

Cassava Production and Utilization in Asia and its Potential as a Bio-Fuel

Reinhardt Howeler

November 2009



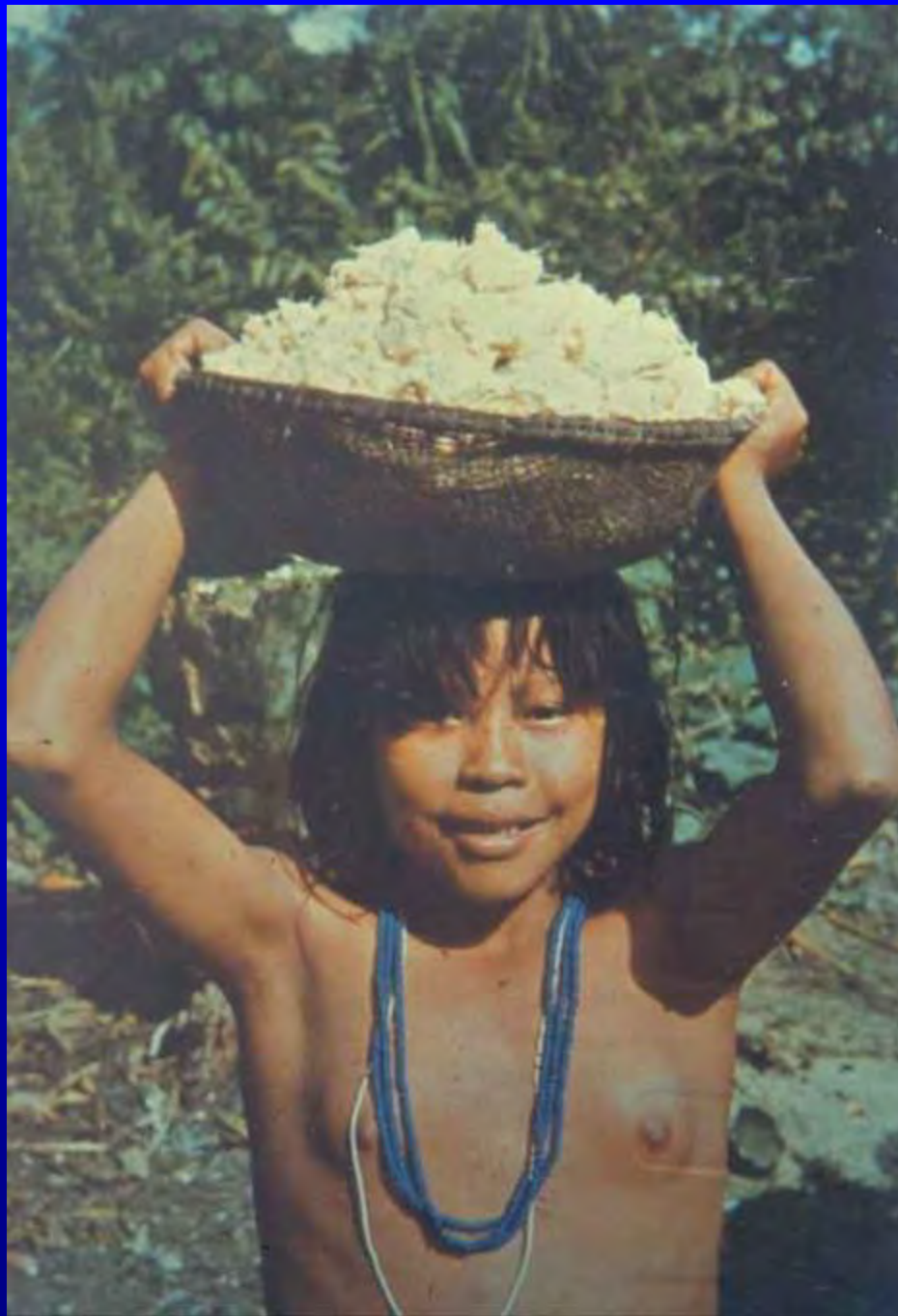
Cassava

**The best kept
secret.....**

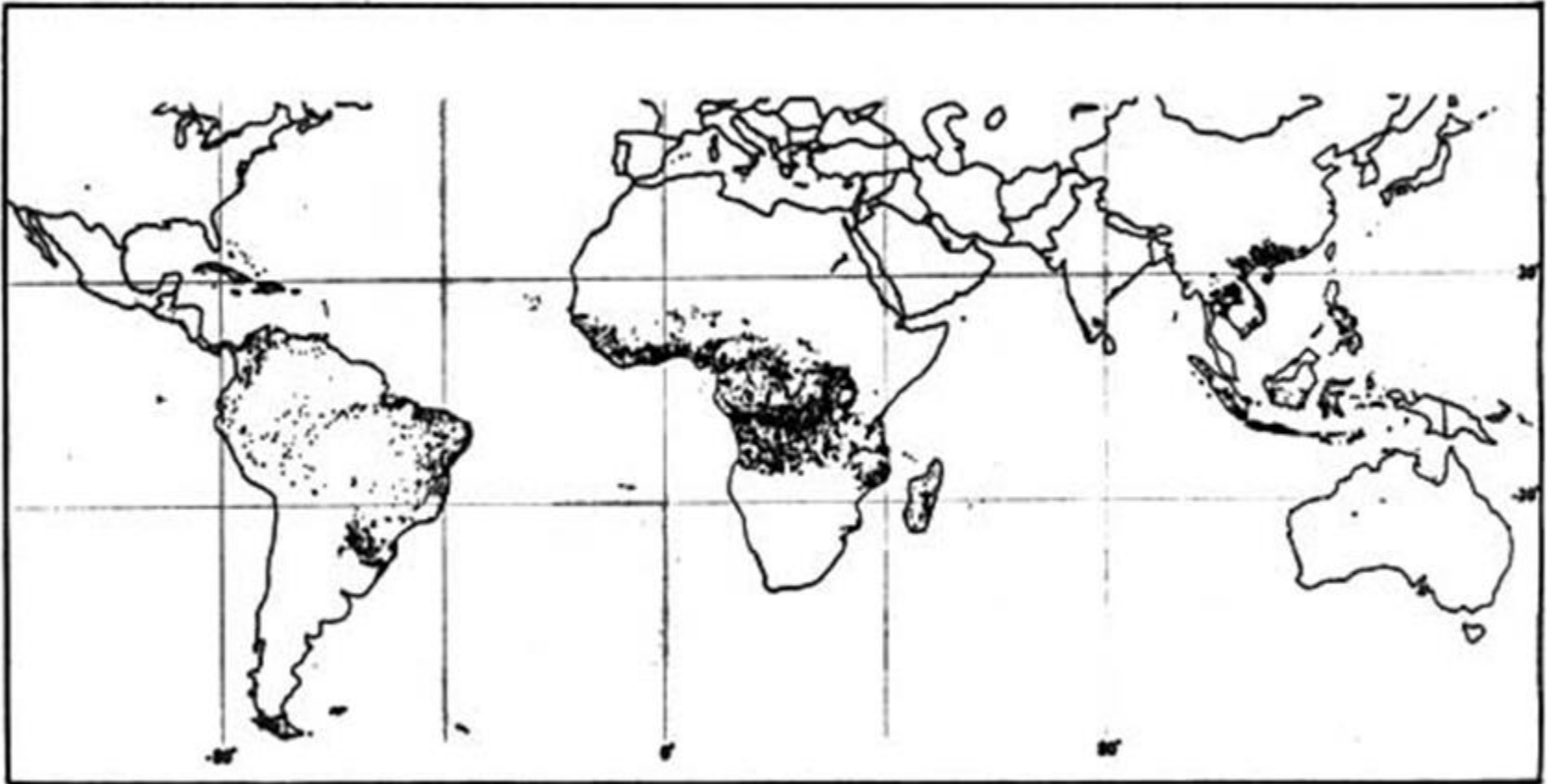
An almost unknown food
crop, but the 5th most
widely grown crop in the
world, after wheat, maize,
rice, and sugarcane



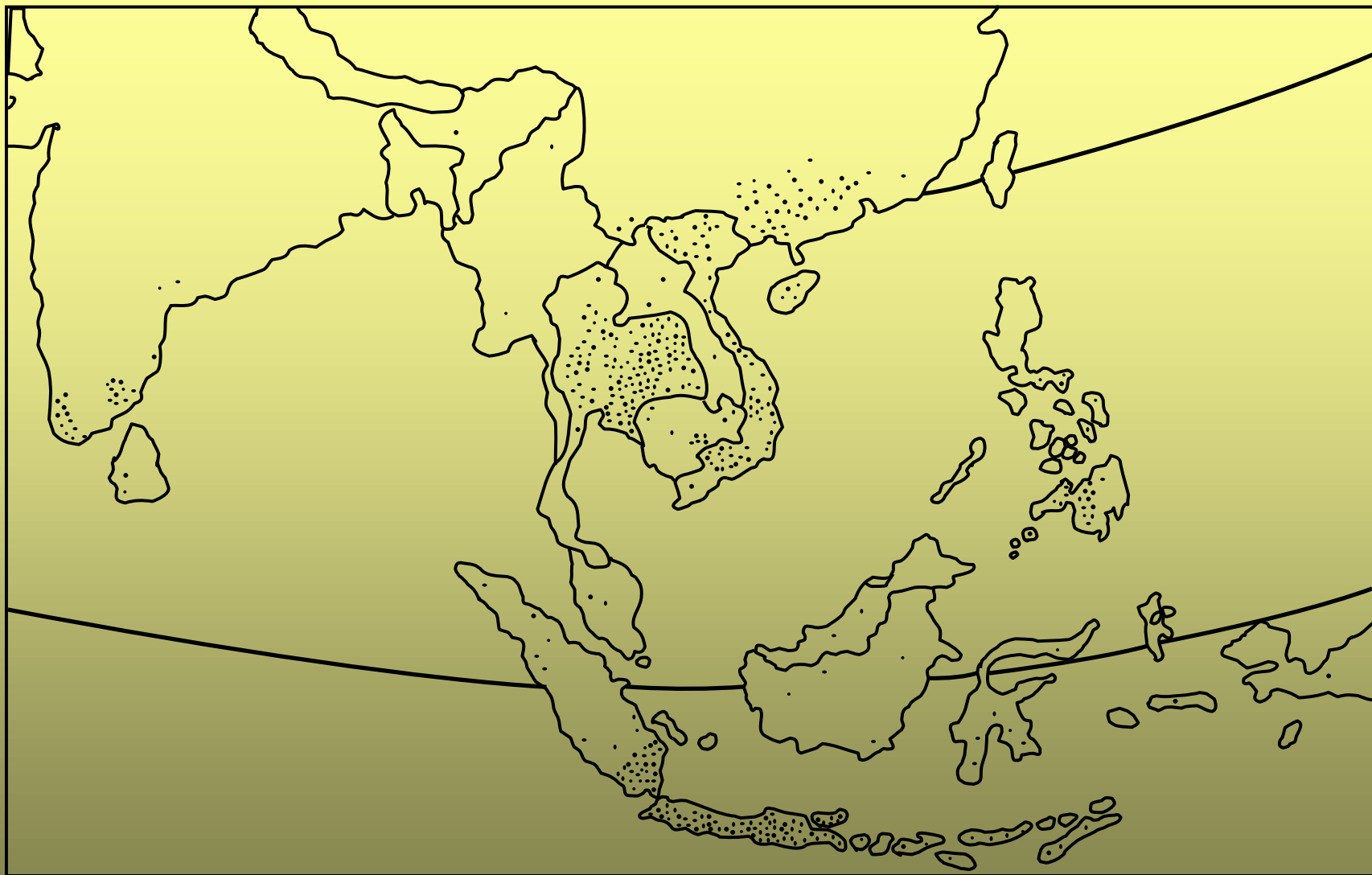
Cassava originated in Latin America and has been grown by the native Indian population for at least 4000 years



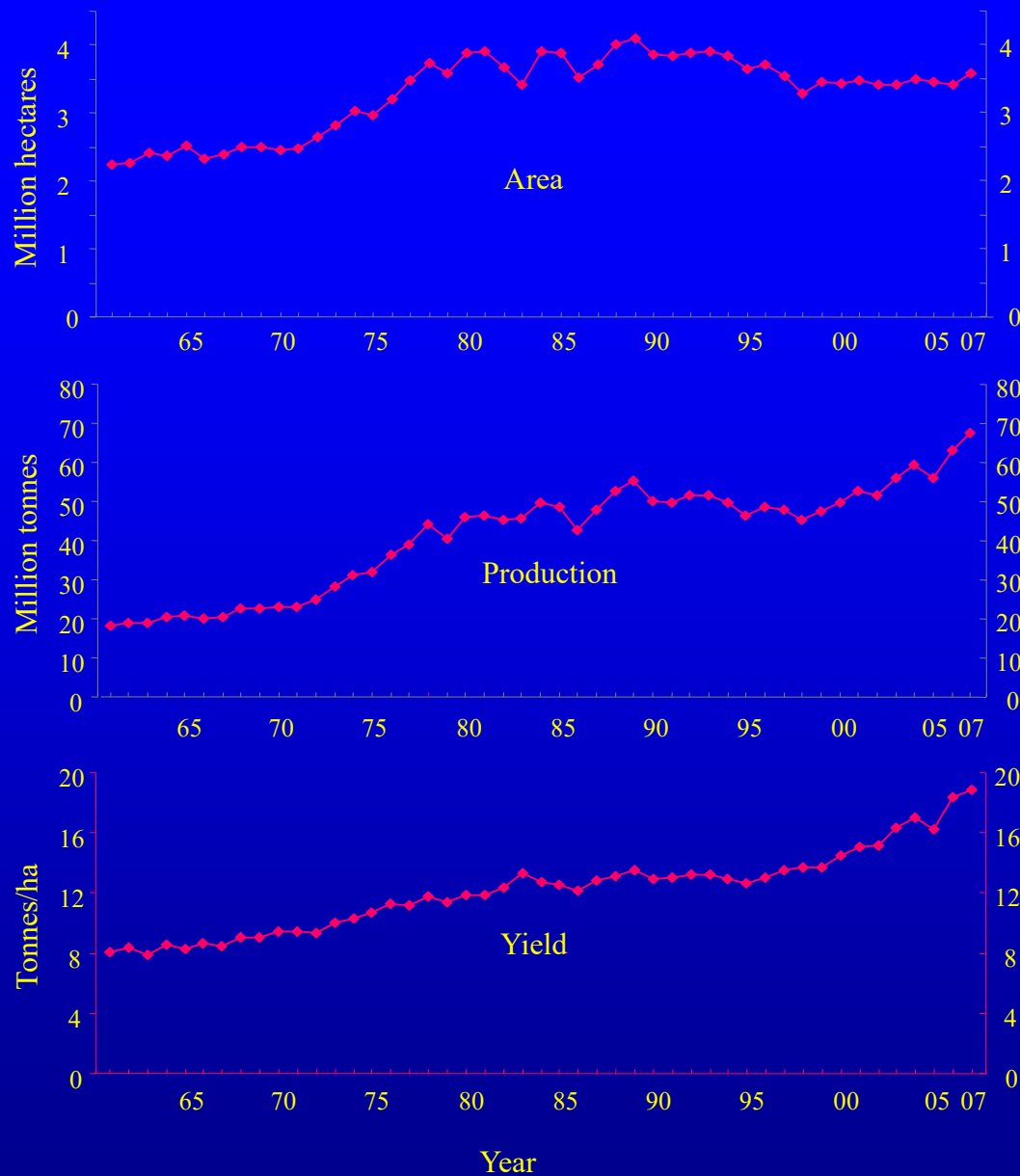
....where it was used as
a staple food after
rasping and squeezing
out the toxic juice



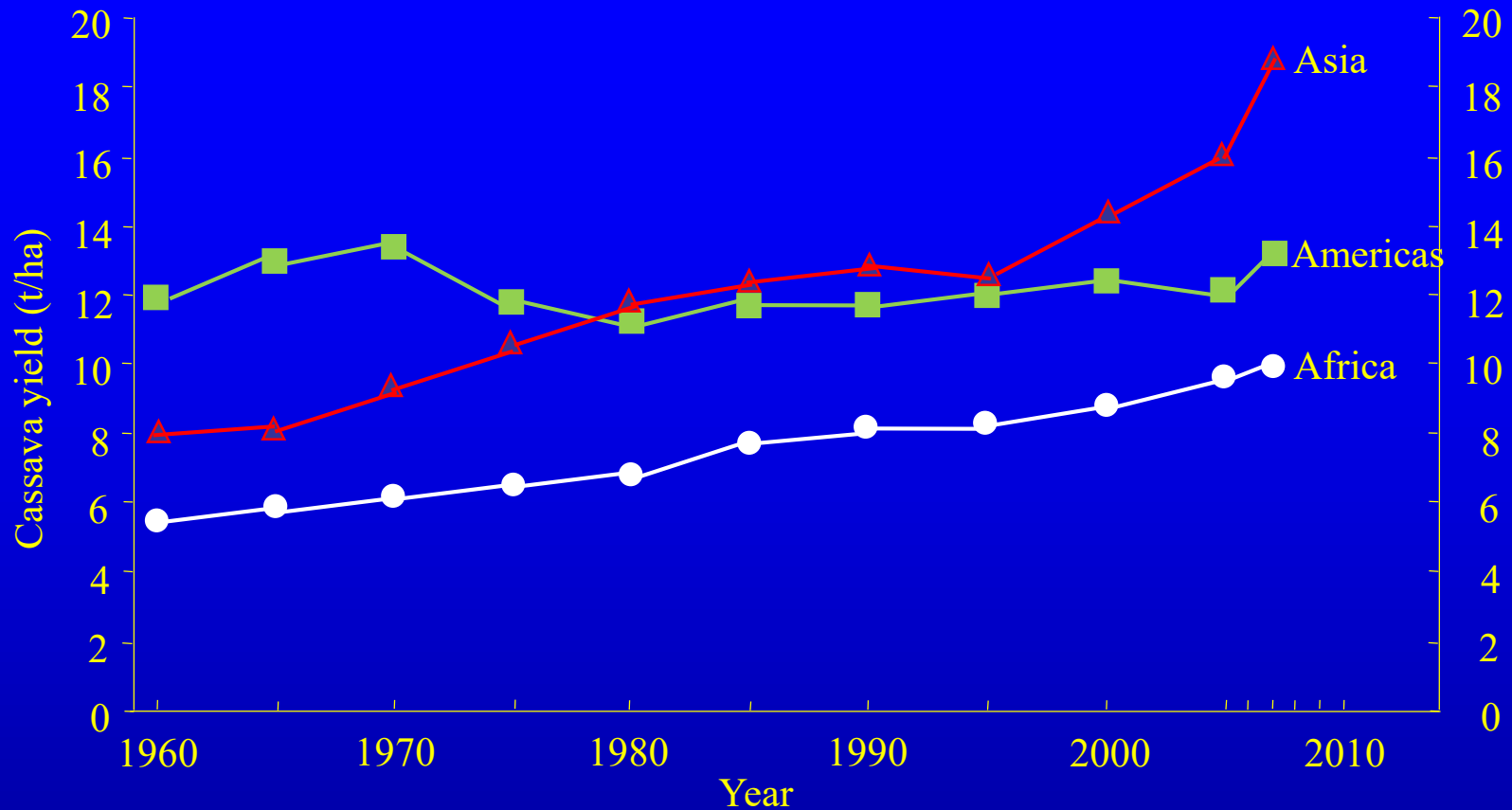
Current distribution of cassava in the world



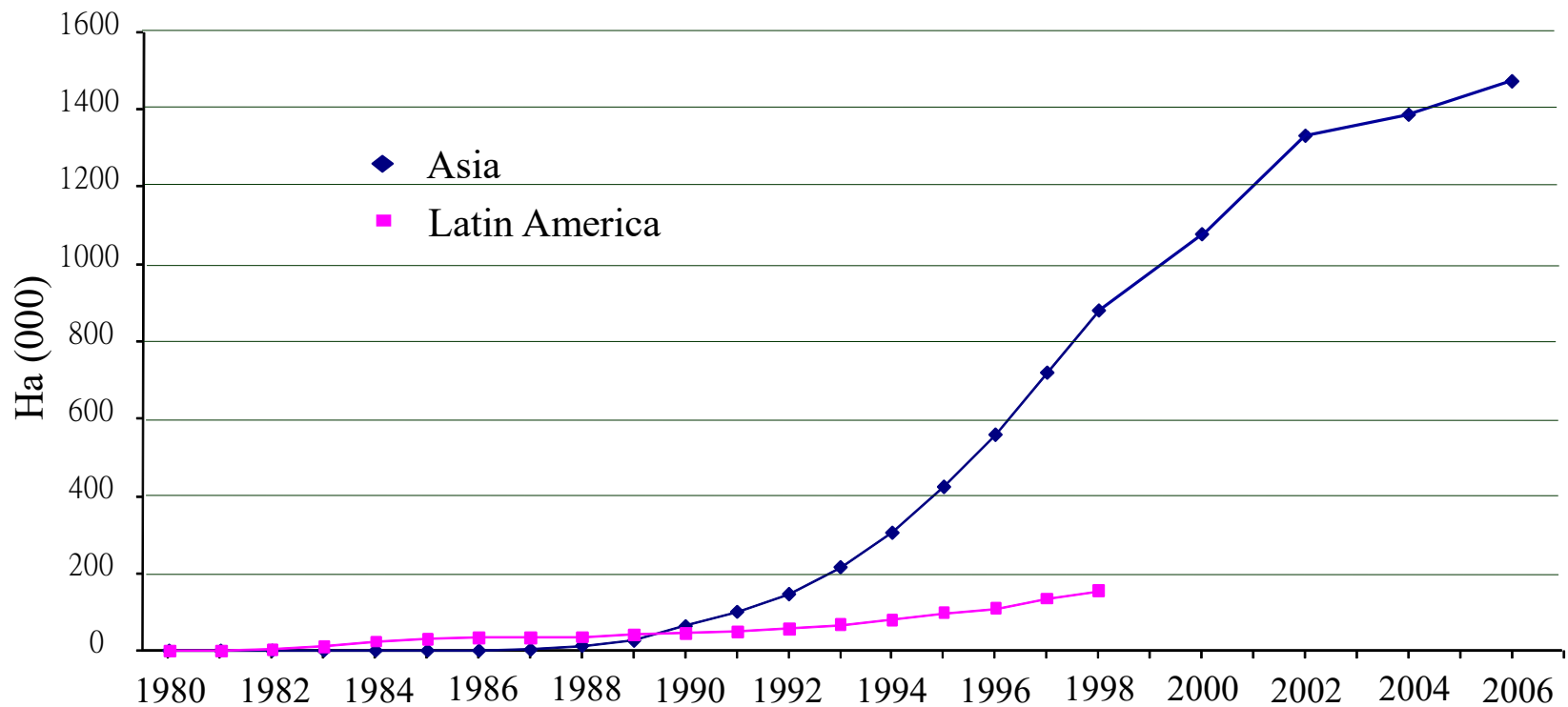
Cassava distribution in Asia in 2007. Each dot is 10,000 ha



Total harvested area, production and yield of cassava in 12 cassava growing countries in Asia, 1961-2007.

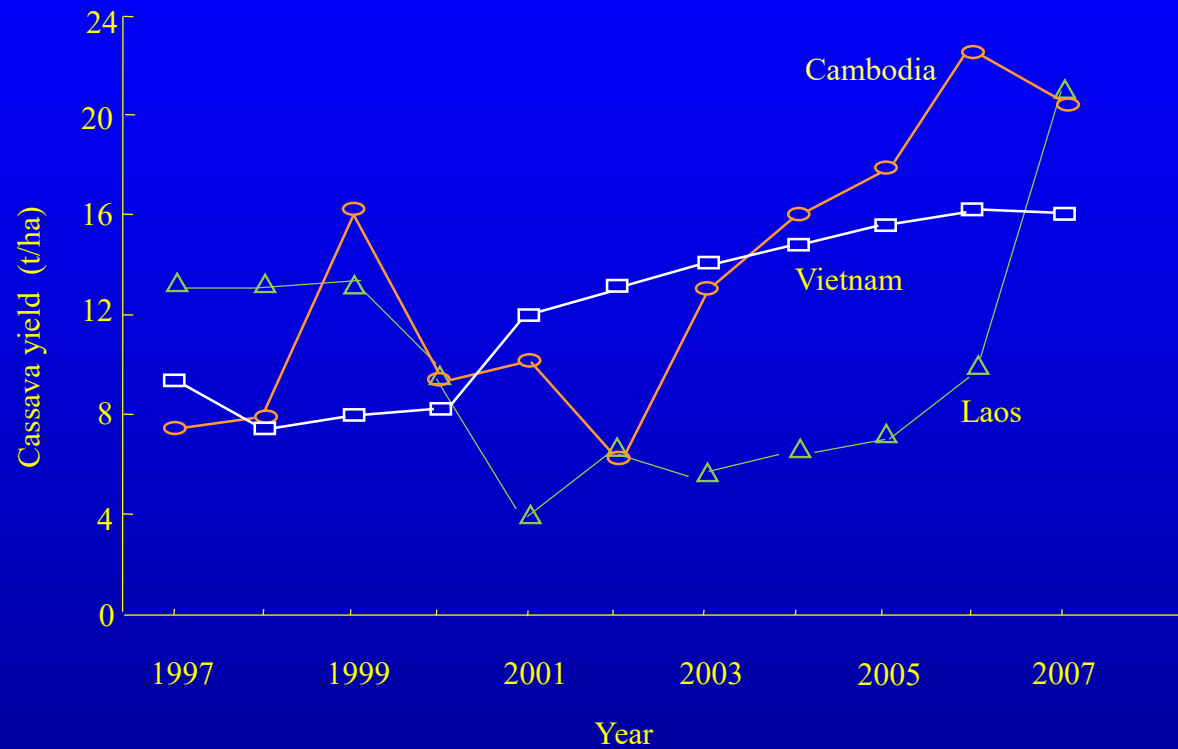


Trend of cassava yields in Africa, Latin America and Asia from 1961 to 2007.



. Adoption of CIAT-related cassava varieties in Latin America and Asia to 2006.

Source. C.H. Hershey; 2000-06 estimated by R. Howeler



Change in cassava yields in Cambodia, Laos and Vietnam from 1997 to 2007

Cassava production, area, and yield in the world, the continents and in various countries in Asia in 2007

	Production (‘000 tonnes)	Area (‘000 ha)	Yield (t/ha)
World	214,515	18,555	11.56
-Africa	104,952 (49%)	11,910	8.81
-Americas	38,429 (18%)	2,809	12.97
-Asia	72,911 (34%)	3,819	19.09
-Cambodia	2,215	108	20.51
-China	4,361	269	16.24
-India	8,429	256	32.87
-Indonesia	19,988	1,207	16.64
-Laos	233	11	21.19
-Malaysia	430	41	10.49
-Myanmar	211	16	12.79
-Philippines	1,871	210	8.92
-Sri Lanka	220	23	9.75
-Thailand	26,916	1,174	22.92
-Timor-Leste	50	12	4.14
-Vietnam	7,985	497	16.07

Production Practices



In Thailand cassava is generally grown in monoculture on very light textured soils with gentle slopes



Weeding is sometimes
done with a “poor
man’s plow”



Cassava roots can be harvested quickly with a simple harvesting tool



In heavier soils, cassava
is now harvested with a
tractor-mounted
harvesting tool



Kasetsart 50

Released in 1992



Rayong 7

Released in 2005



In Vietnam cassava is often grown on rather steep slopes



.....or on very steep slopes



Along the Central coast
of Vietnam cassava
grows well in the snow



Along the Central coast
of Vietnam cassava
grows reasonably well in
the white sandy soils
where nothing else will
grow



In China cassava is generally grown in monoculture or intercropped with watermelon or peanut



In Guangxi, China, cassava is often grown on plastic mulch



The plastic mulch helps to warm up the soil resulting in more rapid initial growth



In Java island of Indonesia
most cassava is
intercropped with
maize.....

....or rice and maize
followed by short-
duration grain
legumes

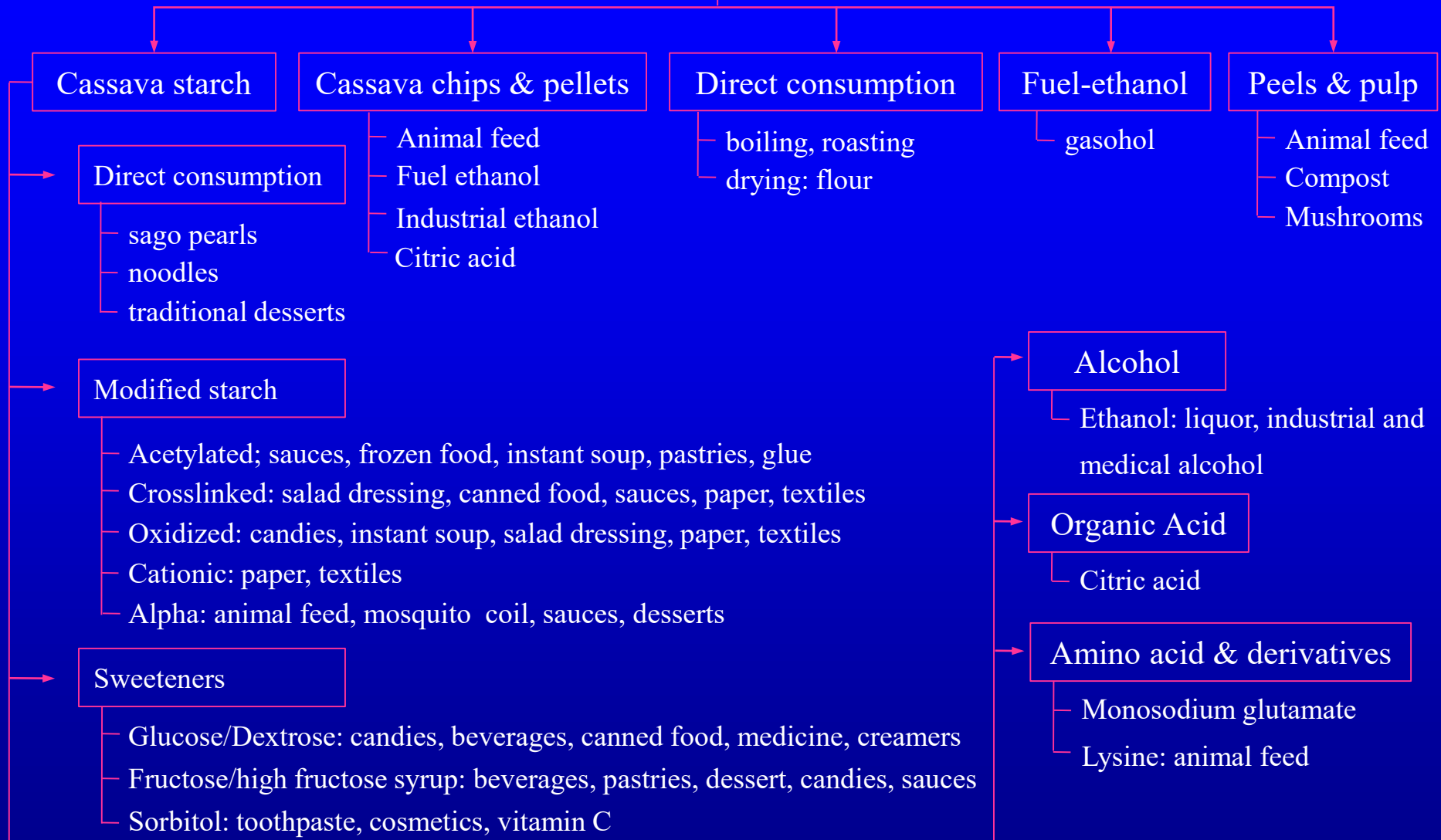


Utilization



Cassava roots have about 90% starch and 2-3% protein
(on DM basis)

Cassava roots



Cassava root processing into value-added products

Human Food



In Laos boiled cassava roots are a staple food for many ethnic minority people



In rural China, boiled cassava roots are a favorite snack



In Indonesia peeled and sun-dried cassava roots are called *gaplek*; this is sold in stores for use as human food and animal feed



Gaplek is pounded
into flour which is
used to make *tiwul*

Animal Feed



In north Vietnam, fresh
cassava roots are
chipped using a simple
cutting board.....

.....or a more
elaborate machine
made from bicycle
parts





Chips are sun dried in any available space





In Central Vietnam,
cassava leaves are
chopped for making
silage



Feeding pigs with ensiled cassava roots and leaves



In China farmers feed dry
or ensiled cassava leaves
and roots to pigs

and fresh leaves to fish





In Thailand cassava roots are chipped and sundried
on large concrete drying floors



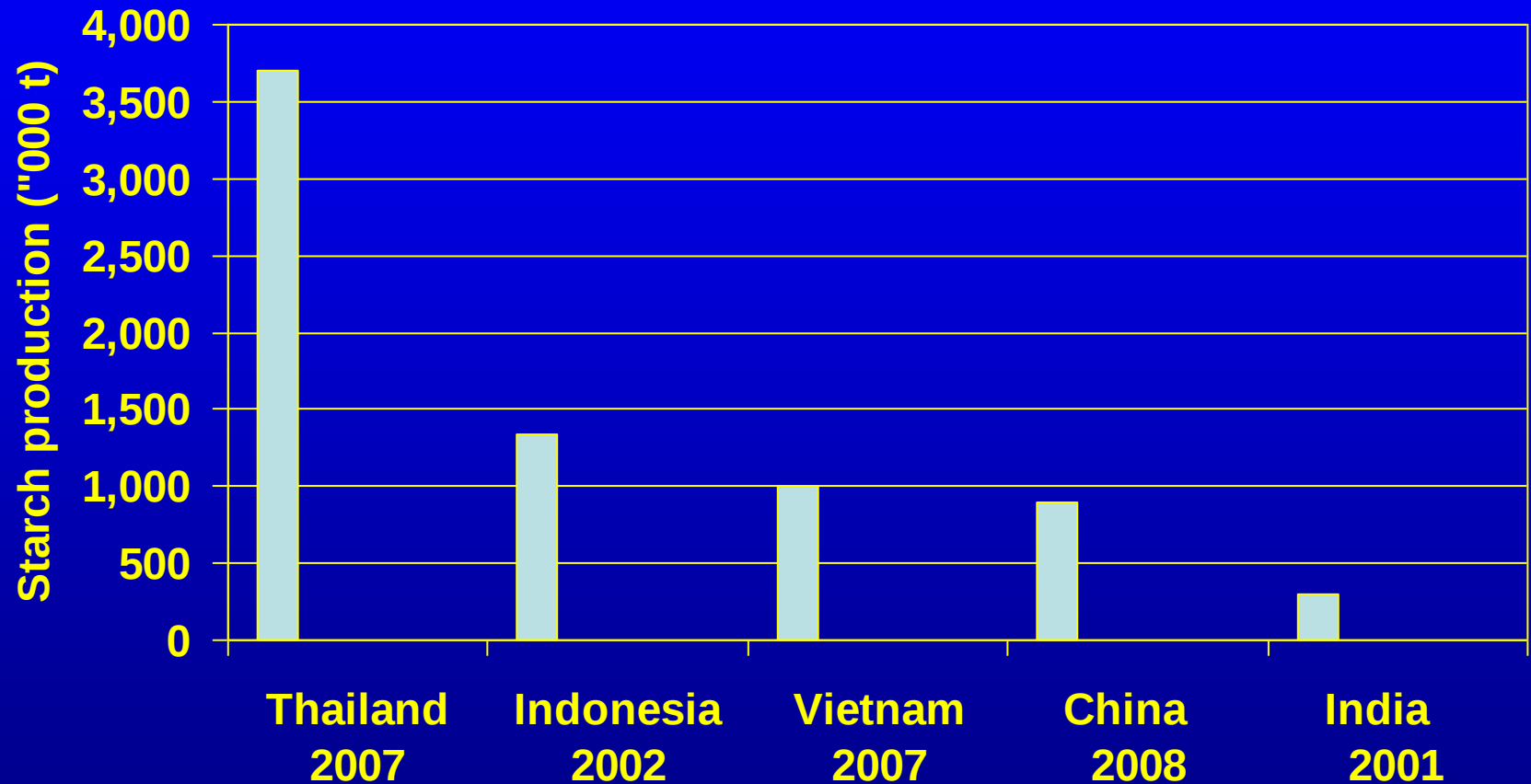
When regularly turned the chips will dry in 2-3 days
of sunny weather



Cassava chipping and drying is big business in Thailand

Starch and Starch Derivatives

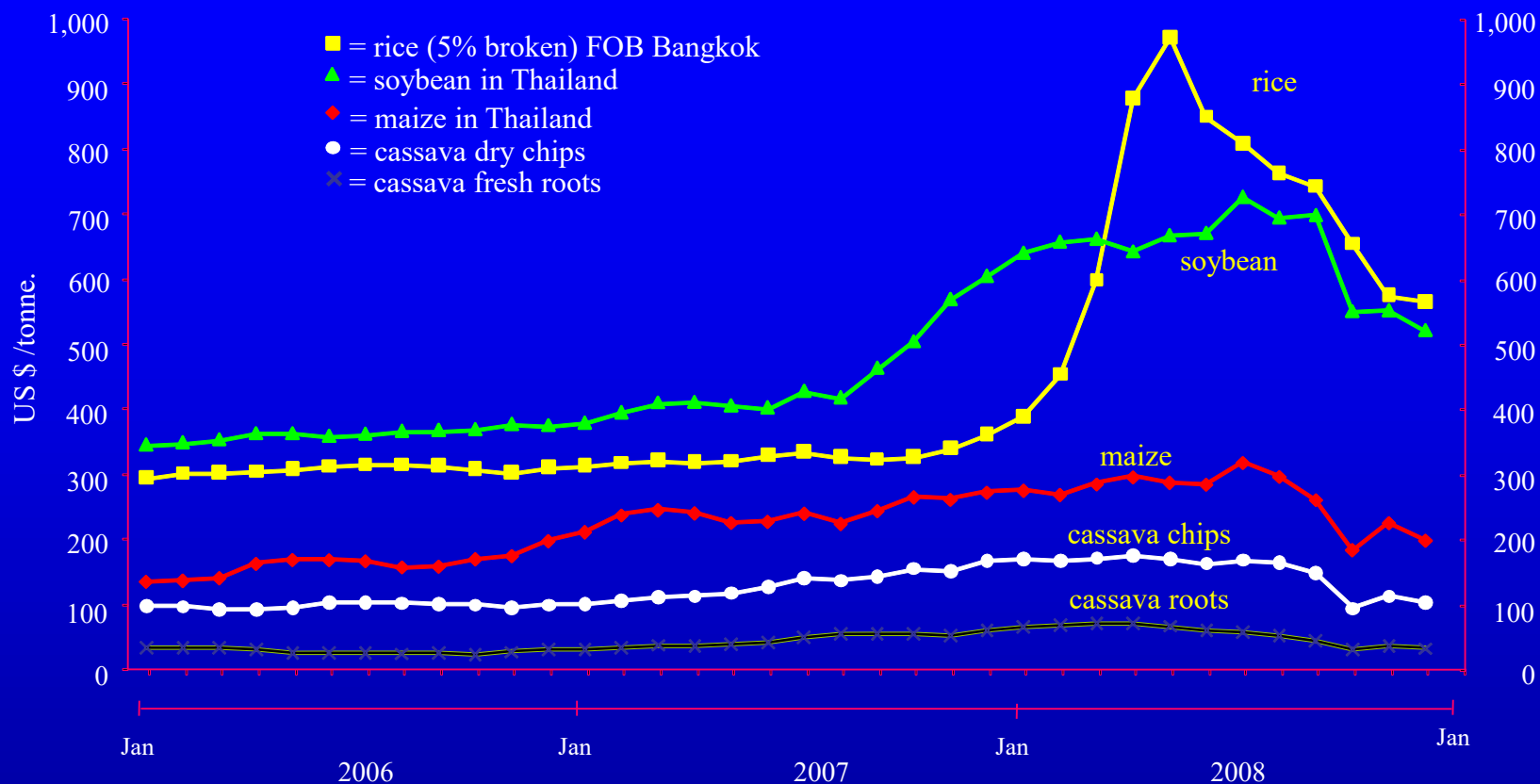
Annual cassava starch production in various countries in Asia, 2001-2008



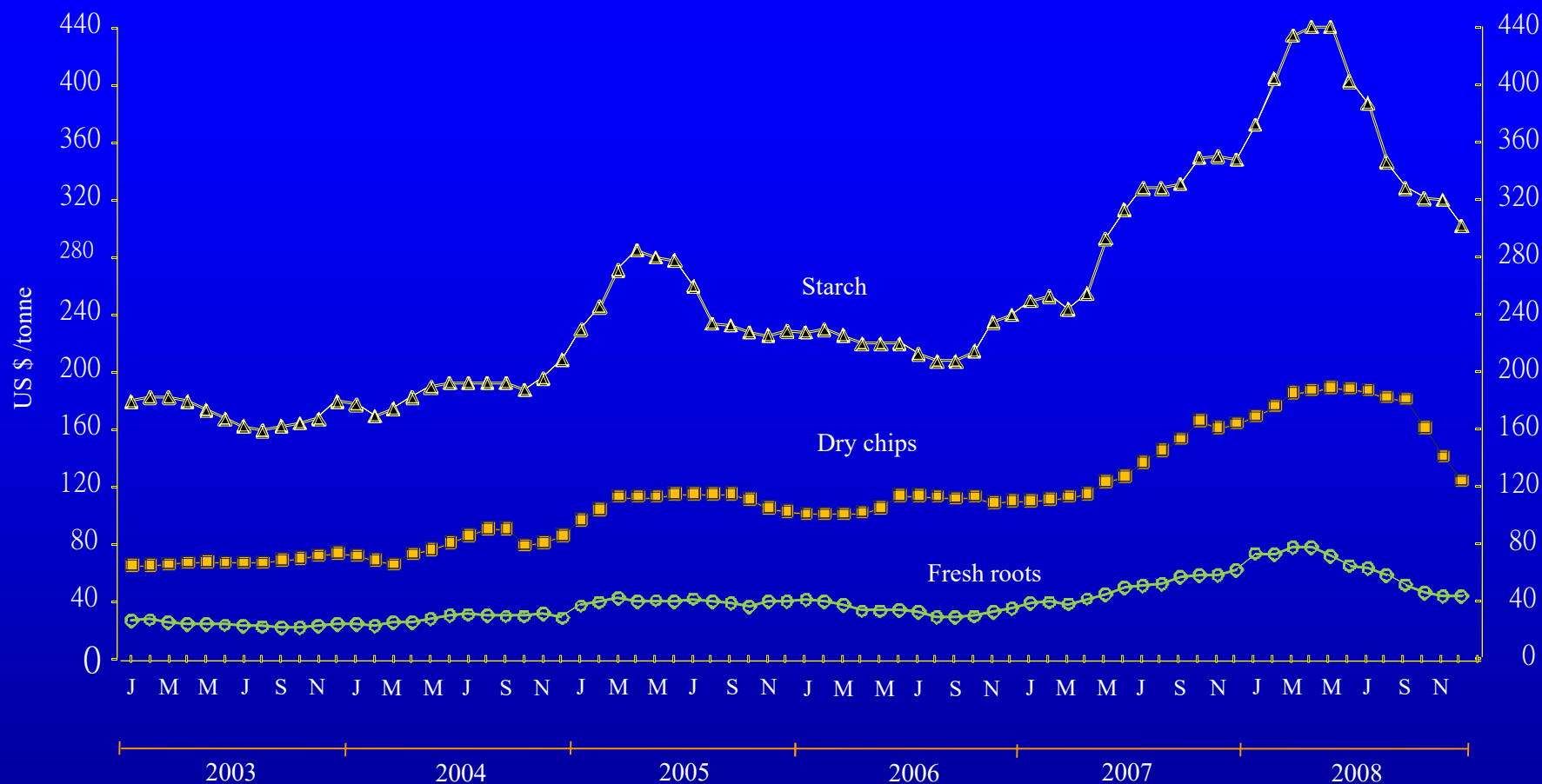
Cassava starch can be produced at many different scales



Marketing



Trends in the price of rice, soybean, maize, cassava fresh roots and dry chips in Thailand from 2006 to 2008.



Trends in the price of cassava fresh roots, dry chips and starch (FOB Bangkok) in Thailand from 2003 to 2008.

Total world trade in cassava products in 2004.

	Exports ('000 t)					Total
	Fresh root equivalent	Starch	Tapioca pearl	Chips+ pellets	Flour	
World	23,895	1,376	88	6,467	81	8,012
-USA	6	1	-	0	-	1
-EU(15)	959	6	0	365	3	374
-Asia	22,551	1,346	86	6,006	76	7,514
-China	75	3	12	0	-	15
-India	6	0	1	0	0	1
-Indonesia	1,659	185	29	234	0	448
-Japan	1	0	0	0	-	0
-Korea (ROK)	1	0	0	0	-	0
-Philippines	2	0	0	1	0	1
-Thailand	18,259	1,040	27	5,019	76	6,162
-Vietnam	1,874	-	-	750	0	750

Total world trade in cassava products in 2004.

	Imports ('000 t)					Total
	Fresh root equivalent	Starch	Tapioca pearl	Chips+ pellets	Flour	
World	26,168	1,825	57	6,672	15	8,569
-USA	293	21	9	58	0	88
-EU(15)	6,701	33	5	2,602	1	2,641
-Asia	18,330	1,621	40	3,995	7	5,663
-China	14,142	1,088	4	3,473	0	4,565
-India	19	0	4	0	0	4
-Indonesia	286	56	1	2	0	59
-Japan	741	130	2	30	1	163
-Korea (ROK)	1,204	10	0	460	0	470
-Philippines	268	46	1	12	0	59
-Thailand	4	0	0	0	1	1
-Vietnam	-	-	-	-	-	-

Source: FAOSTAT, April 2006.

New market potential

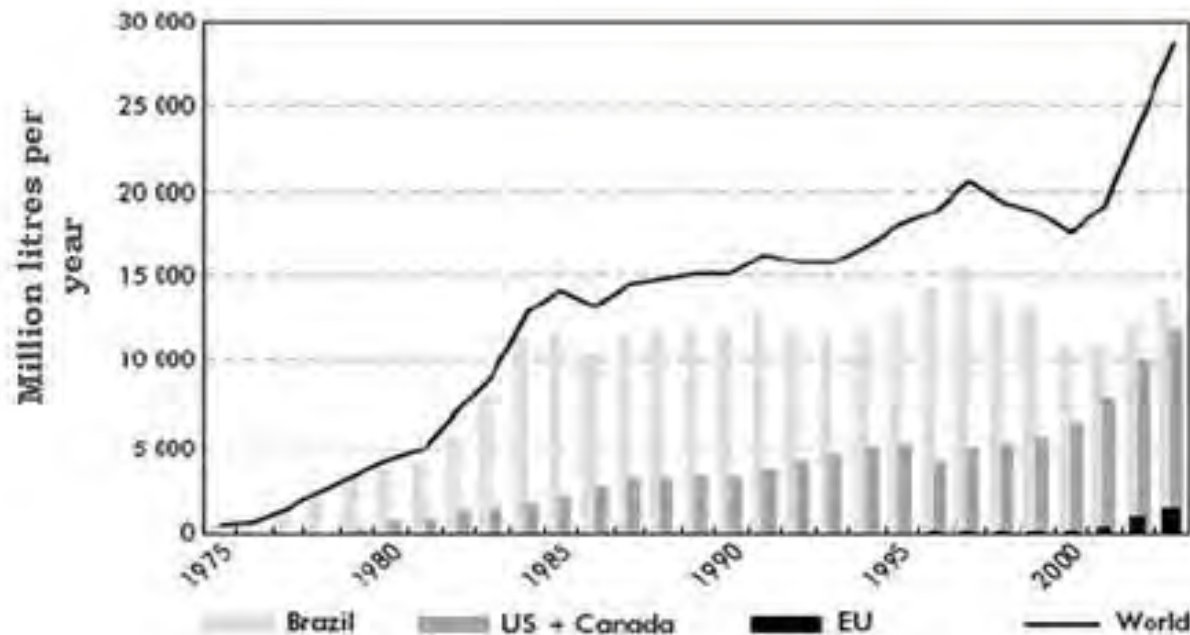
Mainly production of fuel-ethanol, but also increasing amounts of starch and animal feed

Bio-ethanol



In Brazil ethanol made from sugarcane and cassava has been used as a bio-fuel since the mid 1970s

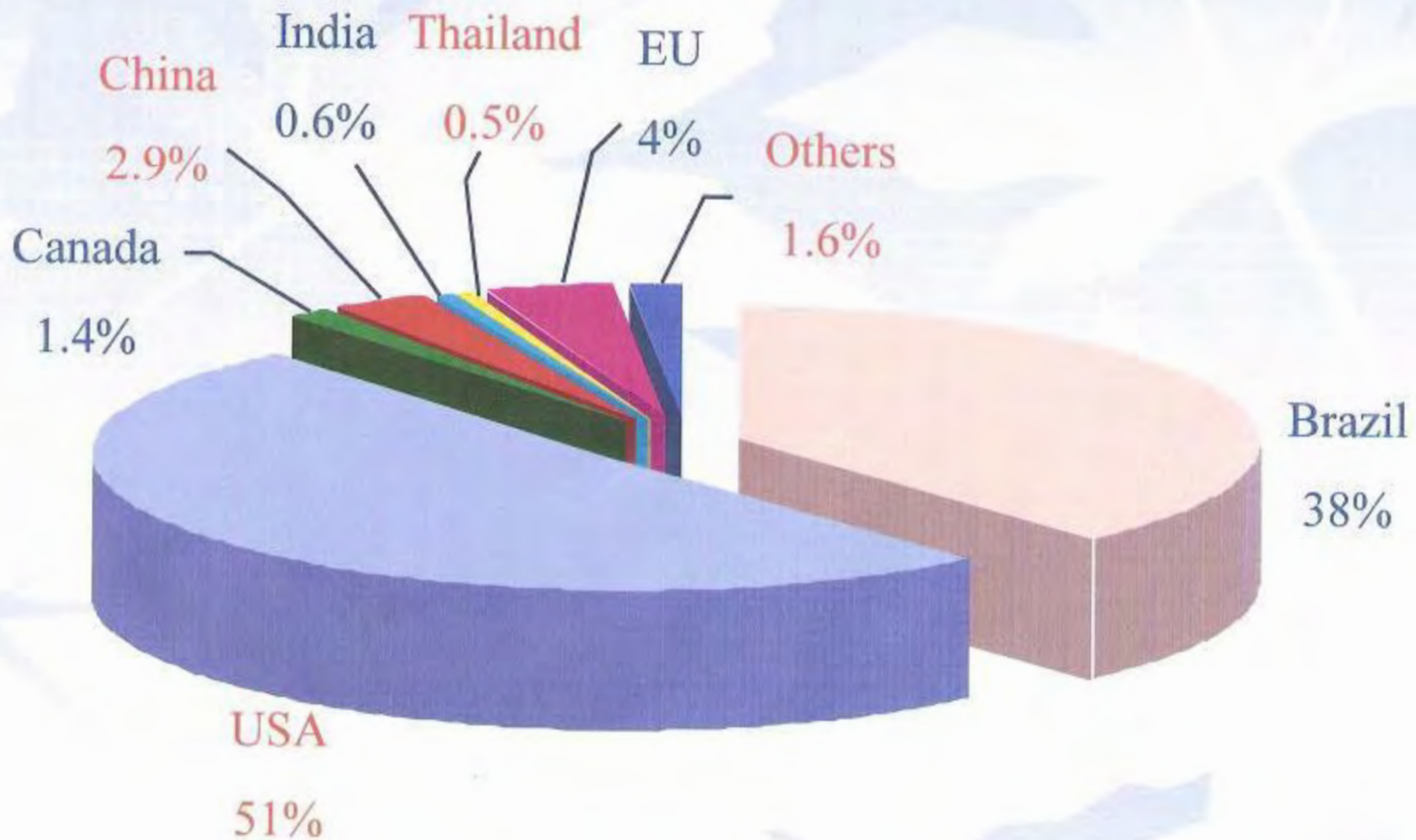
Ethanol in the world



Chiều hướng sử dụng ethanol trên thế giới 1975-2005

Source: <http://www.ethanol.com/ethanopoly/fin/compass.html#world>

Fuel Ethanol Market 2008



63,421 million litres

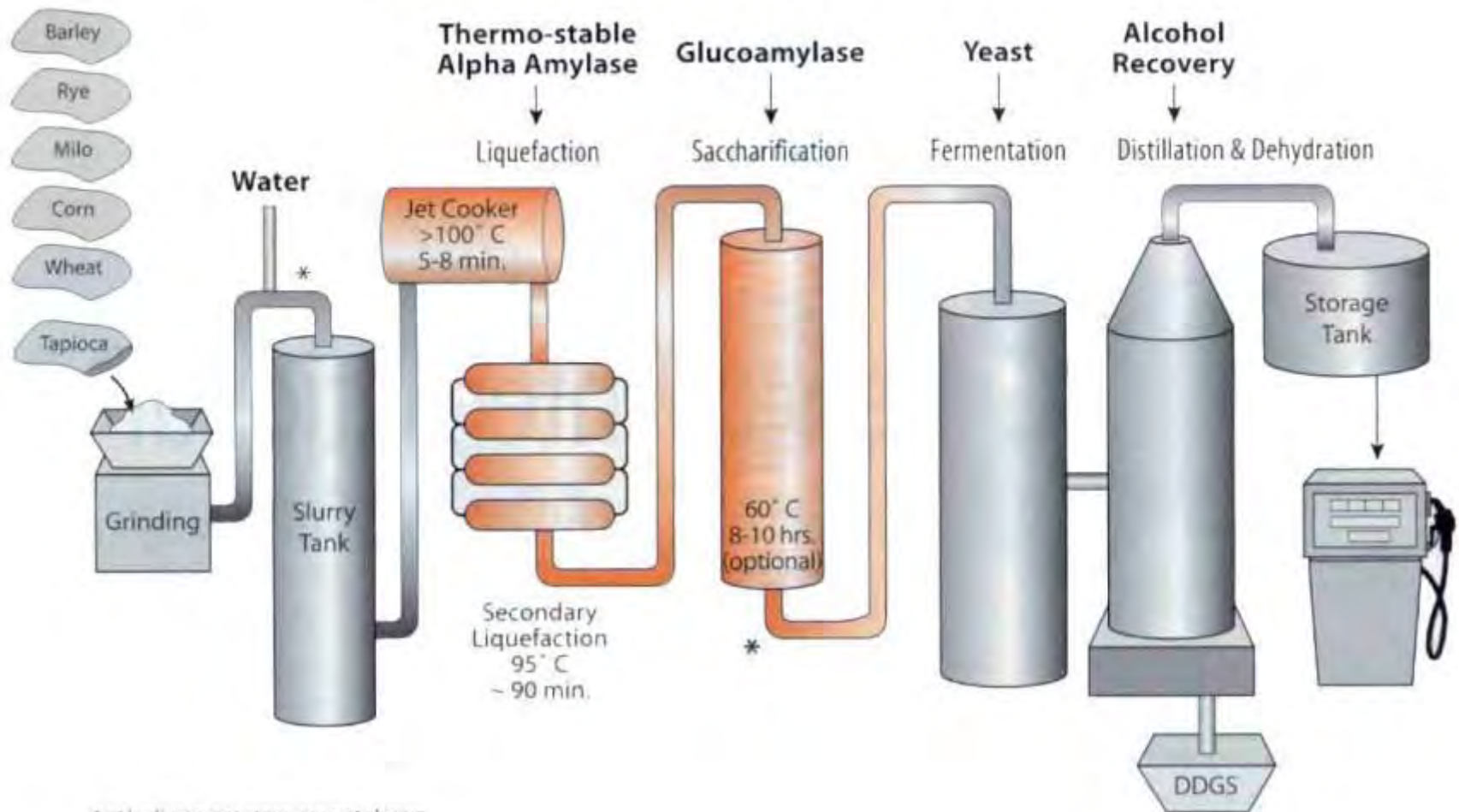


Lộ trình sử dụng nhiên liệu sinh học ở một số nước và khu vực trên thế giới (Nguồn: IEA Task 30 report May 2007)

Targets for Bio-fuels to Replace Fossil Fuels for Transport

- China 15% by 2020, requiring 39-44 mil. t/year
- Japan 10% by 2030, requiring 4.7 mil. t/year
- Thailand 1.9% by 2011, requiring 1.28 mil. t/year
14% by 2022
- Indonesia 10% by 2010, requiring 1.46 mil. t/year
- Vietnam 0.4% by 2010
1.0% by 2015, requiring 0.25 mil. t/year
5% by 2025, requiring 1.8 mil. t/year
- Lao PDR 5% by 2015
- USA 2% ethanol in all petrol in 2009
15% in 2017
- Brazil 22-26% ethanol in all petrol in 2009

Conventional Ethanol Production Process



The conventional dry mill ethanol production process



1. Cây sắn có hiệu suất thu hồi cồn cao, giá rất cạnh tranh so với các cây khác



Bio-ethanol in Japan

Bio-ethanol situation in Japan

- Local feedstock resources: sugar beet, sugarcane and wheat
- Plan to use ethanol to produce ETBE: 0.84 mil. kl/year in 2010 (as ethanol 0.36 mil. kl/year)
- Petroleum Assoc. of Japan started sales in April 2007
- First ethanol factory: Mitsubishi/JA Group Hokkaido
 - capacity: 15,000 kl/year
 - feedstock: sugar beet and out-spec wheat
 - start operation: early 2009
- “Bio-gasoline” is 3% ethanol in gasoline = E3
 - or 7% ETBE (equivalent to 3% ethanol) to replace MTBE
- Japan has limited supply of feedstock for ethanol production and will therefore need to import either feedstock or ethanol from SE Asia or Brazil; in the long-term it will use mainly local cellulosic waste materials to produce ethanol

Potential Domestic Biofuel Production in Japan in 2030

Fuel type	Raw material	Ethanol equivalent	Crude oil equivalent
Bioethanol	Sugar and starch	50	30
	Grass (including rice straw and wheat straw)	1,800-2,000	1,100-1,200
	Resource crops	2,000-2,200	1,200-1,300
	Wood	2,000-2,200	1,200-1,300
Biodiesel and others		100-200	60-120
Total		approx. 6,000	approx. 3,600

Units: thousand kl/year

Source: MAFF

Bio-ethanol in Thailand

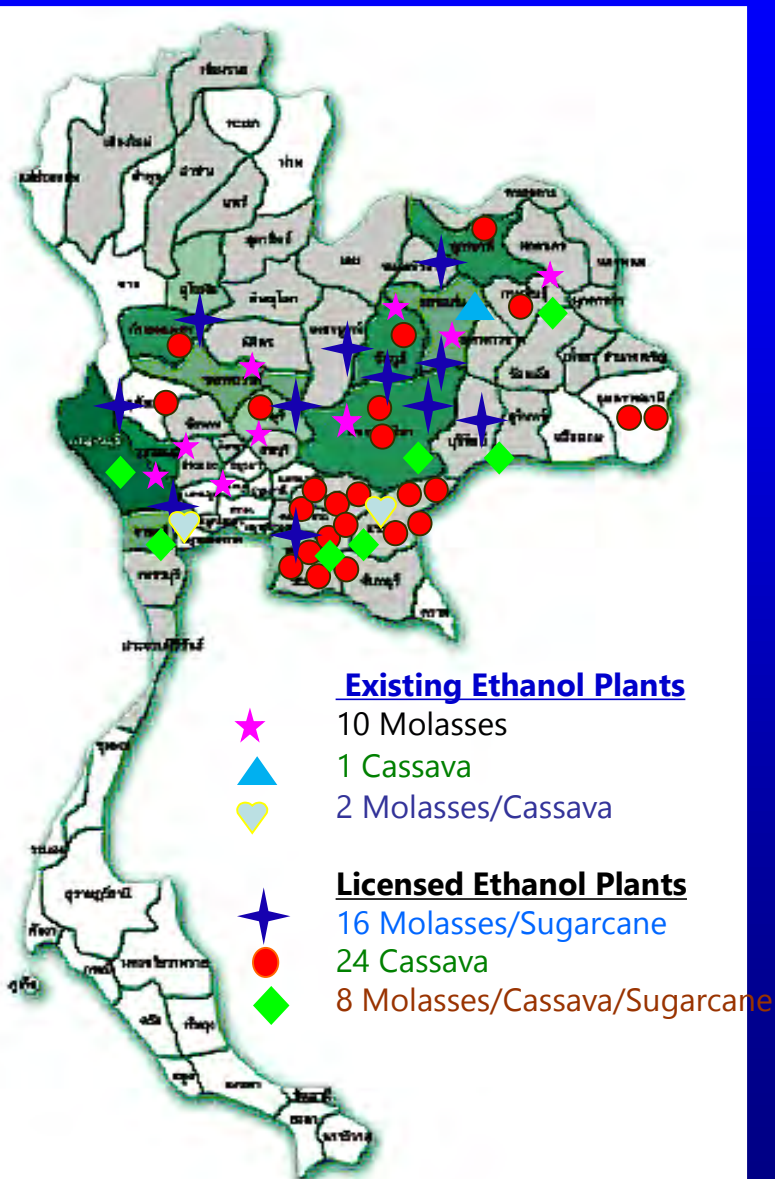


In Thailand, the biofuel program started around 1980 following successful Royal Projects under His Majesty the King's patronage

Resolutions on strategies to promote the use of gasohol in Thailand

- 2000 Cabinet resolution to use fuel ethanol to replace gasoline
- 2001 Cabinet resolution to use bio-diesel to replace diesel fuel
- 2004 Discontinue the use of MTBE as an octane booster in benzene 95
Government support the sale price of gasohol (E10)95 and 91
Government agencies are required to buy cars that can use gasohol
Government cars are required to use gasohol
Testing of the use of gasohol in cars with carburetors
- 2005 Government and State Enterprise cars must use gasohol
- 2006 Agreement on the way to liberalize the setting up of ethanol factories
- 2008 Start using E20
- 2011 Ethanol requirement will reach 2.4 million liters/day
- 2012 Start using E85

Ethanol Production in Thailand



Previously approved licenses for 48 companies

Total capacity 12.5 million liters/day

- Molasses as raw material = 16 factories with total capacity of 2.89 million liters/day
- Cassava as raw material = 24 factories with total capacity of 8.39 million liters/day
- Cassava & Molasses as raw material = 8 factories with total capacity of 1.22 million liters/day

Currently (Oct 2009) operating

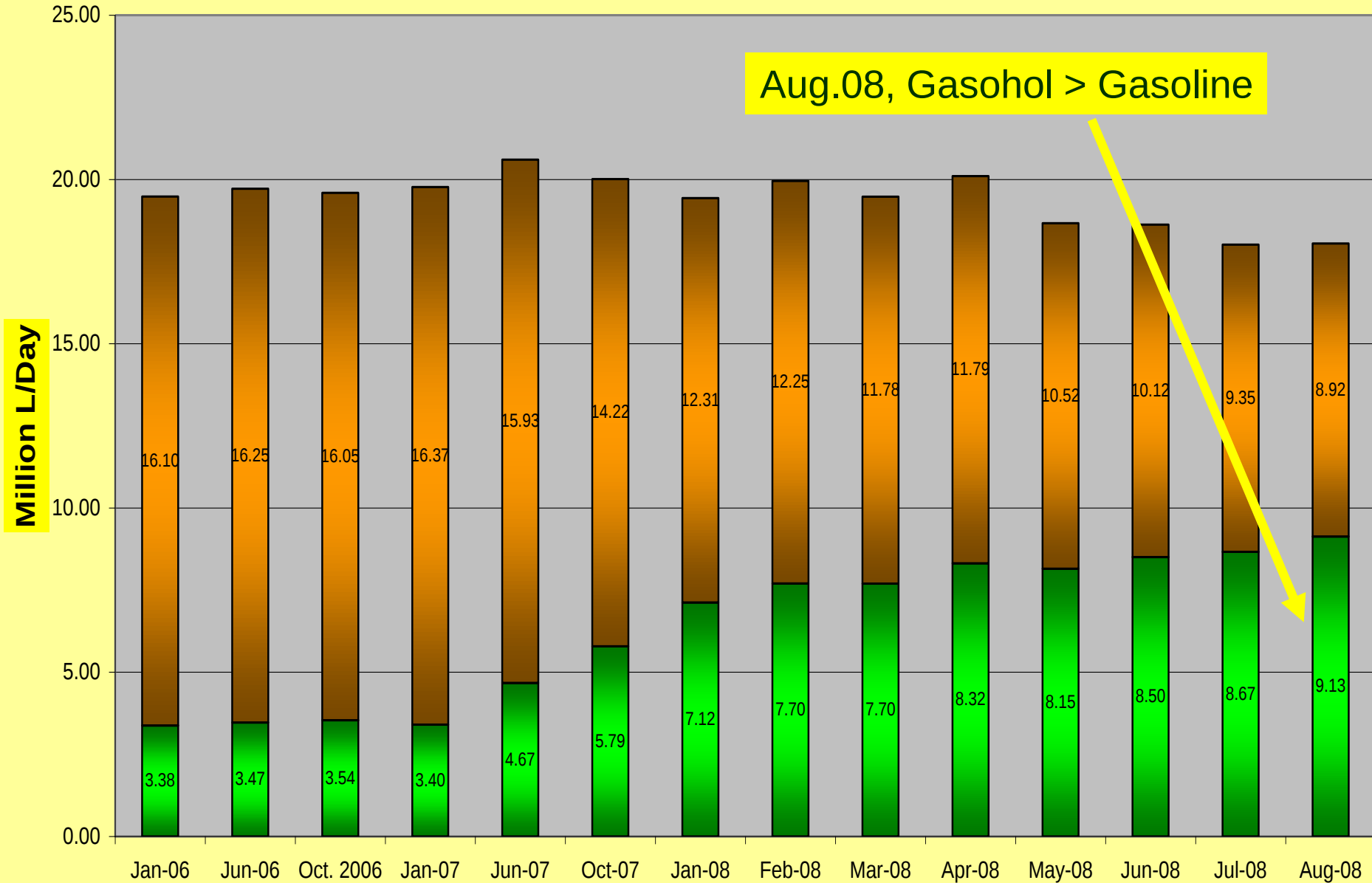
- 17 factories with total capacity 2.58 million liters/day

Under construction in 2009-2010

- 5 new ethanol factories with total capacity 2.27 million liters/day

**Total installed capacity 4.85 million liters/day
(about 1.15 million t/year) in 2010**

Gasoline and Gasohol Sales Volume ML/Day



Gasohol Use in Thailand in 2008

- 11 Ethanol factories: 1.575 mil. l/day capacity;
Sales = 1.22 mil. l/day
On Aug 31, 2008: Total gasohol sales (E10 Octane 95, E10 Octane 91 & E20) = 9.13 mil. l/day = 50.6% of gasoline market share
- Outlets: 3,926 stations selling gasohol
- Total ethanol stock: 49 mil. liters
- April 2007-March 2008: Exports = 28 mil liters, of which 60% to Singapore, 28% to EU

Unit: liters/day

Existing ethanol factories

Companies	Installed cap. (liters/day)	Raw material	Province	Commencing date
1. Pornwilai International Group Trading	25,000	Molasses	Ayutaya	Oct 03
2. Thai Alcohol	200,000	Molasses/Starch	NakhonPathom	Aug 04
3. Thai Agro Energy	150,000	Molasses	Suphanburi	Feb 05
4. Thai Nguan Ethanol	130,000	Cassava	Khon Kaen	Nov 05
5. Khon Khan Alcohol	150,000	Molasses/Starch	Khon Kaen	Jan 06
6. Petrogreen	200,000	Molasses	Chaiyabhum	Dec 06
7. Thai Sugar Ethanol	100,000	Molasses	Kanchanaburi	Apr 07
8. KI Ethanol	100,000	Molasses	Nakhon Ratchasima	Jul 07
9. Petrogreen	200,000	Molasses/Starch	Kalasin	Jan 08
10. Akarat Pattana	200,000	Molasses	Nakhon Sawan	Mar 08
11. Thai RoongRuang Energy	120,000	Molasses	Saraburi	Mar 08
12. Ratburi Ethanol Co., Ltd.	150,000	Cassava/Molasses	Ratchaburi	Nov 08
13. ES Power Co., Ltd.	150,000	Cassava/Molasses	Sra Kaew	Jan 09
14. Mae sord PaLung Ngan Sa ard Co., Ltd.	200,000	Sugar Cane	Trak	May 09
15. Sapthip Co., Ltd.	200,000	Cassava	Lopburi	May 09
16.Tai ping Ethanol Co., Ltd.	150,000	Cassava	Sra Kaew	Jul 09
17. P.S.C. Starch Product Plc.	150,000	Cassava	Chonburi	Aug 09
Total	2,575,000	Update: Oct. 2009		

Unit: liters/day

Ethanol factories under construction

Company	Installed capacity (liters/day)	Feedstock	Province	Expected date of operation
1. Petrogreen Co., Ltd.	200,000	Molasses	Suphanburi	Q4-09
2. Sima Inter Product Co., Ltd.	150,000	Cassava	Chasoengsao	Q1-10
3. Double A Ethanol Co., Ltd.	500,000	Cassava	Nakhon Ratchasima	Q1-10
4. TPK Ethanol Co., Ltd.	1,220,000	Cassava	Nakhon Ratchasima	Q4-09
5. Impressed Technology Co., Ltd	200,000	Cassava	Lopburi	Q2-10
Total	2,270,000			

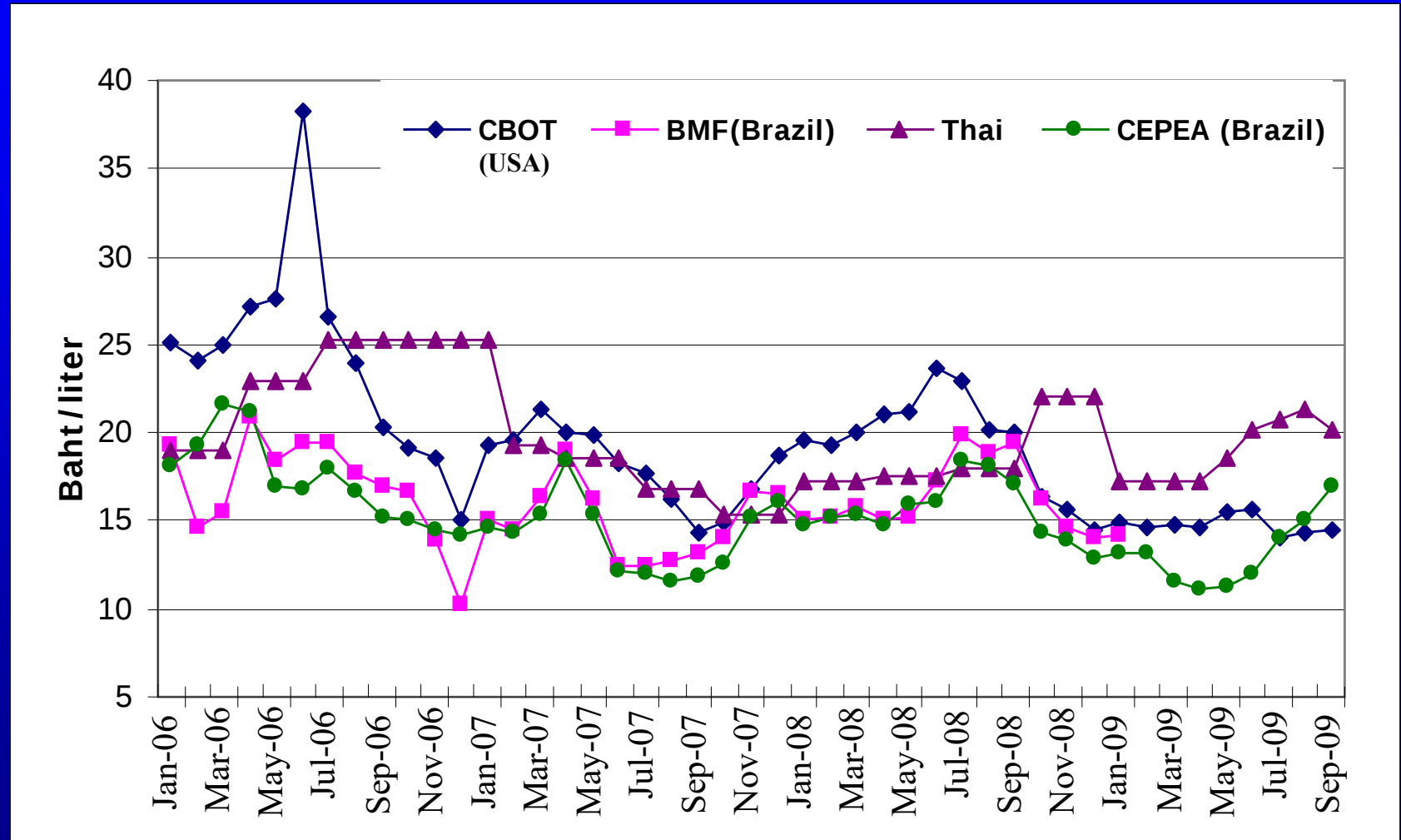
Update: Oct. 09

Thailand's ethanol exports from Jan 2008 to Sept 2009

Producers	Export (million liters)		Destination
	Sep 09	Accum. (Jan.08-Sep.09)*	
Khonkan alchohol	-	13.89	Singapore, Philippines, Australia
Petrogreen	-	37.74	Singapore, Netherland, Arab Emirates, Japan
Thai Sugar	-	0.14	Taiwan
Akarat	0.093	21.74	Singapore, Taiwan, Korea, Indonesia
Thai Nguan	-	0.0002	Philippines
Total	-	73.54	

Update
Oct 2009

Thai and global ethanol prices from Jan 2006 to Sept 2009





Thai-Nguan Ethanol factory in Phon, Khon Kaen, Thailand



Production capacity is 130,000 liters/day requiring about 700 t fresh roots



Liquefaction: milled cassava roots are mixed with water and cooked for at least one hour at 100°C ; followed by Saccharification at 60°C in the presence of enzymes for 8-10 hours



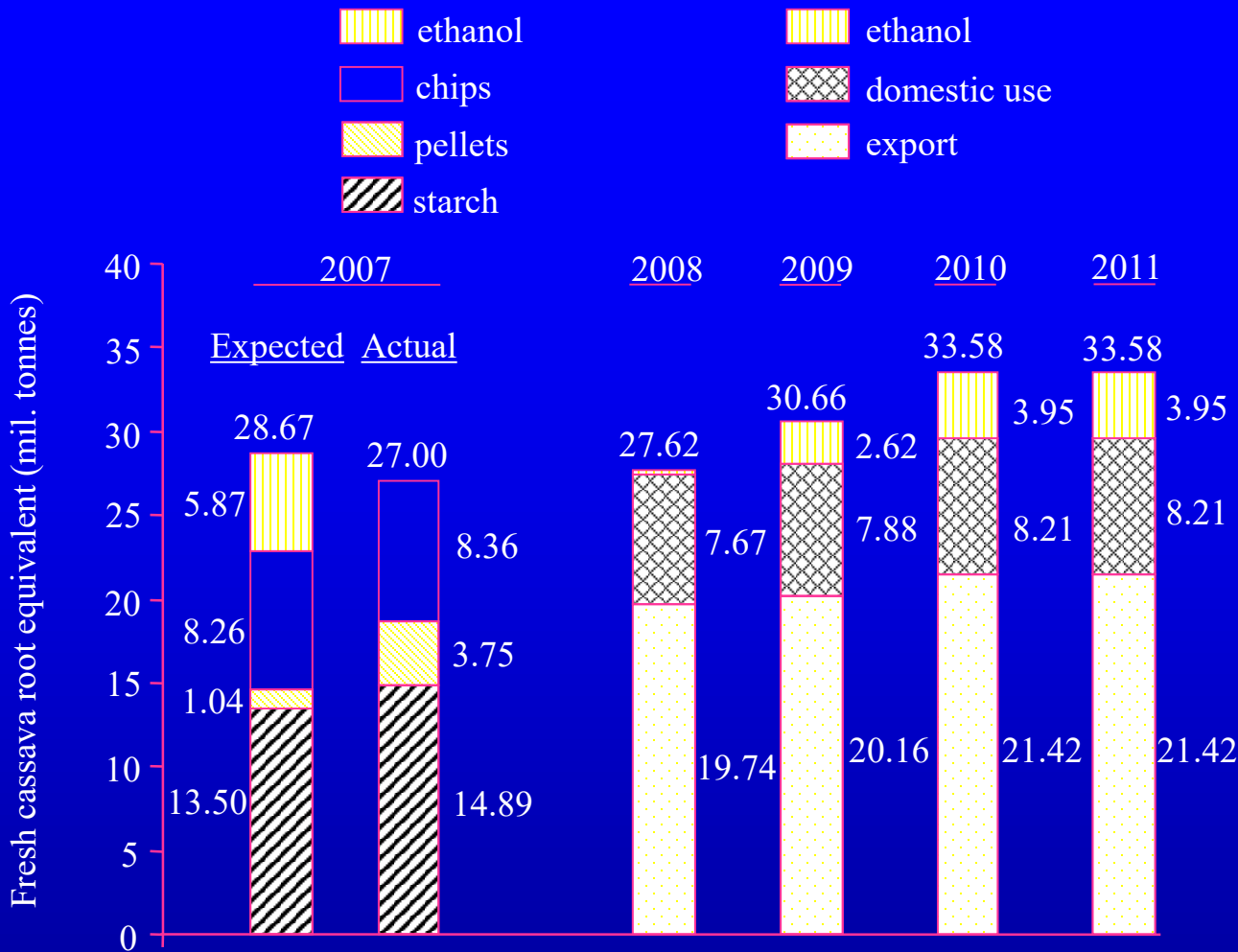
Tanks for batch fermentation to produce 8-10% ethanol



Distillation towers to
produce 95% ethanol



Dehydration: Using molecular sieves to eliminate water to produce 99.5% ethanol which is suitable as fuel-ethanol



Expected and actual demand for various products made from cassava in Thailand in 2007, and the expected need for cassava products for ethanol, starch, chips and pellets for export and domestic use from 2008 to 2011.

Source: Phetphirum, Thai Ministry of Energy

Table 13. Cassava varietal differences in root yield, starch content and ethanol conversion efficiency when harvested at 12 and 18 months after planting in Thailand.

Months at harvest Variety	Root yield (t/ha)	Starch content (%)	Ethanol conversion (l/t fresh roots)	Ethanol yield (l/ha)
12 months				
Rayong 5	30.1	25.5	147	4,425
Rayong 9	30.9	30.8	208	6,427
Rayong 72	34.1	23.5	145	4,944
Rayong 90	31.2	27.5	174	5,429
Kasetsart 50	31.2	25.6	154	4,805
18 months				
Rayong 5	43.3	23.5	139	6,019
Rayong 9	48.7	29.3	194	9,448
Rayong 72	40.6	20.9	135	5,481
Rayong 90	41.0	25.6	155	6,355
Kasetsart 50	45.9	23.8	137	6,288

Source: Charoenrath et al., 2006.

Rayong 9



Table 16. Ethanol production costs using two Thai cassava varieties in 2007.

	Rayong 9	Rayong 90
Starch content (%)	30	27
Fresh root requirement (t/1000 l) ²⁾	4.81	5.75
Fresh root price (US\$ /t) ¹⁾	50.84	48.05
Cost of raw material (US\$/1000 l)	244.54	276.29
Ethanol processing cost (US\$/1000 l) ³⁾	186.27	186.27
Total cost of ethanol production (US\$/1000 l)	430.81	462.56

¹⁾Baht 1.64/kg (\$ 50.84/t) fresh roots at 30% starch with 0.03 baht (\$ 0.93) reduction for every 1% reduction in starch content

²⁾ **Source:** Charoenrath et al., 2006.

³⁾ **Source:** Phetphirum, 2008.

Processing cost of ethanol from molasses and cassava in Thailand in 2007.

	Molasses —————(baht/liter)—————	Cassava	Molasses —————(US\$/1000 liter) ¹⁾ —————	Cassava
1. Labor	1.0	0.50	31.05	15.52
2. Chemicals	0.25	1.50	7.76	46.57
3. Energy	1.35	2.00	41.91	62.09
4. Maintenance	0.25	0.30	7.76	9.31
5. Insurance	0.15	0.15	4.66	4.66
6. Administration	0.50	0.30	15.52	9.31
7. water	0.05	0.05	1.55	1.55
8. depreciation	0.97	1.00	30.11	31.05
9. Waste water treatment	0.65	0.50	20.18	15.52
10. Benefit from biogas	⁻²⁾	-0.30	⁻²⁾	-9.31
Total	5.17	6.00	160.50	186.27

¹⁾ 1 US\$ = baht 32.21 in 2007

²⁾ already substracted from energy costs

Source: Phetphirum, 2008.

Table 13. Cost of production of ethanol using either dry maize grain, fresh cassava roots, molasses or sugarcane as the raw material for ethanol production under US and Thai conditions in 2006 and 2007, respectively.

	USA (2006)		Thailand (2007)			
	Maize	Cassava	Maize	Cassava	Molasses	Sugarcane
Crop yield (t/ha)	11	35	3.8	22	2.82	60
Crop price (\$/tonne)	81	25	257	51	70	21
Ethanol yield (liters/t raw material)	379	180	379	166	250	70
Raw material costs (\$/liter ethanol)	0.21	0.14	0.67	0.31	0.28	0.30
By-product credit (\$/liter ethanol)	-0.063	-0.004	-0.063			
Processing costs (\$/liter ethanol)	0.16	0.21	0.16	0.19	0.16	0.16
Ethanol production costs (\$/liter)	0.31	0.35	0.83	0.50	0.44	0.46

Note: Ethanol price in Thailand in 2007: US\$ 0.48-0.55/liter

Source: adapted from Shetty, 2006, by R. Howeler

Bio-ethanol in China

Chinese government policy for bio-fuel development

- Non-food or feed (no more use of maize or wheat)
- Should not compete for land used for food crops (grown on marginal land)
- Diversify the feedstock resources (mainly cassava in the south and sweet sorghum in the north)

Comparison of economic value of ethanol production using different raw materials(RMB/ton) in China

	Cassava fresh roots	Cassava dry chips	Sugar cane	Molasses	Maize	Wheat	Potato	Sweet potato
Price of raw material	450	1250	380	900	1530	1640	800	480
Raw material consumption (t/t)	7	2.8	16	5	3.2	3.28	9	8.7
Cost of raw material	3150	3500	6080	4500	4896	5379	7200	4176
Processing cost	800	600	700	500	800	800	800	800
Cost of ethanol	3950	4100	6780	5000	5696	6179	8000	4976
Price of ethanol	5600	5600	5600	5600	5600	5600	5600	5600
Net income	1650	1500	-1020	600	-96	-579	-2400	624



COFCO cassava-based ethanol factory in Hepu, Guangxi, China, with a capacity to produce 840,000 l ethanol/day, requiring about 4,500-5,000 tonnes fresh roots/day

Bio-ethanol in Cambodia



In Cambodia, MH Bio-energy Co's fuel-ethanol factory in Kandal province has a capacity to produce 144,000 liters of ethanol per day, requiring 900 tonnes of fresh cassava roots

Table 3. Actual or planned factories for the production of anhydrous ethanol from cassava in Asia (January 2009).

Country	Company	Location	Capacity ('000 l/day)	Status	Fresh root requirement ('000 t/year) ¹⁾
Cambodia	MH Bio-energy Co. Ltd.	Kandal	144	completed in 2008	270
China	Guangxi New Tiande Energy Ltd. Co.	Qinzhou, Guangxi	420	operating	787
	China Food Comp. (COFCO)	Beihai, Guangxi	840	completed in 2007	1,575
	China Food Comp. (COFCO)	Wuzhou Guangxi	1,260		2,362
	Other factories		1,510	planned	<u>2,832</u> 7,556 ²⁾
Indonesia	Sampoerna Bio-energy: 3 factories	East and Central Java	2,500	planned	4,688
	Sorini Corporation	SE. Sulawesi	2,500	planned	4,688
	EN3 Co. Ltd: 3 factories	S. Sulawesi	600	planned	1,125
	Medco Energi	Lampung	200	start construction Feb 2009	375
	Budi Acid Jaya	Lampung	200	planned	<u>375</u> 11,251
Thailand	Thai Nguan Ethanol Co. Ltd	Khon Kaen	130	operating	244
	International Gasohol Corp	Rayong	150	completed, not operating	281
	Phakwantip Co. Ltd.	Prachinburi	60	completed, not operating	112
	6 factories cassava and/or molasses		1,000	to be completed in 2008	1,875
	16 factories		7,170	licensed	<u>13,443</u> 15,955
Vietnam	Petrosetco+Itochu Co.	HCM city	333	to be completed in 2009	624
	Petrosetco	Binh Dinh	375	planned	703
	Petrosetco	Baria Vungtau	375	planned	703
	Hai Phong Engine Comp.	Gia Lai	400	planned	<u>750</u>
		Quang Nam		planned	2,780
		Quang Nam		planned	
		Dak Lak		planned	
		Yen Bai		planned	

¹⁾based on 300 working days per year and a conversion of 160 l ethanol/t fresh roots.

²⁾In next 10 years China will require 3.1 mil. tonnes ethanol/year from cassava or 24.22 mil. tonnes fresh roots.

Production costs of fuel ethanol in various countries (US\$/liter)

	Cassava	Maize	Sugarcane/ molasses
Brazil (2008)			0.22
USA (2006)	0.35	0.31	
China (2008)	0.71-0.74	1.03	1.23
Thailand (2007)	0.43-0.46	0.83	0.44-0.46
Japan (2007) ¹⁾			1.75

¹⁾ Hisane Masaki: Japan steps up its biofuel drive; Asia Times Online Dec 2007

In Asia, which crops have the greatest potential as a bio-fuel crop?

In Thailand: **cassava** and sugarcane

In China: **cassava** and sweet sorghum

In Indonesia: **cassava**

In Vietnam: **cassava**

Cassava for fuel-ethanol is markedly increasing the demand for cassava roots, increasing prices and improving the livelihoods of many poor farmers in Asia

The Future is Bright

The future isCassava in Asia!!

By working together, we can make this future
even brighter



This Future!!!