ton in October. This was due to adjustment of the compound feed industry in the EC and the Thai exporters to the CAP reforms which caused a lower export price of tapioca products for animal feed in the EC, and consequently the producers of tapioca chips and pellets had to lower their buying price of roots. As the root price decreased, the supply of root also decreased. Therefore, the immediate impact of CAP reforms on the cassava starch industry was that cassava starch factories were competing with each other to obtain their root supply at a lower price level. This would mean that if farmers were delaying their harvest of root, the price of root would increase in the short-run. However, if the price of tapioca products in the EC decreased to 93 ECU/ton, there would be a drastic decrease of exports to the EC. Eventually, there would be a surplus of cassava root and its price would decrease lower than 700 baht/ton.

If the price were at the level of 700 baht/ton (or US$ 27.67/ton) which would give a net farm gate price of 580 baht/ton (US$ 22.92/ton), it would not be profitable for some farmers to grow cassava. The 1993/94 root production cost in Nakhon Ratchasima was between 664.80-578.50 baht/ton (US$26.28-22.87/ton), implying that cassava root production will decrease in the years to come.

Studies from the Department of Agriculture reported that cost of production of cassava root could be decreased to 509.0 bath/ton (US$ 20.12/ton) by following proper agricultural practices and by using the new Rayong 60 variety. Therefore, it is quite clear that if cassava root production were to be profitable, farmers would have to use new agricultural practices and the new variety. At present, the private sector through the trade association has been working closely with the concerned government agencies in providing extension services of new agricultural practices and the new variety to cassava farmers in Nakhon Ratchasima.

Nevertheless, extension service activities are not sufficient to encourage farmers to grow cassava root, if there is no assurance on the farm gate price. Having realized this crucial price assurance problem, the cassava starch factories have initiated and explored the possibility of contract farming of cassava roots for securing their raw material supply.

In order to avoid cassava root surplus, the government had already launched a program of offering incentives and supports to farmers for reducing cassava planted areas of 0.4 million rai

(64 thousand ha) since early 1993. Although it is premature to assess the success of cassava reduction program, it is quite certain that cassava root production will decrease, if the root price level of 700 bath/ton is realized.

Therefore, cassava starch factories will face problems of root supply and the actual operating period of the factories will be less than 8 months if contract farming of cassava root production and extension of new higher starch content and high yielding varieties as well as proper agricultural practices are not realized in the years to come.

It should be noted that as the production of tapioca products for animal feed decreases, the cassava root market will be dominated by starch factories in the cassava producing areas. During the peak season of root, it will be impossible for the local cassava starch factories to buy all the root supply, so the price of root will decrease to a level at which the chip and pellet factories find it profitable to start their operation. Therefore, a new market equilibrium of root price will be established at a price level which is profitable for chip/pellet producers and farmers. Such a price level will very much depend upon the export price of chip/pellet and the domestic demand for these products.

At any rate, it would be a mutual benefit for both farmer and cassava starch factories to set up a system which can regulate the root supply. Eventually, cassava root will supply the high value-added starch processing industry and low starch content root will find a second market in the chip and pellet processing industry. This is the envisaged scenario, if the export of tapioca products as animal feed to the EC is decreased drastically. At this juncture, it may be too soon to believe that such a scenario is likely to happen.

As root production decreases due to low price and decreasing demand for root for tapioca products for animal feed for export, the root marketing period will be shortened and adjusted to the seasonal demand for tapioca products in the EC market. Cassava starch factories will face shortened operational periods and higher average cost of production. To overcome such problems, the factories have at least two alternatives, increasing capacity per day or minimizing production cost as much as possible.

The first alternative might be possible through merging of factories in the areas. This would mean that only those large and efficient starch factories will be able to survive, and their operation would also be further integrated with high value-added processing activities such as modified starch. In addition, the factories might also be forced to take market positions in the commodity trade rather than acting solely as processors.

The second alternative may be achieved through joint efforts in requesting government authorities to provide a special rate for electricity charges. This is due to the fact that electricity cost accounts for more than 35% of the total processing cost of cassava starch.

The concerned government agencies realized that it would be too naive to assume that CAP reforms will not generate any negative impacts on the Thai tapioca industry, especially those tapioca products for animal feed. The only policy implemented was the program of reducing cassava area planted. At present, the government has not yet formulated short-run and long-run policies on the cassava industry.

Summary and conclusion

The cassava starch processing industry earned a billion US dollars from exports in 1991. The path of industrial development has been, in general, under a free market system with limited government intervention. The Common Agricultural Policy (CAP) of the EC triggered the rapid development of cassava products for animal feed for export in the 1970s. Since then, the whole cassava industry has shifted from starch processing to the processing of tapioca products for animal feed, which was an export oriented industry.

Although in percentage terms, the proportion of exports of cassava starch to total export of cassava products deceased from 25% in 1966 to 11% in 1991, starch export increased at an annual growth rate of 5.5%. The US and Japan have been the major market for Thai cassava starch since 1966. In these markets cassava starch has been competing with domestic corn/maize starch. During the 1980s Taiwan became the third most important market for Thailand. In Taiwan, starch was used in various industries and also in modified starch processing.

In 1982, the signing of EC-Thai Cooperative Agreement, which set a maximum import quantity of 21 million tons within four years, created active exploration for other usage of cassava root. This eventually focused on further value-added processing of cassava starch or so-called modified starch for more industrial applications. The movement of modified starch was a great hope for the whole cassava industry. The initial stage of modified starch was again for export to Japan.

As a matter of fact, cassava starch was used for domestic consumption in both human and industrial consumption in a relatively small quantity in comparison to the exported quantity. In 1965, the estimated total domestic starch consumption was 44,557 tons, while the exported quantity was 148,206 tons. During 1965-80, most of the starch was used by the monosodium glutamate industry (22%), food industries (27%), paper industry (16%) and for direct human consumption (16%).

The outstanding economic performance of Thailand during 1980-1990 in both industrial and agro-industrial sectors drew attention of cassava starch industry entrepreneurs to the domestic utilization of starch and its potential. During 1990-91, a cassava starch industrial survey was carried out with the objective of estimating the domestic starch consumption in various industries and to project the starch utilization scenario into the next decade.

It was found that in 1990 there were 84 cassava or native starch manufacturers with a total capacity of 2.0 million tons of starch per year. However, only 50 factories were actively operating in 1991 and produced 1.4-1.6 million tons of cassava starch. There were 17 modified starch factories with estimated capacity of 0.3 million tons/year and the actual production was about 0.25 million tons.

The estimation of domestic cassava starch consumption was comprised of starch consumption in producing monosodium glutamate (MSG) and lysine, sweeteners (excluding fructose), paper, home consumption, food industry, pearl, textile, plywood, and others. The annual consumption of each item was derived from the percentage of starch used in the finished products. For example, the production of MSG consumed cassava starch as 51% of the total weight, therefore the annual starch used was simply the total MSG production which used starch multiplied with the said percentage. The estimated figures were then checked with industrial participants. Statistical estimation of income elasticity and time trends was also employed in computing the series on starch consumption as well as the projection.

In 1991, the estimated total domestic utilization of starch was 511 thousand tons of which direct human consumption and food accounted for 33%, MSG and lysine 19%, glucose syrup 15%, the paper industry 9%, textiles 3% and the plywood industry only accounted for 1%. The projected starch consumption in 2001 was 1,184 thousand tons. This scenario showed that direct human consumption and other food industries will decrease to 18%, and that of textile and plywood will also decease to only 2% and 0.2% respectively. However, the starch consumption in MSG and lysine will increase to 27% and paper industry increase to 15%.

The scenario of total cassava starch utilization in 1991, which was the summation of total domestic consumption and total export, was at 1,250 thousand tons, and it was projected to increase to 2,594 thousand tons in 2001. The export projection covered only two major markets (Japan and Taiwan).

In spite of the fact that domestic consumption of cassava starch has been increasing over time, the domestic price formation of starch has been very much dependent upon the export price of starch, especially the modified starch in recent years. It is envisaged that the cassava starch industry and the cassava industry as a whole will still be an export oriented industry for the years to come. Therefore, the CAP reforms of the EC, which reduced the domestic cereal prices by 29% within the period of July 1993 to June 1996, will have strong impacts on the cassava industry.

An assessment of impacts of the decrease of cereal price in the EC to 117 ECU/ton in 1993/95 on Thai pellet price in the major market in the EC (Rotterdam) was conducted. This has predicted a decrease in the Thai pellet price in Rotterdam to 93 ECU/ton which, in turn, decreased the farm gate price of cassava root in Nakhon Ratchasima province in Thailand to US$ 23/ton in 1993/94. This farm gate price is slightly higher than the production cost. If such a scenario materialized, then the cassava starch industry will be the major cassava root buyer in the domestic market. However, if the CAP reforms drastically decrease Thai tapioca exports to the EC, the production of cassava root in the future would decrease. This would imply that cassava starch factories would have problems of obtaining their raw material supply. In order to overcome such problems, it will be of mutual benefit for starch factories and cassava farmers to have a contract farming system.

Despite the unclear impacts of CAP reforms on the Thai cassava industry, one can conclude that domestic cassava starch consumption will increase and export of starch will have an increasing trend. By and large, the whole cassava industry in Thailand is an export dominated industry which has been facing many trade restrictions. Therefore, the conclusion of the Uruguay Round of the GATT negotiations will have strong impacts on the cassava industry, especially the starch industry. In fact, it is timely for a review of the potential of the cassava starch industry in each cassava producing country in light of its economic comparative advantage over other starch which is produced domestically and its international economic comparative advantage.

As far as the future development of Thai cassava and starch industry is concerned, the following recommendations are put forward:

- research on new usage of both cassava roots and starch should be carried out jointly by private and public sectors;
- research on cost reduction technologies for cassava roots should be enhanced and disseminated to farmers as soon as possible;
- coordination and cooperation between the public and private sectors should be strengthened through frequent dialogue and consultation; and
- short-run and long-run government policies on cassava industry as a whole should be formulated.

Triploid cassava for industry

M.T. Sreekumari, K. Abraham and J.S. Jos*

In India, Cassava (Manihot esculenta Crantz) is widely grown in the Southern States of Kerala, Tamil Nadu and Andhra Pradesh. The use of cassava varies greatly from direct human consumption to use in various industries. Moreover, cassava flour is a partial substitute for wheat flour. To exploit cassava as a better source of starch and other products for the pulp and paper industry, high starch varieties are being evolved. The Central Tuber Crops Research Institute (CTCRI) has achieved this goal to a great extent through polyploidy breeding, especially triploidy.

Triploid cassava was produced by crossing the normal diploids (2n = 36) with induced tetraploids (2n = 72). Induction of tetraploidy was achieved through colchicine treatment (0.5%, 12 hr). Even though tetraploids were not better than the respective diploids in economic characters, they were very useful as pollen parents for the production of triploids (2n = 54). Several combinations of diploid x tetraploid crosses were attempted of wich the recovery of triploids was 96.1% in two crosses viz. OP4 (2x) X S.300 (4x) and OP-4(2x) X H.2304 (4x). The triploid progeny from the above two crosses was thoroughly evaluated.

The triploids possessed several desirable attributes such as compact plant type, vigorous growth habit, thick broad leaves, high leaf retention capacity and comparative tolerance to cassava mosaic disease. The above attributes directly or indirectly contribute to higher productivity per unit area.

There was a high frequency of high yielders (>3.0 kg per plant) in the triploid progeny. However, the occurrence of poor yielders also (up to 12%) in the progeny indicates that higher tuber yield is not concomitant with triploidy per se. In the seedling generation, mean tuber yield was 2.8 kg per plant which was increased to 4.5 kg in the subsequent clonal generations among the triploids compared to 1.3 and 3.5 kg per plant in the seedling and clonal generations respectively among the diploids. Fifty-two superior triploid selections are under different stages of evaluation

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at CTCRI, of which two of them viz. 76/9 and 2/14 were tested in multi-locational and onfarm trials to confirm the higher productivity (Table 1).

Table 1 Performance of the superior triploid selections at different locations.

Variety	Location (yield t/ha)			
	1	2	3	4
76/9 (3x)	32.1	35.5	37.4	33.9
2/14 (3x)	29.5	33.3	33.4	35.7
H.1687 (2x)	24.5	20.4	33.7	34.4
H.2304 (2x)	27.0	23.1	30.1	26.5
Local	16.6	17.9	17.3	20.0
CD 5%	10.03	8.33	11.83	7.27

Triploid cassava in general possessed high dry matter (>44.0%) and starch content (>35.0%) compared to diploids and tetraploids, which is highly beneficial for industrial use. This attribute may therefore be considered to be due to the effect of higher ploidy per se. In the two selections mentioned above, the mean dry matter content was 46.9% and starch 37.1% on fresh weight basis compared to 31.5% starch in diploids (Table 2). Based on yield, starch content and taste, the triploid 2/14 has been proposed for release from CTCRI under the name *Sree Harsha*.

Table 2 Dry matter and starch content of triploid selections in comparison with diploids.

Variety	Dry matter (%)	Starch (%)
76/9 (3x)	48.2	37.8
2/14 (3x)	45.6	36.5
H.1687 (2x)	38.5	31.0
H.2304 (2x)	40.1	32.3
M4 (2x)	39.0	31.2

Although genetic improvement has taken major strides in innumerable crops including cassava, improvement for economic characters through polyploidy breeding in this crop has not received much attention. The production of high starch varieties by changing the ploidy level of the genotype is worthwhile since cassava starch has an important place in several industries.

CGPRT Centre News and Activities

Women's Role in Upland Farming Development

A regional workshop on Women's Role in UPland Farming was held in Chiang Mai, Thailand from 31 January to 3 February 1995, jointly organized by the Office of Agricultural Economics of the Ministry of Agriculture and Cooperatives of the Royal Government of Thailand and the CGPRT Centre. The objective of the workshop was to identify opportunities for enhancing the welfare of rural women and households by integrating women in the development of upland farming, particularly in CGPRT crop based agriculture. Special attention was to be given to the role of women in marketing and processing of CGPRT crops.

A future issue of Palawija News will be devoted to this workshop.

Sustainable Upland Agriculture in South-East Asia

In line with the growing global concern for environmental problems, the Centre recently initiated a research project on Sustainable Upland Agriculture in South-East Asia focusing on CGPRT crops and upland agriculture. The objective of this project is to identify constraints to and prospects for developing sustainable resource management of marginal upland agriculture in South East Asia.

This objective implies that the Centre and its three partner institutes aim to develop methodologies to measure sustainability in upland agriculture. The focus of the project is on the measurement of farmer resource management. The intention of the project is thus to develop yardsticks for farmer resource management which can be used in designing or evaluating development projects for sustainable upland agriculture.

To this end, projects were selected in Indonesia, the Philippines and Thailand. Each of these projects aimed at development of sustainable upland agriculture and had already been completed for some years. This allows measurement of the effect of farmer resource management over time.

The following research agencies are participating with the Centre in the implementation of this project. The selected country projects are also listed:

- Indonesia
  The Central Research Institute for Food Crops, Bogor.

  Upland Agriculture and Conservation Project, 1984-1992, located in Central and East Java.

- The Philippines
  The Bureau of Agricultural Research, Department of Agriculture, Manila.

  The Palawan Integrated Area Development Project I, 1982-1989, located on Palawan island.

- Thailand
  The Office of Agricultural Economics of the Department of Agriculture and Cooperatives, Bangkok.

  The Mae Kham Pong Project and Pioneering Watershed Project Mae Lai Basin of the Agricultural Diversification and Peoples Irrigation Project in North Thailand 1987-1992, located in Prae Province.

During the first quarter of 1995 the project coordinators from the Centre visited all three partner agencies. Then, the national teams started their field work for the project by conducting informal surveys and interviewing farmers about their experiences with the improvements made in each of the project sites.

The final report on this project is expected in the latter part of 1995.

Agricultural Diversification and Food Crop Trade: their Implications for Agricultural Policies in South-East Asia

The project aims to develop a food crop sub-sector model to test the impact of policy options on the welfare of producers, processors and consumers. The first module, based on Javanese farming systems analysis, has been completed. The development of the second part of the model (commodity chain and consumption) is under preparation.

In February the research team started cooperation with the Office of Agricultural Economics in Bangkok (Thailand) and organized a training session on farming systems and commodity chain data analysis to prepare for the development of a similar model in Thailand.

Market Prospects of Upland Crop Products and Policy Analysis in Selected Countries in Asia

The project, funded by the Japanese Government, started smoothly in November 1994 with the arrival of the Japanese expert. During February 22-24 1995, a planning meeting was held for the first country group, attended by representatives from India, Indonesia, the Philippines and Thailand. Dr. Boonjit Titapiwatanakun, Faculty of Economics, Kasetsart University in Bangkok assisted the Centre in implementing the project throughout the planning meeting as a resource person. The national experts will carry out their respective country studies until September 1995. Meanwhile, the Centre is identifying suitable experts for the second country group, which includes China, Pakistan and Vietnam.

From the Database Section

One of the countries participating in the Regional Statistical Database System is Sri Lanka, and its participation has finally been rewarded with the recent publication of CGPRT Crops in Sri Lanka: A Statistical Profile. Pakistans profile is in the works right now, and Centre staff are making significant steps towards its completion.

The RSDS staff are fine-tuning their data storage and retrieval system, and are working on other ideas to help researchers with their studies. The Centres human resources development project will use these concepts to form curricula for courses it will conduct late this year. Subjects to be covered include data management, computer systems planning and maintenance, etc.

Using maps to communicate data and research findings has always been of great interest to the Centre, due to the clarity of information presented this way. Recently, RSDS staff have made advances in producing computer-editable maps for all of Asia. The learning process is, as always, still under way, but major hurdles have been overcome.

Publication Section:

Three new publications were issued recently:

- **Marketing and Processing of Food Legumes and Coarse Grains: Effects on Rural Employment in Asia,** T. Napitupulu, J.W.T. Bottema, D.R. Stoltz, eds., CGPRT Centre. Proceedings No. 29. 1994. 214 p. ISBN 979-8059-56-5.

  This book contains collaborative research results from throughout Asia. The studies in this proceedings were carried out in eight countries: Indonesia, Philippines, Viet Nam, Pakistan, Sri Lanka, China, Thailand and Malaysia, focusing on types of marketing and processing and their effects on employment structures and opportunities.

- **CGPRT Crops in Sri Lanka: A Statistical Profile,** Y.K. Wickramasinghe, G. Balasuriya, Terry A. A. van Dreumel, CGPRT Centre. Working Paper No. 16. 1995. 108 p. ISBN 979-8059-57-3.

  Fifth in its series, this report provides price, production and trade statistics for a wide variety of CGPRT crops. Information is included for rice, maize, cassava, soybean, groundnut, and a dozen other crops. Production is categorized by season, district, and national criteria. Prices are provided on a monthly basis. Costs of cultivation, annual food balance sheets and general indicators are also supplied.

- **Upland Agriculture in Asia,** J.W.T. Bottema and D.R. Stoltz, eds., CGPRT Centre. Proceedings No. 30. 1994. 258 p. ISBN 979-8059-55-7.

  This volume provides an impression of the development and changes in upland Asia. It highlights the diversification and commercialization of upland agriculture, changing food consumption, agro-industry, rural income, resource management and sustainable upland agriculture. It provides a great deal of information and recommendations of use to policy makers and research administrators.

26th International Course on Applied Plant Breeding

International Agricultural Centre, Wageningen, the Netherlands

March 10 - June 22, 1996

The course is an in-service training course intended for university trained specialists in plant breeding, mainly from developing countries, who have not recently had the opportunity to acquaint themselves with modern plant breeding techniques.

Its aim is to upgrade the participants' knowledge of and to give information on new developments in applied plant breeding through lectures and practical training. To be eligible, candidates should have been engaged in plant breeding activities for several years, either in a breeding program, in teaching or in a crop improvement program where breeding is a major component.

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CGPRT Centre

The Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops in the Humid Tropics of Asia and the Pacific (CGPRT Centre) was established in 1981 as a subsidiary body of UN/ESCAP.

Objectives

In co-operation with ESCAP member countries, the Centre will initiate and promote research, training and dissemination of information on socio-economic and related aspects of CGPRT crops in Asia and the Pacific. In its activities, the Centre aims to serve the needs of institutions concerned with planning, research, extension and development in relation to CGPRT crop production, marketing and use.

Programmes

In pursuit of its objectives, the Centre has three programmes which are mutually supportive:

1. Research, which entails the preparation and implementation of studies covering production, utilization and trade of CGPRT crops in the countries of Asia and the South Pacific;
2. Training of national research and extension workers;
3. Information and documentation which encompasses the collection, processing and dissemination of relevant information for use by researchers, policy makers, and extension workers.

Palawija News

Contributors are invited to submit concise summaries of significant social research related to CGPRT crops for publication. Figures (graphs or tables) may accompany the article. All articles are subject to editing to meet space limitations.

Please send all queries relating to articles in *Palawija News* to Publications Section, CGPRT Centre, Jalan Merdeka 145, Bogor 16111, Indonesia.

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