ROLE OF CHEMICAL METROLOGY IN THAI ECONOMY

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INMETRO, Rio de Janeiro, Brazil

CONTENTS

- From NIST to NMIs
- Facts about Thailand
- National STI Policy and Strategic Plan
- History of Thailand Metrology
- Achievements

From NIST to NMIs

Chemical Metrology and Its Impact on Industry and Quality of Life

A National Program in Chemical Metrology is a Great Investment that Pays Significant Dividends to the National Economy and Quality of Life through Underpinning

- **Transactional efficiency in National and International Trade**
- **Fact-based Environmental Decision-Making**
- **Assessment Food Safety and Nutritional Content**
- **Healthcare Decision-Making**
- **National Security**
- **Innovation and Industrial Competitiveness**

Courtesy by Dr. Willie E. May, Aug 2009

Chemical Metrology and Its Impact on Industry and Quality of Life

Facts about Thailand

Chemical Metrology and Its Impact on Industry and Quality of Life

General Facts

- Locate in the middle of Southeast Asia
- Member of ASEAN and APEC
- Population: 65 million
- Literacy: 96%
- GDP 2006: $206 billion
  - Agriculture: 9%
  - Manufacturing: 39%
  - Services: 52%
- GDP per Capita: US$ 3,176

Lesser-Known Facts about Thailand

- 5th world largest exporter of agricultural and food products (Total export value ~ US$ 7.5 billion/year)
- Leading exporter for natural rubber, cassava and rice
- Unique biodiversity
- Very strong in fisheries and aquaculture
- Major player in some EE and ICT fields
  - World #1 hard disk drive exporter
- Manufacture >1 million cars/year
- World capital of medical tourism

Lesser-Known Facts about Thailand

1 of 5 top exporters of food and agricultural products in the world

Major exporter of:

- Rice
- Canned & frozen seafood
- Pineapples
- Cassava
- Sugar
- Natural rubber

More than 9,000 food processing companies

Major food processing companies in Thailand:

- Ajinomoto
- Grampian
- Kraft Foods
- Nestle
- Pepsi Co.

Thailand: World's Medical Service Center

- **World-class hospital services, high-quality medical treatment with Thai hospitality**
- **Thai doctors study abroad, speak international languages and are among the best in the region.**
- **Most private hospitals are gearing toward capturing patients from overseas. Health tourism increased over 200% in last few years, becoming the largest in the World.**

Number of foreign patients (million people)		
2001	-	0.5
2002	-	0.63
2003	-	0.97
2004	-	1.1
2005	-	1.28
2006	-	1.4
2007	-	1.5

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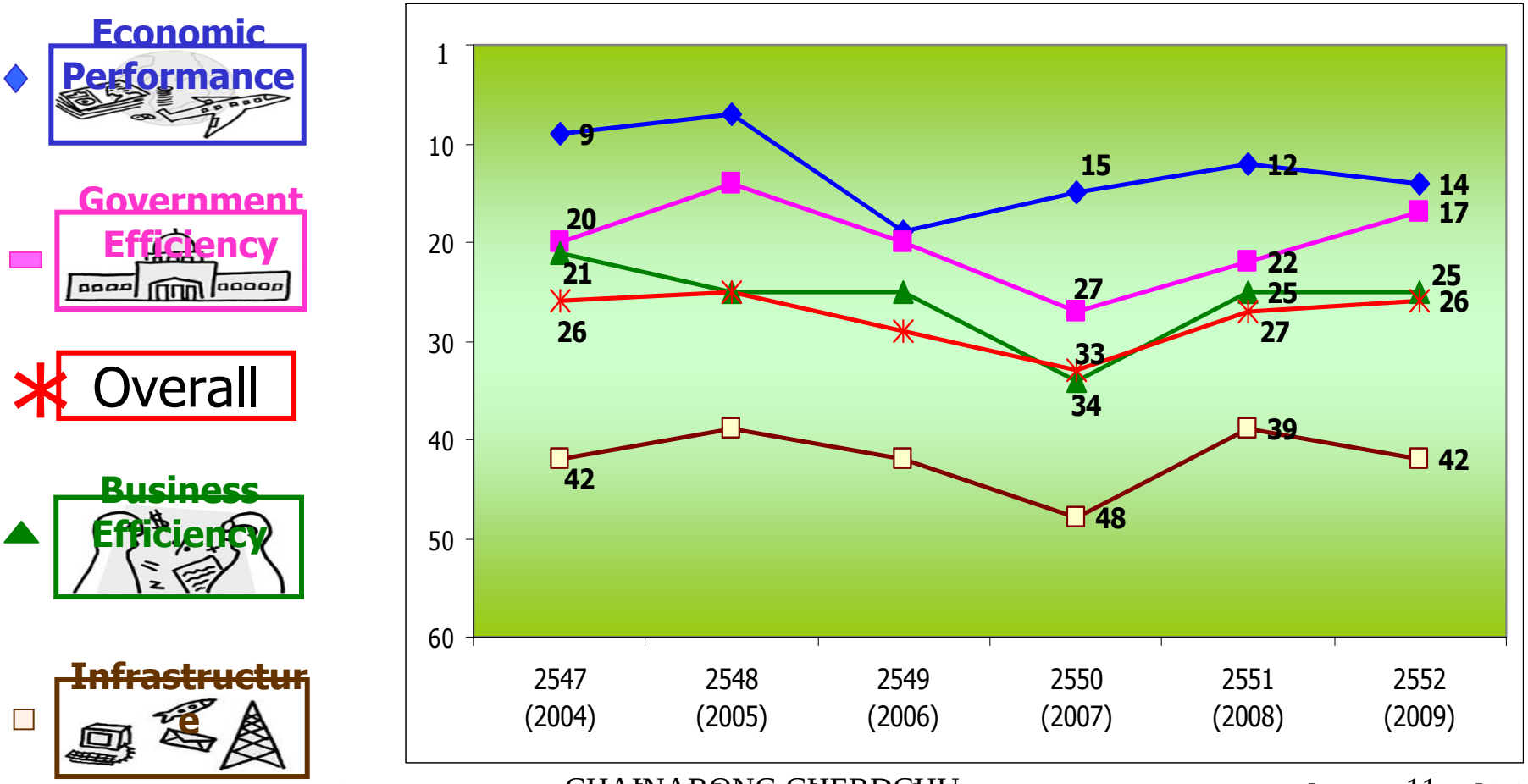
Competitiveness Ranking of Thailand 2004-2009 (By Factor)



Source: International Institute for Management Development (2004 2009). World Competitiveness Yearbook 2004-2009.

Scientific and Technological Infrastructure Competitiveness Ranking of Thailand 2004-2009 (Selected Countries)

ปัจจัยหลัก	2547 (2004)	2548 (2005)	2549 (2006)	2550 (2007)	2551 (2008)	2552 (2009)	Factor
โครงสร้างพื้นฐานทางวิทยาศาสตร์	46	47	45	49	37	40	Scientific Infrastructure
โครงสร้างพื้นฐานทางเทคโนโลยี	38	37	41	48	43	36	Technological Infrastructure
จำนวนประเทศทั้งหมด	**51**	**51**	**53**	**55**	**55**	**57**	**Number of Countries**

Source: International Institute for Management Development (2004-2009). World Competitiveness Yearbook 2004-2009.

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Scientific Infrastructure Competitiveness Rankings of Countries in the Asia Pacific Region for 2004-2009 (IMD)

อันดับโครงสร้างพื้นฐานทางวิทยาศาสตร์ (Scientific Infrastructure Ranking)						
ประเทศ (Country)	**2547 (2004)**	**2548 (2005)**	**2549 (2006)**	**2550 (2007)**	**2551 (2008)**	**2552 (2009)**
ญี่ปุ่น (Japan)	2	2	2	2	2	2
เกาหลี (Korea)	17	13	10	7	5	3
จีน (China)	20	18	15	15	10	6
ไต้หวัน (Taiwan)	7	8	5	6	4	8
สิงคโปร์ (Singapore)	16	16	14	13	8	12
ออสเตรเลีย (Australia)	22	23	21	20	18	18
ฮ่องกง (Hong Kong)	35	30	28	36	27	24
อินโดนีเซีย (Indonesia)	38	38	39	43	22	25
นิวซีแลนด์ (New Zealand)	26	27	26	25	26	27
อินเดีย (India)	30	26	24	26	29	32
มาเลเซีย (Malaysia)	33	35	32	31	28	33
ไทย (Thailand)	**46**	**47**	**45**	**49**	**37**	**40**
ฟิลิปปินส์ (Philippines)	49	49	50	54	53	56
จำนวนประเทศทั้งหมด (Number of Countries)	**51**	**51**	**53**	**55**	**55**	**57**

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Technological Infrastructure Competitiveness Rankings of Countries in the Asia Pacific Region for 2004-2009 (IMD)

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ประเทศ (Country)	**2547 (2004)**	**2548 (2005)**	**2549 (2006)**	**2550 (2007)**	**2551 (2008)**	**2552 (2009)**
สิงคโปร์ (Singapore)	2	3	3	2	2	2
ไต้หวัน (Taiwan)	7	5	4	15	5	11
ฮ่องกง (Hong Kong)	3	4	2	3	8	6
เกาหลี (Korea)	8	2	6	6	14	14
ญี่ปุ่น (Japan)	9	9	10	20	16	16
มาเลเซีย (Malaysia)	19	20	19	18	18	17
ออสเตรเลีย (Australia)	18	18	18	21	22	23
นิวซีแลนด์ (New Zealand)	26	27	26	29	29	28
ฟิลิปปินส์ (Philippines)	36	31	32	31	31	35
จีน (China)	33	32	29	27	32	21
อินเดีย (India)	40	36	37	37	41	37
ไทย (Thailand)	**38**	**37**	**41**	**48**	**43**	**36**
อินโดนีเซีย (Indonesia)	51	51	53	55	55	53
จำนวนประเทศทั้งหมด (Number of Countries)	**51**	**51**	**53**	**55**	**55**	**57**

National S&T Policy and Strategies

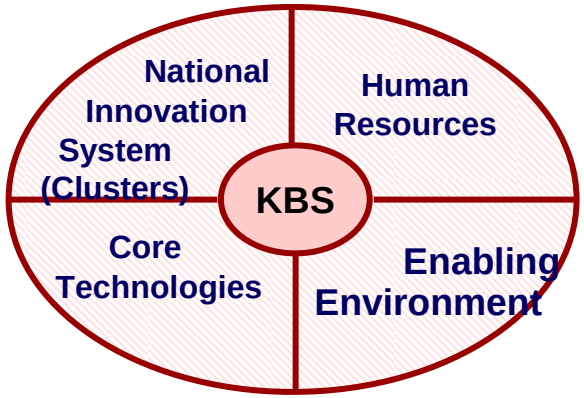
National Science and Technology Strategic Framework (2004-2013)

Vision: Strong economy with knowledge society and better social well-being

Sustainable competitiveness	Community economy	Learning society	Q of life/ Environment

Core technologies:

1) ICT
2) Biotechnology
3) Material Technology
4) Nanotechnology



Goals

- Number of enterprises having innovation increases to 35% and value of knowledge-intensive products/services reaches the average range of OECD.
- Higher income, stronger community economy and better quality of life.
- S&T ranking of Thailand above the median of IMD ranking.

National S&T Strategic Plan 2004- 2013

Economy **Society**

1 *Develop Clusters and Strengthen Community Economy and Quality of life*

Food | Auto-mobile | Software & Microchip | Textile | Tourism | Health | Bio Industry | OTOP | Environment | Youth | The Underprivileged

Core Technologies

Bio technology | ICT | Materials technology | Nano technology

Scientific Knowledge

life science, physics, math, computer, material science

2 *Develop S&T human resource*

3 *Develop S&T infrastruc-ture and institutions*

4 *Enhance S&T Public awareness*

5 *Improve S&T management system*

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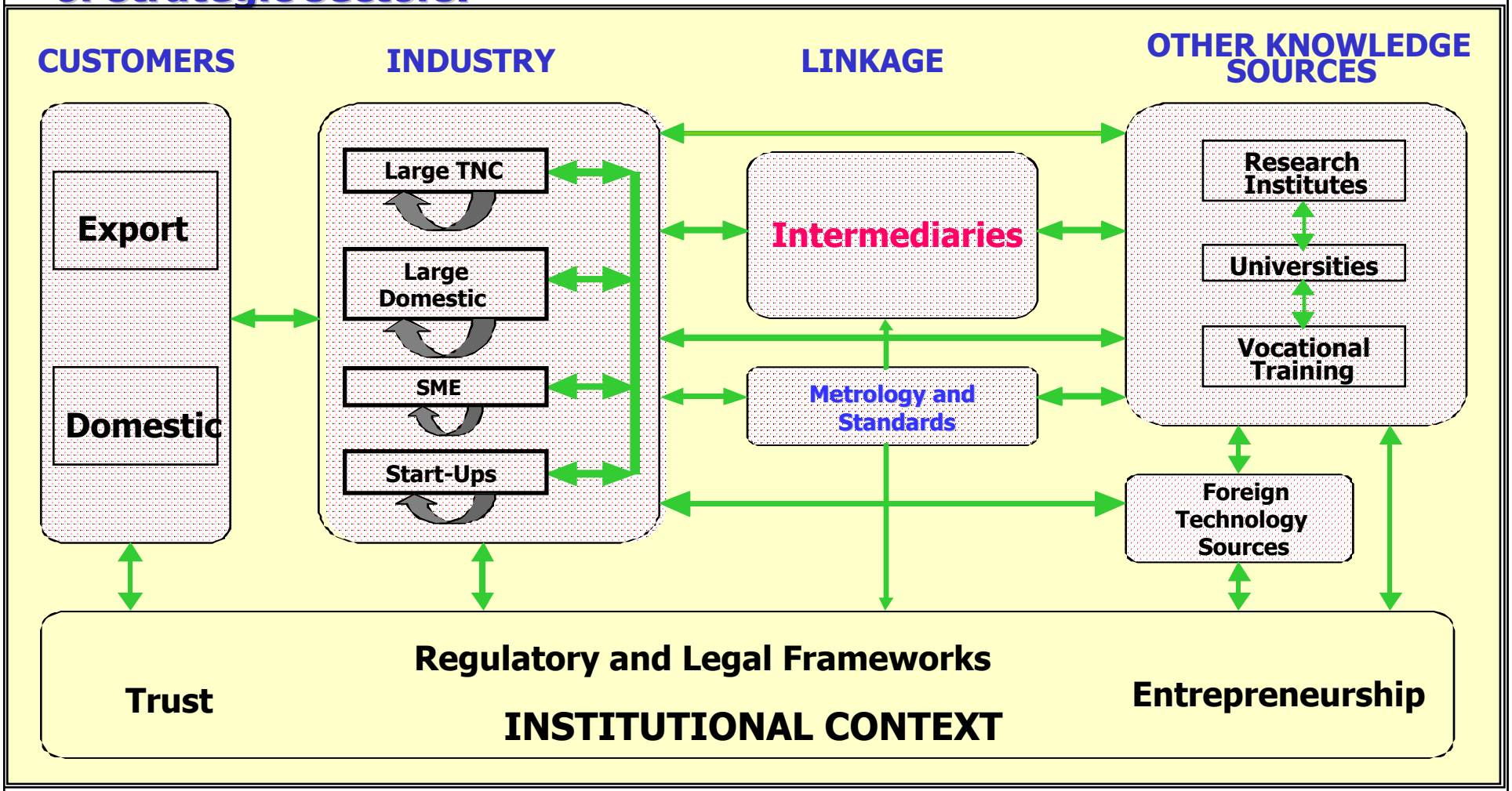
The National S&T Strategic Plan (2004-2013) suggested adoption of "clustering" as an approach to enhance technological capability of strategic sectors.

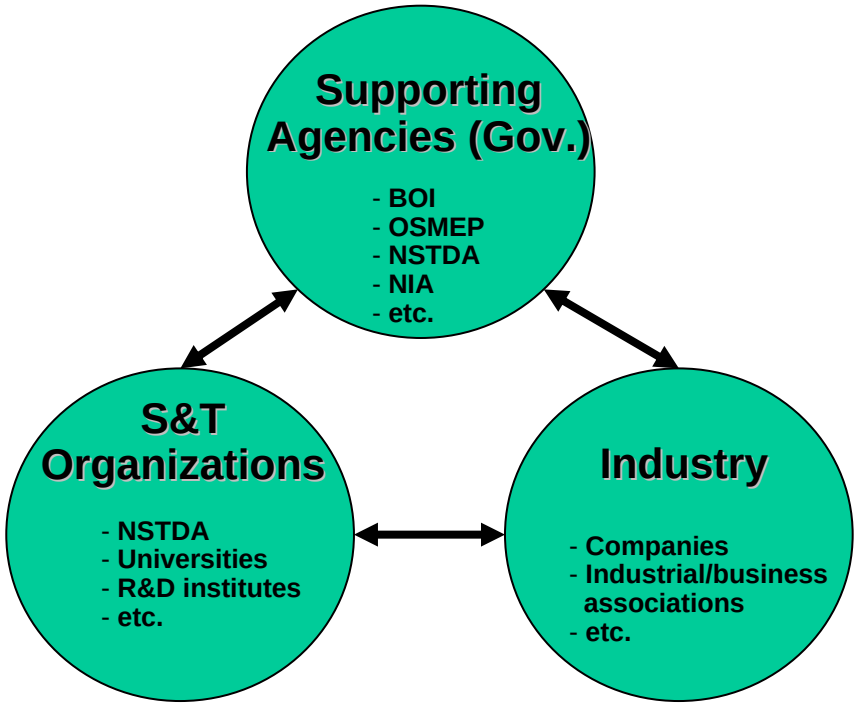


Source: adapted from Arnold et.al. (2000)

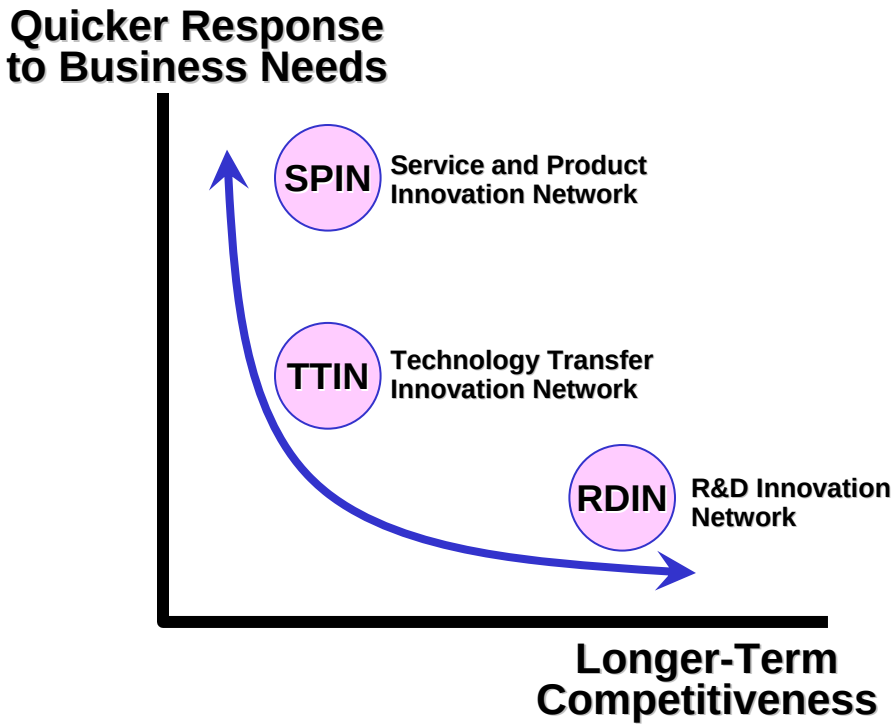
Chemical Metrology and Its Impact on Industry and Quality of Life

The implementation began with development of the so-called "Sub-Sectoral Innovation Network", SSIN.

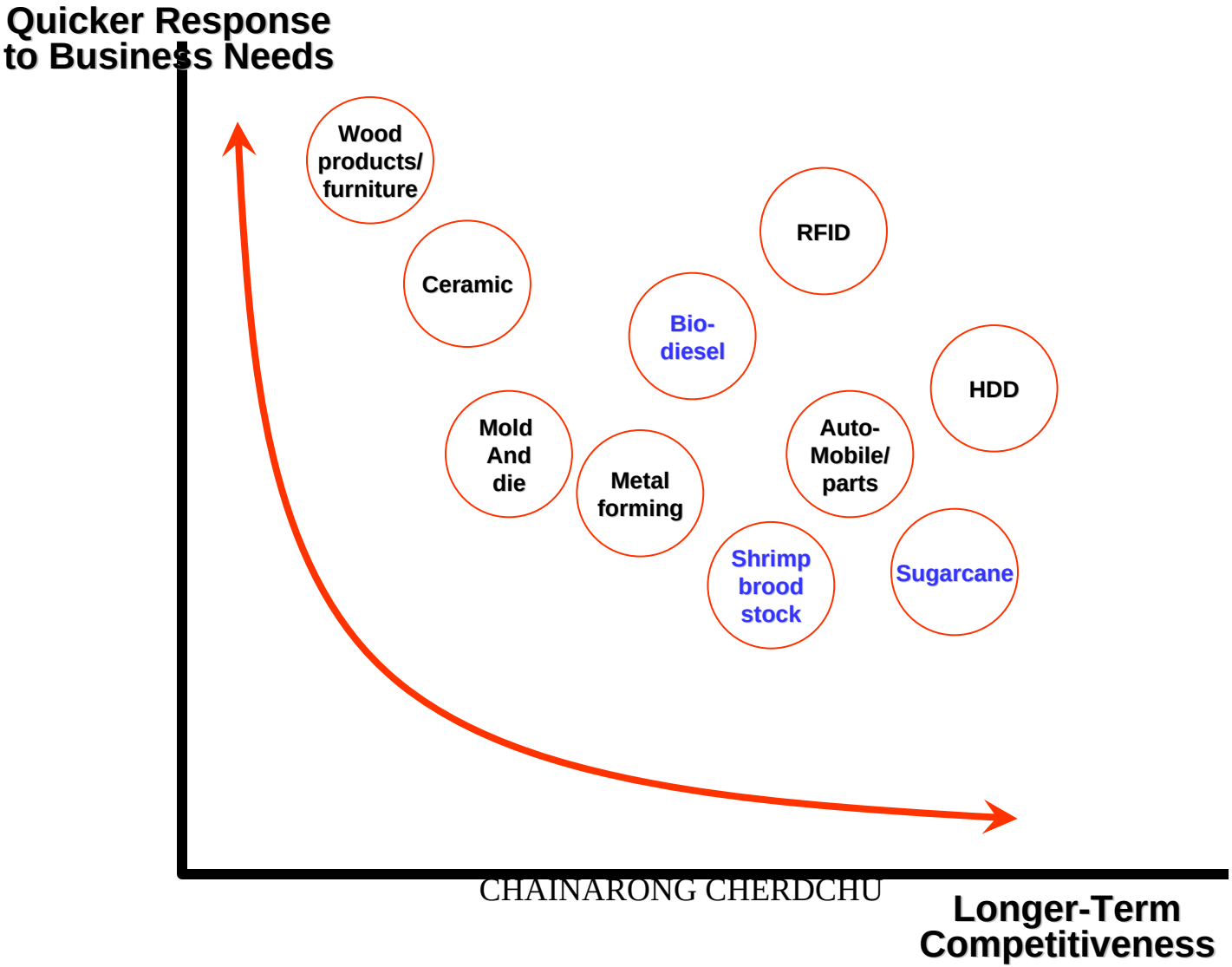
Stimulating Tri-Partite Collaboration



Three Types of SSIN

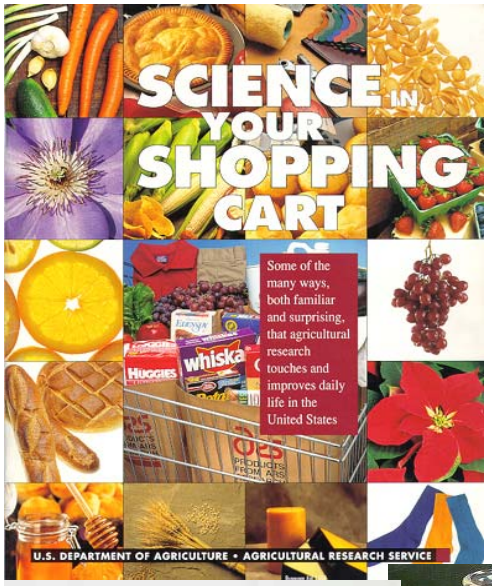


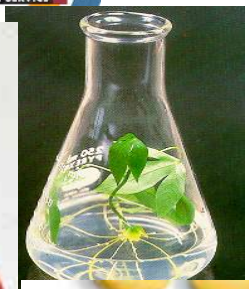
Examples of Currently Developed SSINs



Product of STI-Policy and Strategy: Case of Biotechnology

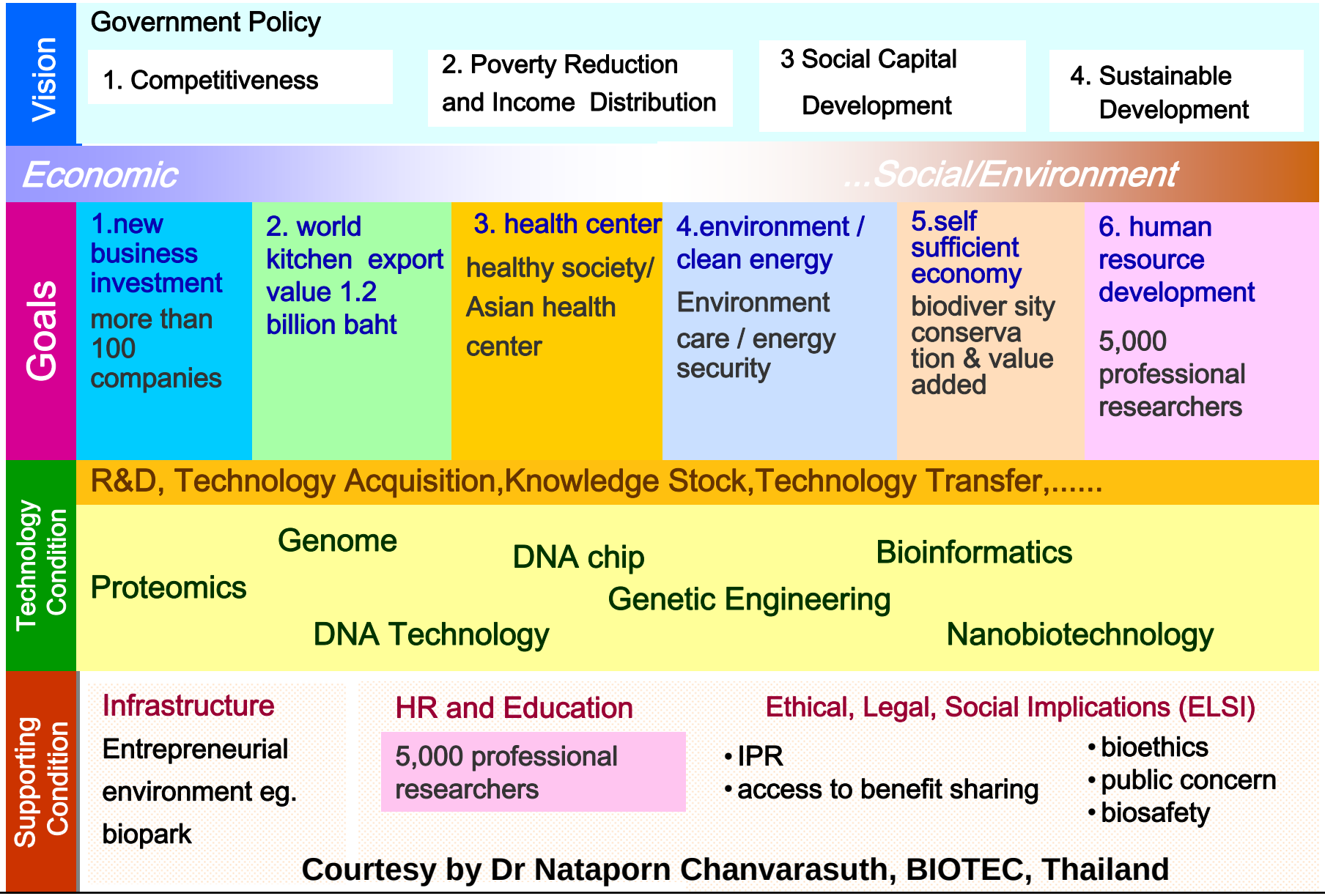
National Biotechnology Policy





- National Biotechnology Committee
  - formed in 2003: chaired by the Prime Minister
- Cabinet approved Biotech Policy in 2004
  - 6 Goals
  - aimed at supporting country's key industries
  - Time frame: 6 years (2004-2010)

Chemical Metrology and Its Impact on Industry and Quality of Life



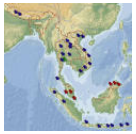
Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

Chemical Metrology and Its Impact on Industry and Quality of Life

Goal No.1 "New Bio-Business"

2004

Foreign policy in expanding market to neighboring countries



Set up a biotechnology park

Government measures to promote investment in bio-technology

2005

Establish venture capital to invest in biotechnology

Investment in research and development from abroad begins to increase

Initiate taxation measures and other privileges

2006

Set up 20 new companies in bio-technology business

2007

Set up provincial biotechnology parks

Initiate partnership with neighboring countries in bio-business

2008

SMEs becom strong and have linkages with large companies

Fortify bio-business in service sector

Bio-technology companies listed on the Stock Exchange of Thailand

2009

Emergence and development of new bio-business

Establish over 100 new biotechnology companies

Investment in research and development reaches over 5 billion Baht in value

200% or more increase in number of biotechnology-related patents

Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

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Goal No.2 "Kitchen of the World"

2004

Cooperation among organizations under different authorities

Agricultural research utilizes more biotechnology tools

Management mechanisms in place to control food safety and inspection

A clear policy toward GMOs is established

Host of Shrimp Cluster identified

2005

Service business on food/ seed inspection for export

Widespread use of DNA technology for plant and livestock breeding

An organization established to handle information for trade-related decision-making and negotiation

Database network on food and safety

Rice and cassava clusters formulated

2006

Have capability in risk assessment of food

25% of exported vegetable/ fruit utilize biocontrol for pest management

Domesticated shrimp broodstock occupy 50% of total supply

Post-harvest and packaging technologies utilized to expand vegetable/ fruit market

Food research institute established

2007

Probiotics replace upto 25 % of antibiotics usage

Thai livestock products accepted in global market

Export value of Thai fruit increased to 53 billion Baht

Thailand sets standard for exporting food products e.g. shrimp

2008

New best-seller marine products on top of shrimp

A policy shift from contract seed producer to R&D and seed exporter

2009

Biotechnology promotes Thailand as kitchen of the world

Total food export value reaches 1.2 trillion Baht

Export of processed agricultural products ranked top 5 in the world

Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

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Goal No.3 "Healthcare Center"

Large investment in genomics and bioinformatics

Manufacture premium health care products made of essential herbs for export

Hospitals and community health centers equipped with user-friendly diagnostic devices

A national committee on bioethics and law to be set up

Diagnostic kits and health service business achieve high growth

Thailand becomes the center for tropical diseases technology development, transfer and training

Surveillance system for emerging and re-emerging diseases is established

Expand medical products manufactured by means of linkage with neighboring markets

Infrastructure for new drug development

Thailand as healthcare center of Asia

Health service business achieves considerable growth

Discover new drug for tropical diseases such as malaria

Small and medium-sized enterprises start to operate genetic testing business

Diagnostic/ testing business extended to neighboring markets

Thailand becomes the center for clinical testing

Community healthcare strengthened

Thailand becomes the center for research and development in tropical diseases/ emerging diseases

Manufacture of standard vaccines for e.g. encephalitis and viral hepatitis B with accepted international standards

Public health of neighboring countries improved

Thailand's biotechnology products represent a significant proportion of good health services for all

2004 **2005** **2006** **2007** **2008** **2009**

Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

Chemical Metrology and Its Impact on Industry and Quality of Life

Goal No.4 "Clean Environment and Energy"

2004

Starch industry produces energy from wastewater

Livestock farms produce energy from waste

Low-interest-rate loans to support production of energy from waste

Joint policy among 4 relevant ministries

2005

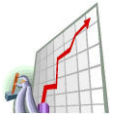
Measures leading to investment on energy production from wastes

Development of technologies for surveillance/ treatment/ rehabilitation and recycling for the environment

Utilization of biofertilizer and biomass to rehabilitate soil quality

Utilization of biomass energy and gasohol is increased

2006



Service business for environment achieves considerable growth

Benchmarking energy consumption in each category of food industry

Prototype of product s made from biodegradable plastic

2007

Food industry factories using biogas energy becomes widespread

2008

Utilization of biotechnology to conserve the environment and produce clean energy

2009

Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

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Goal No.5 "Self-Sufficient Economy"

Training on food safety provided for local communities

Local communities produce starter culture for fermented food, biofertilizers, probiotics, and other biological products

Production of new ornamental plants/ new type of plant products from tissue culture

Establishment of local resource database for sustainable biotechnology business

Establishment of center for biodiversity research

Environmental Standards put in place for production of community products

Community business adopting biotechnology at progressive rate

Raw material for community products derived from cultivation and domestication

Bio-technology as the key factor for self-sufficient economy

Community able to use appropriate S&Tin combination with local wisdom

2004 2005 2006 2007 2008 2009

Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

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Goal No.6 "Human Resource"

Database of biotechnology experts

Encourage employment of foreign experts

Human resource development system from cooperation among research institutions, universities and private sector

Joint investment between government and private sector in human resource development to meet the targets

200 managers in biotechnology

A system to develop biotechnology personnel in parallel with career development on a continual basis

Thailand becomes the hub of human resource development in biotechnology in ASEAN

At least 20% of new entrepreneurs belong to biotechnology business

Thai biotechnologists play important role in developing international biotechnology business

Qualified human resource system established

500 managers in biotechnology

5,000 professional researchers

10,000 graduates in the field of biotechnology

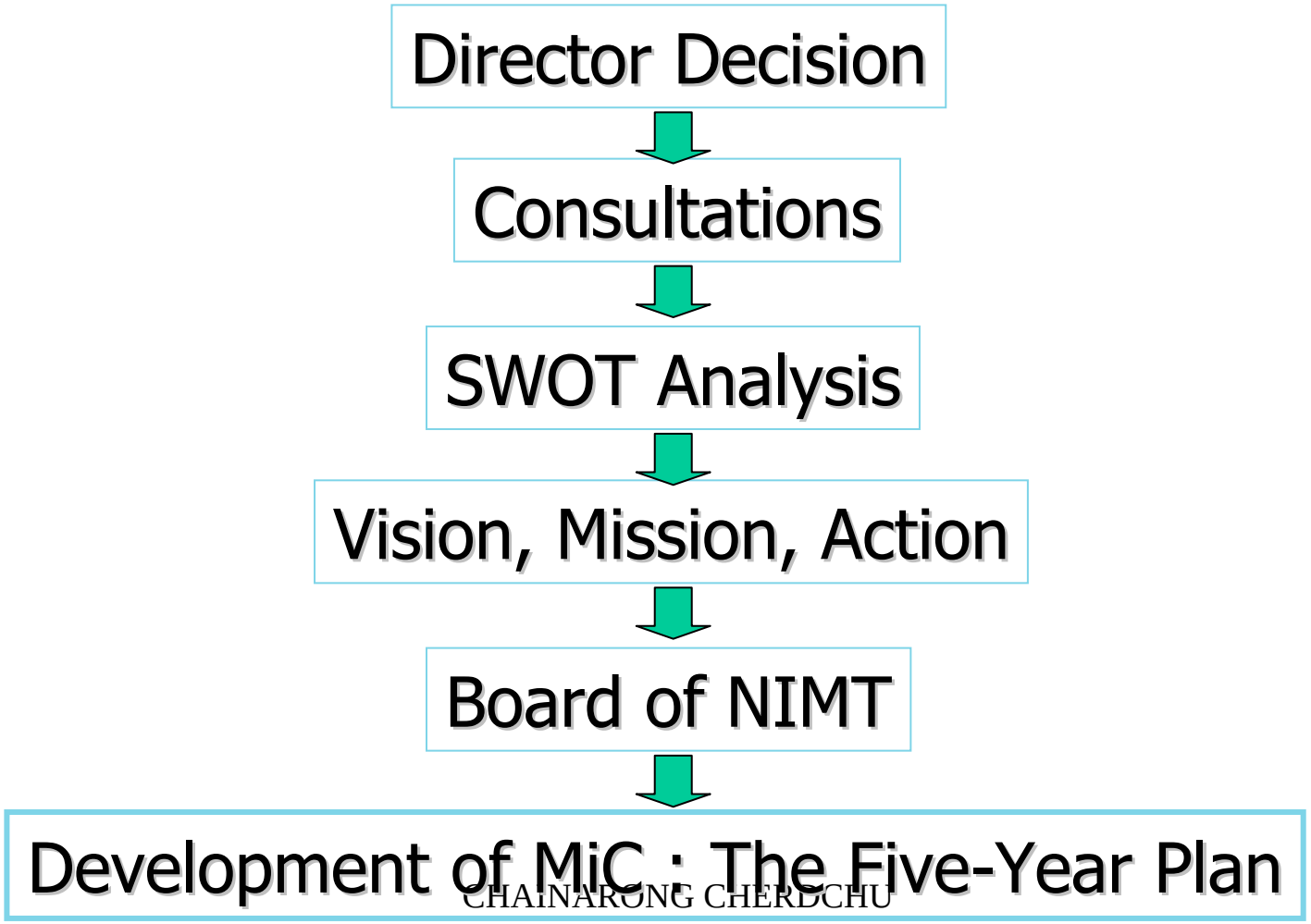
2004 2005 2006 2007 2008 2009

Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

HISTORY OF THAILAND METROLOGY

- Metre Convention(1875) full member since 1912
- Legal Metrology Act, 1923
- Thailand Institute of Scientific and Technological Research(TISTR), 1961
- The Royal Thai Airforce, 1965
- Department of Science Service(DSS), 1966
- Metrology Development Act, 1997
- National Institute of Metrology(Thailand) (NIMT), 1998

DEVELOPMENT OF MiC IN THAILAND



MiC : The Five-Year Plan

- **2005: CMLN, Potential Lab, R&D for RM/PT**
- **2006: Seminar,Workshop,Training,Recruiting, Participating**
- **2007: Implementing, Measuring Service, Calibration Service, Establishment of Measurement Standard**
- **2008: Formation of WGs, Designations, More Active Participation in APMP, CCQM, APLMF, APLAC, etc.**
- **2009: Join with APEC SCSC, APCTT, ASEAN, etc.**

Inter-laboratory comparison measurement(1)

	Detail	Range	Year
1	APMP.QM-P-06: pH measurement (phosphate buffer)	6.85-6.88 pH	2004
2	APMP.QM-P-09: pH measurement (phthalate buffer)	3.99-4.02 pH	2006
3	pH measurement (Bilateral NIMT&NMIJ) 2 buffers phthalate, phosphate buffer (Harned cell)	6.85-6.88 pH 3.99-4.02 pH	
4	CCQM-P20e: Purity assessment of Theophyline	>975 mg/g	
5	CCQM P85: Cadmium (Cd) and Zinc (Zn) in Bovine Liver	Cd 20-100 µg/kg, Zn 70-300 µg/kg	

Inter-laboratory comparison measurement(2)

	Detail	Range	Year
6	APMP.QM-P10: Cadmium (Cd) and Lead (Pb) in Herb	Cd 0.1-0.5 mg/kg Pb 1-5 mg/kg	2007
7	CCQM-P97: Cadmium (Cd) and Lead (Pb) in Herb	Cd 0.1-0.5 mg/kg Pb 1-5 mg/kg	
8	CCQM K56: Calcium (Ca), Copper (Cu), Iron (Fe) and Zinc (Zn) in soybean	Ca 1000-2000 mg/kg Cu 5-20 mg/kg Fe 30-100 mg/kg Zn 10-80 mg/kg	
9	CCQM-P90: Mass fraction of Chloramphenicol as residue in milk	0.3 µg/kg	

Inter-laboratory comparison measurement(3)

	Detail	Range	Year
10	CCQM-P88: Malachite green in Fish Tissue	MG 0.5-5 µg/kg LMG 3-10 µg/kg	2007
11	CCQM-P20f.: Organic purity assessment series: Digoxin	>975 mg/g	
12	Proficiency Testing: Analysis of Preservatives in Curry paste	Sorbic acid 200 – 300 mg/kg, Sodium benzoate 400 – 500 mg/kg	

Inter-laboratory comparison measurement(4)

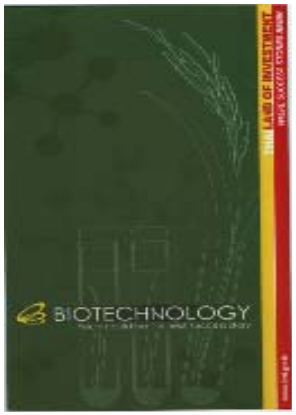
	Detail	Range	Year
13	APMP.QM-K24: Cd content in Rice Powder	0.1-1 mg/kg	2008
14	CCQM-P109: Determination of Acrylamide in Potato Chips	0.2-2 µg/kg	
15	APMP.QM-S2: O_2 in N_2 (Bilateral NIMT&NMIJ)	at atmospheric level	
16	CCQM-P113: Relative quantification of genomic DNA fragment extracted from Maize powder	200-2,000,000 copies	
17	CCQM-K51: CO in N_2	5 ppm	
18	CCQM-P106: Cadmium (Cd), Chromium (Cr), Mercury (Hg) and Lead (Pb) in polypropylene	Cd 20-80 mg/kg Cr 100-400 mg/kg Hg 200-600 mg/kg Pb 200-600 mg/kg	

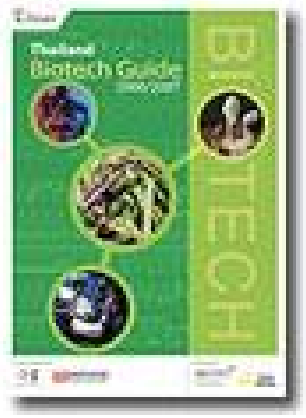
Parameter of Calibration services

	Description	Range	Accuracy/Uncertainty
1	Micropipette	20 µL to 1 ml	0.15 µL
2	Volumetric Flask	25 mL to 2000 mL	Class A (A)
3	Pipette	1 mL to 50 mL	Class A (A)
4	Burette	Up to 100 mL	Class A (A)
5	pH meter with associated electrode	1-11 pH	0.020 pH
6	Assigned pH value for sample	1.00-11.00 pH	0.020 pH
7	Potassium Dichromate Standard Solutions (Recalibration)	20, 40, 60, 80 and 100 mg/kg (each set choose from the concentrations above)	0.01 A
8	Potassium Iodide Standard Solution (Recalibration)	10 g/L	0.5 nm
9	Holmium Filter (Recalibration)	200 nm to 700 nm	0.5 nm
10	Didymium Filter (Recalibration)	200 nm to 700 nm	0.5 nm
11	Neutral Density Filter (Recalibration)	400 nm to 700 nm	0.5 nm

Achievements

- > 80 emerging biotechnology companies
- > 100 existing companies investing in R&D using biotechnology
- > 20 foreign companies investing in biotech business in Thailand
- ~ 10 biotech R&D centers
- Maximum tax incentives for biotech companies
- Biopark in the extension of Thailand Science Park





Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

Chemical Metrology and Its Impact on Industry and Quality of Life

Facilities Available at Thailand Science Park

Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

สถาบันมาตรวิทยาแห่งชาติ
National Institute of Metrology (Thailand)
NIMT

New Chemical Metrology Building

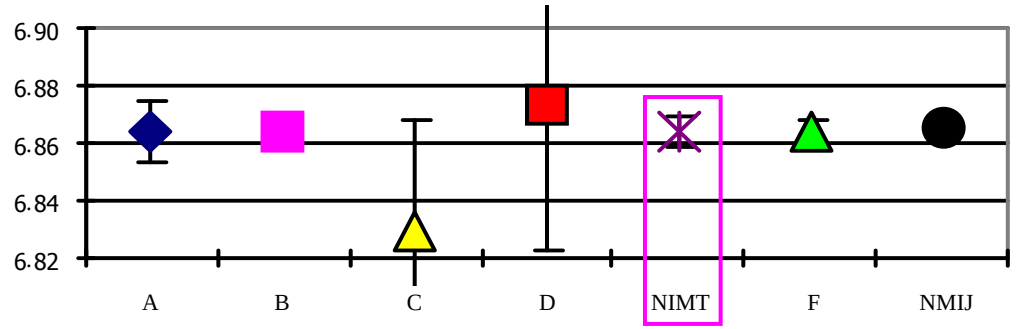

NIMT

The result of inter-laboratory comparison and proficiency test

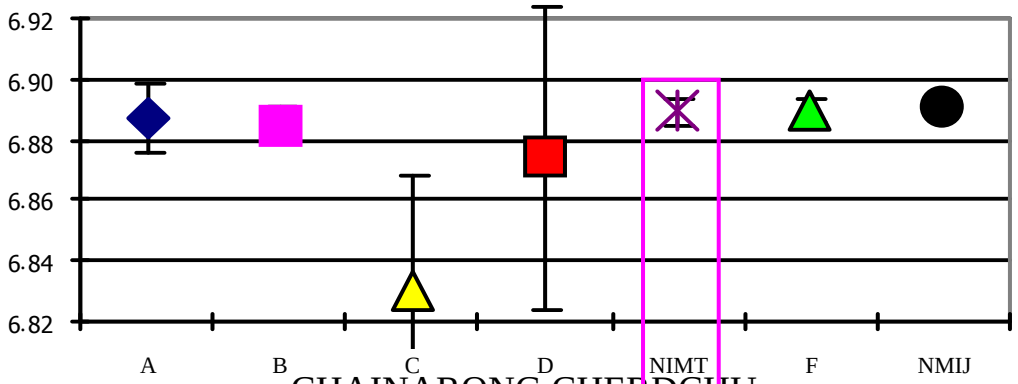
▷ APMP.QM-P06: pH measurement (phosphate buffer)

2004

(a)

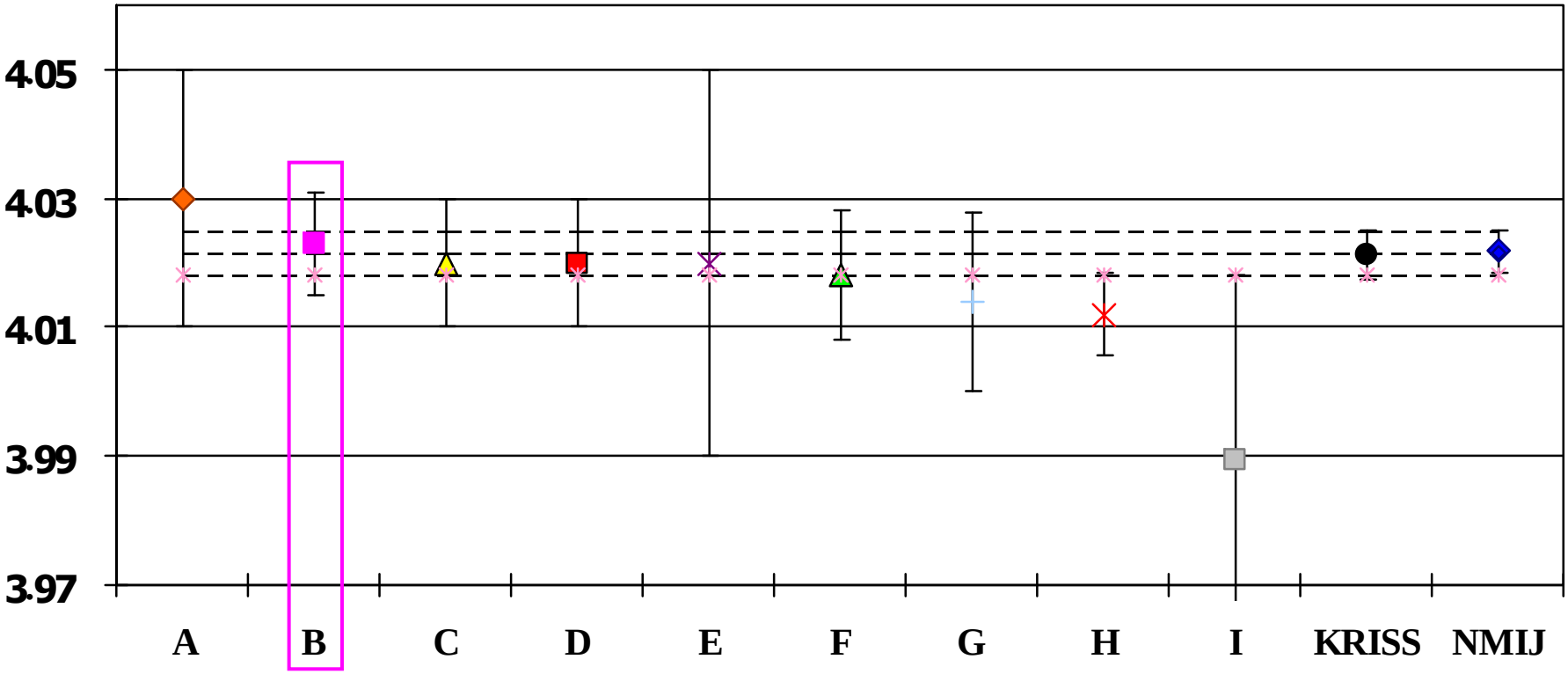


(b)

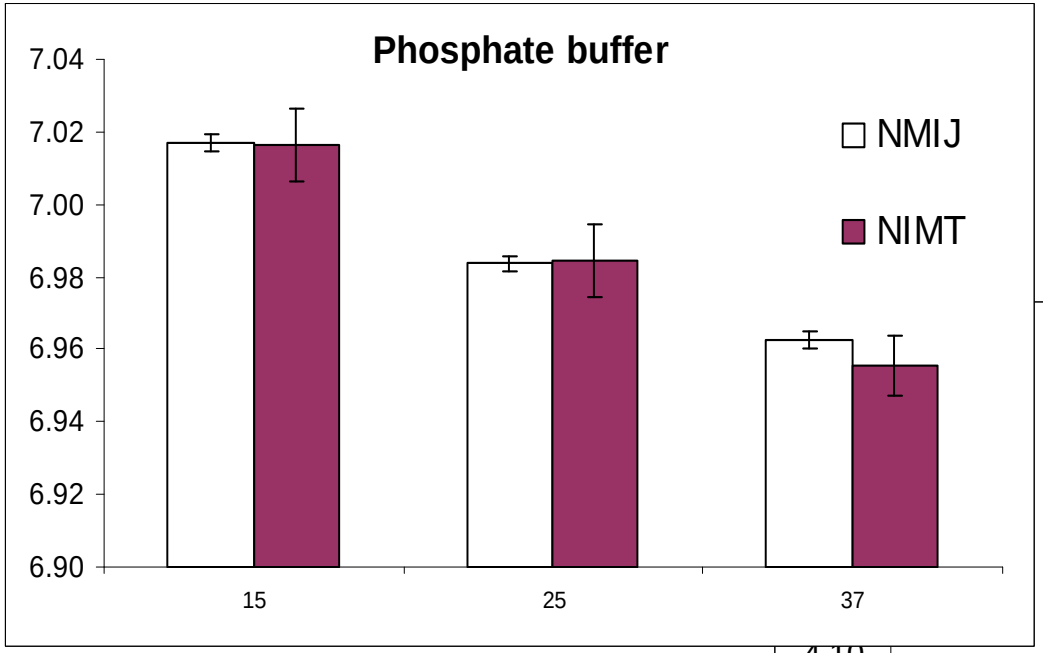


The result of inter-laboratory comparison and proficiency test

2006 ▷ **APMP.QM-P09: pH measurement (phthalate buffer)**

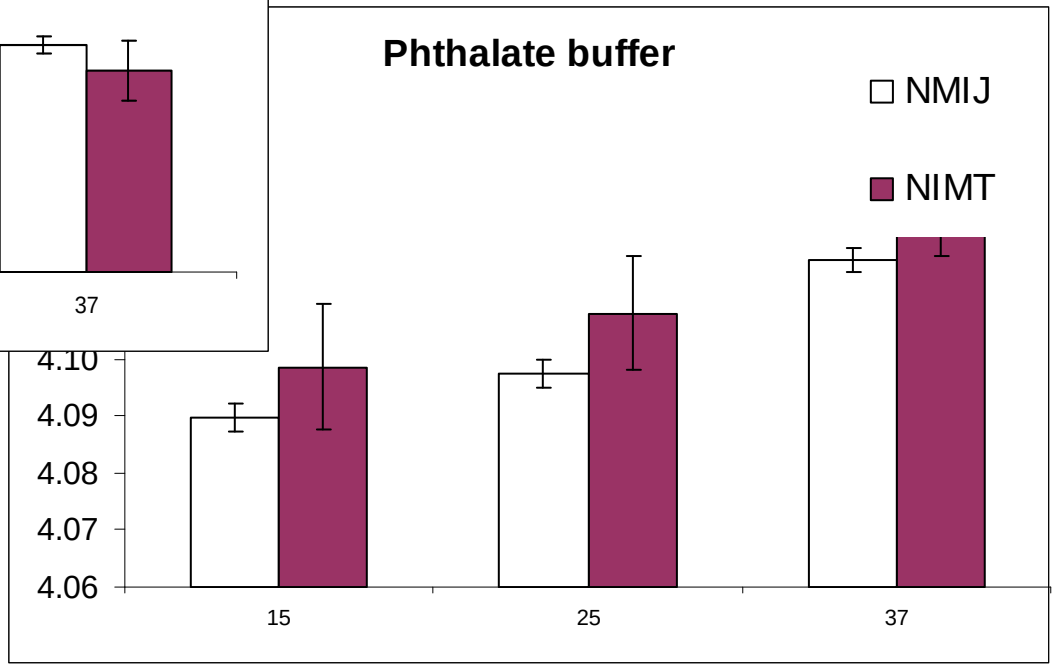


The result of inter-laboratory comparison and proficiency test



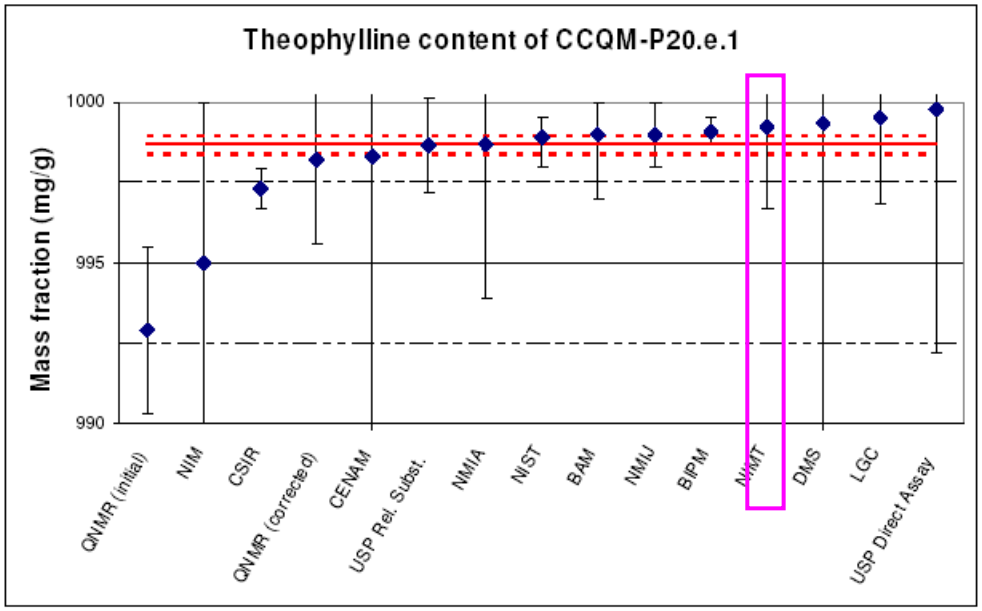
2006

▷ **Bilateral comparison with NMIJ (Harnned Cell)**



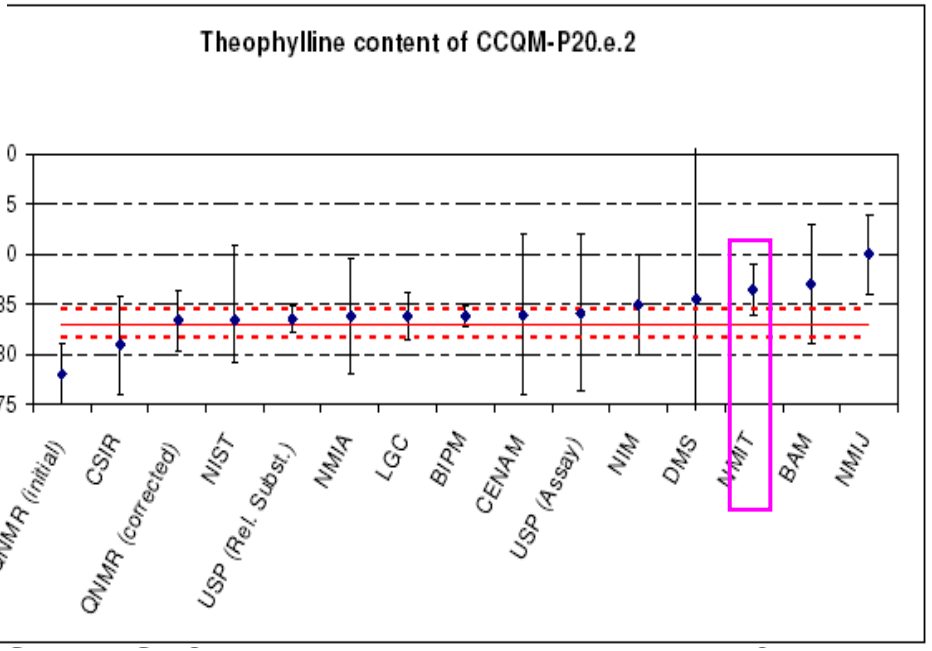
Chemical Metrology and Its Impact on Industry and Quality of Life

The result of inter-laboratory comparison and proficiency test



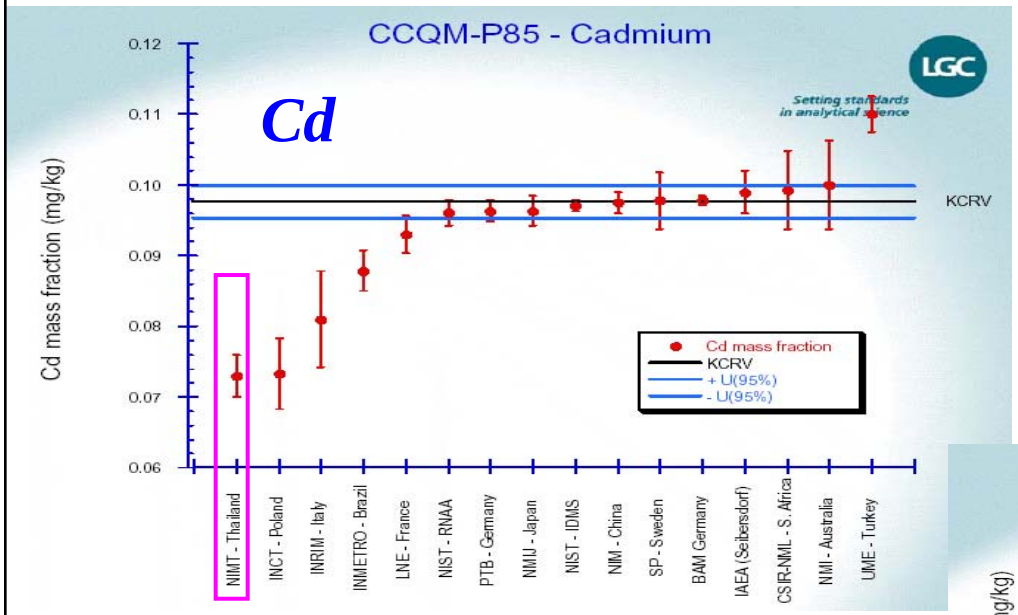
2006

▷ **CCQM-P20e: Purity assessment of Theophyline**



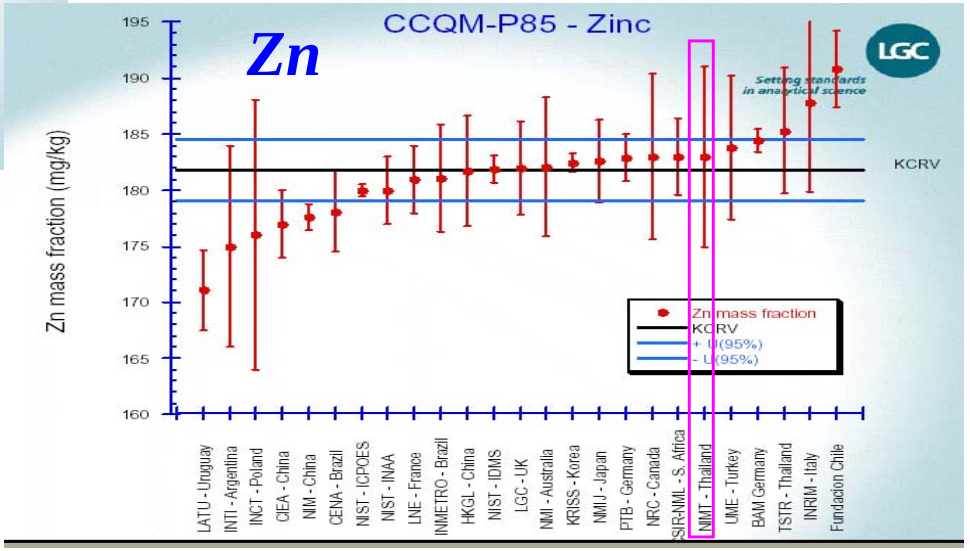
Chemical Metrology and Its Impact on Industry and Quality of Life

The result of inter-laboratory comparison and proficiency test



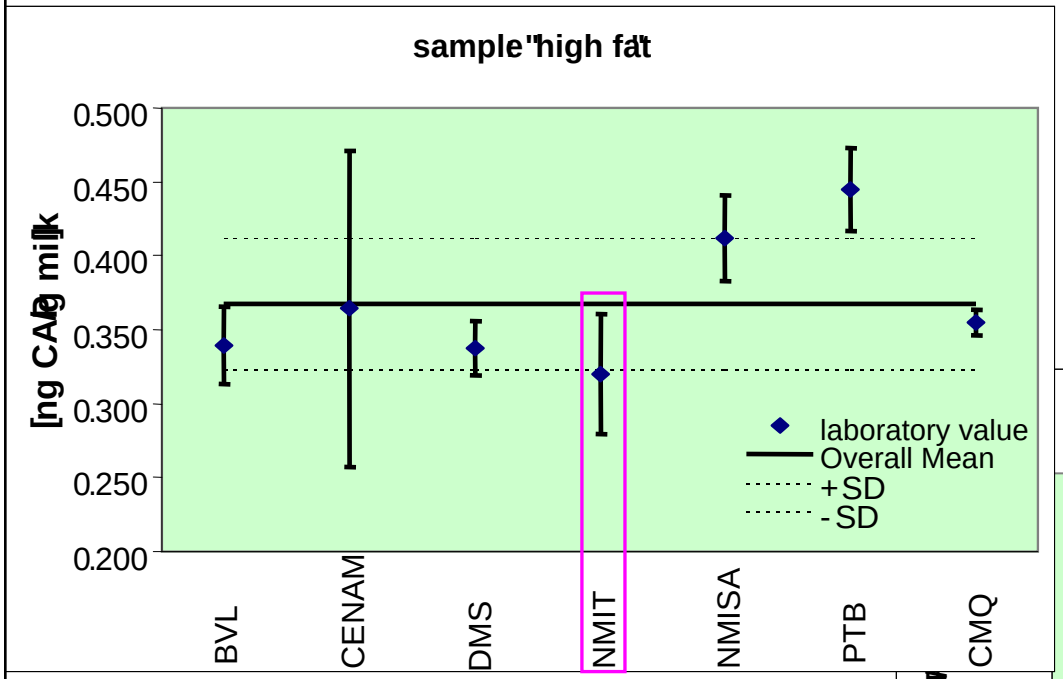
2006

▷ **CCQM-P85: Cadmium (Cd) and Zinc (Zn) in Bovine Liver**



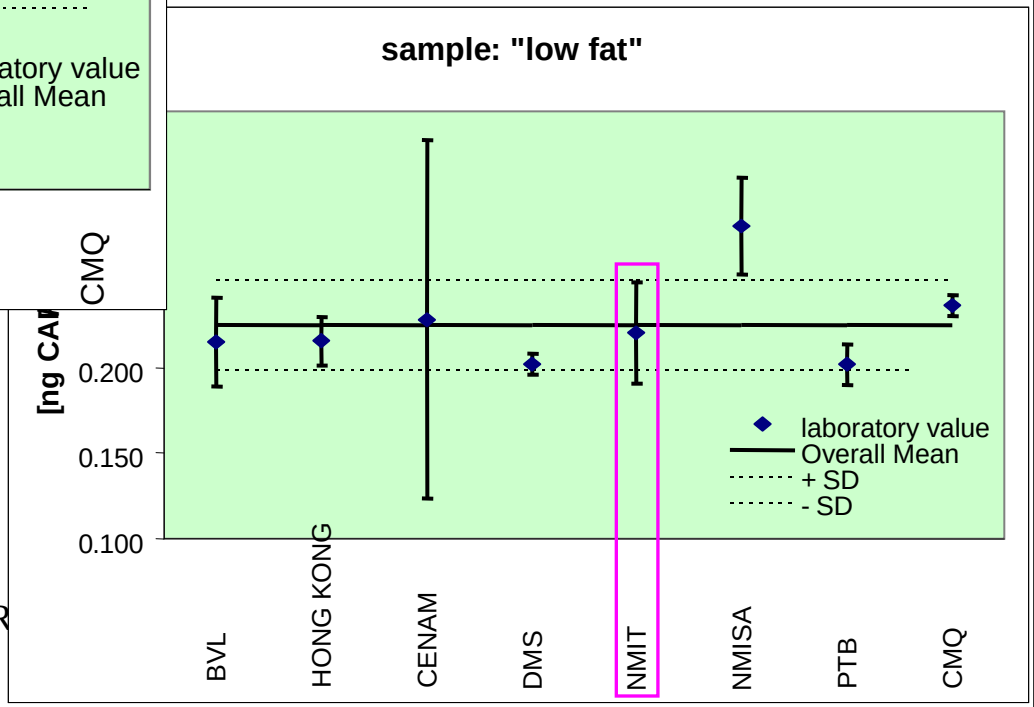
Chemical Metrology and Its Impact on Industry and Quality of Life

The result of inter-laboratory comparison and proficiency test



2007

▷ **CCQM-P90:** Mass fraction of chloramphenicol as residue in milk



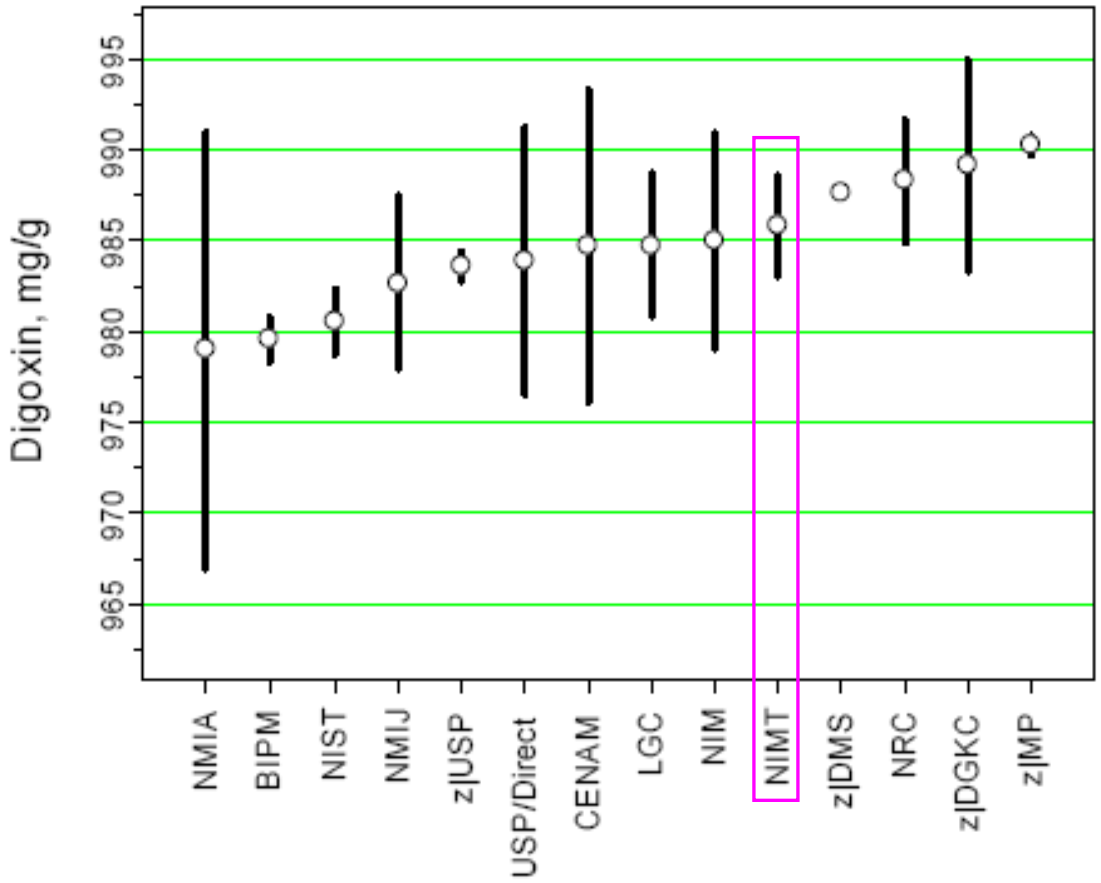
CHAINAR

Chemical Metrology and Its Impact on Industry and Quality of Life

The result of inter-laboratory comparison and proficiency test

▷ **CCQM-P20.f: Purify assessment of Digoxin**

2007

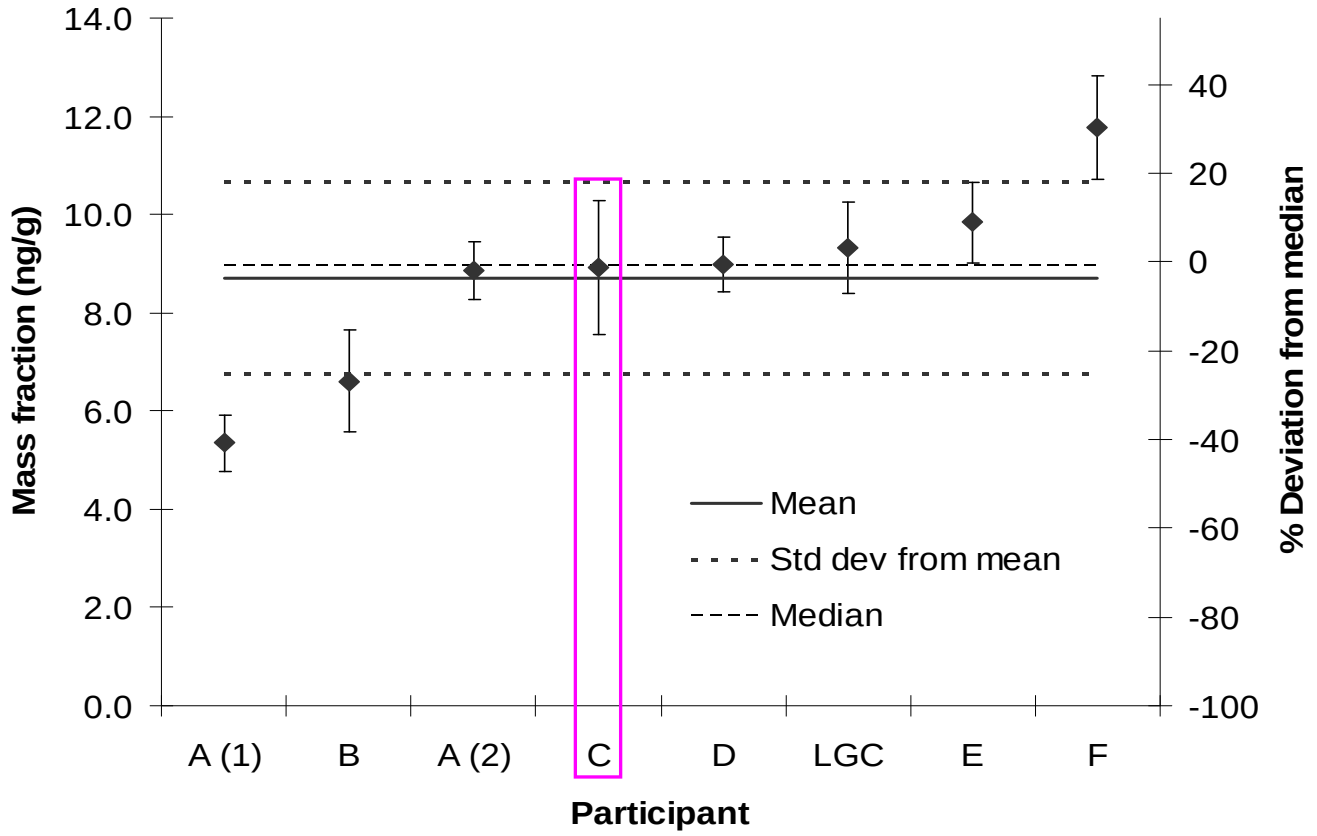


...

The result of inter-laboratory comparison and proficiency test

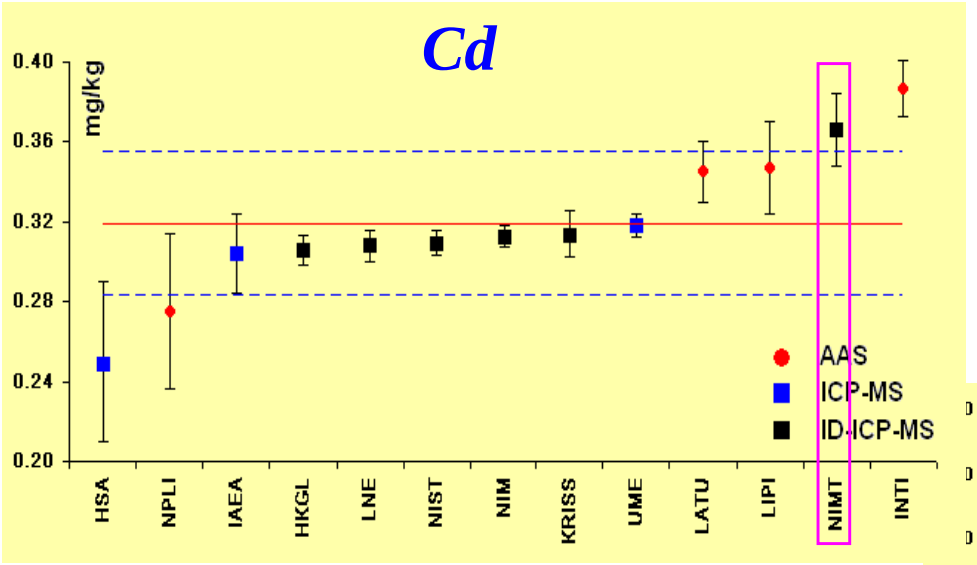
- **CCQM-P88: Malachite green and Leucomalachite green in fish tissue**

2007



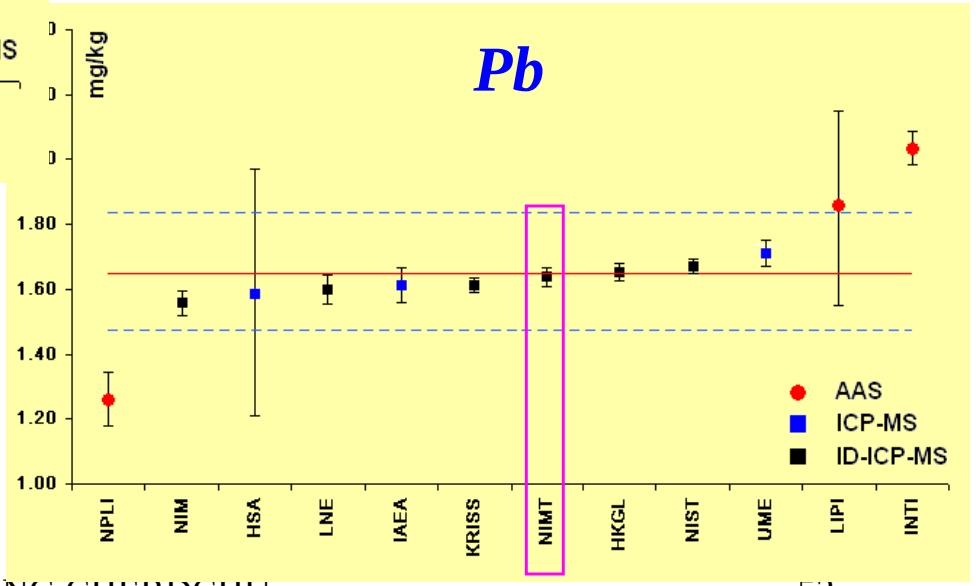
Chemical Metrology and Its Impact on Industry and Quality of Life

The result of inter-laboratory comparison and proficiency test

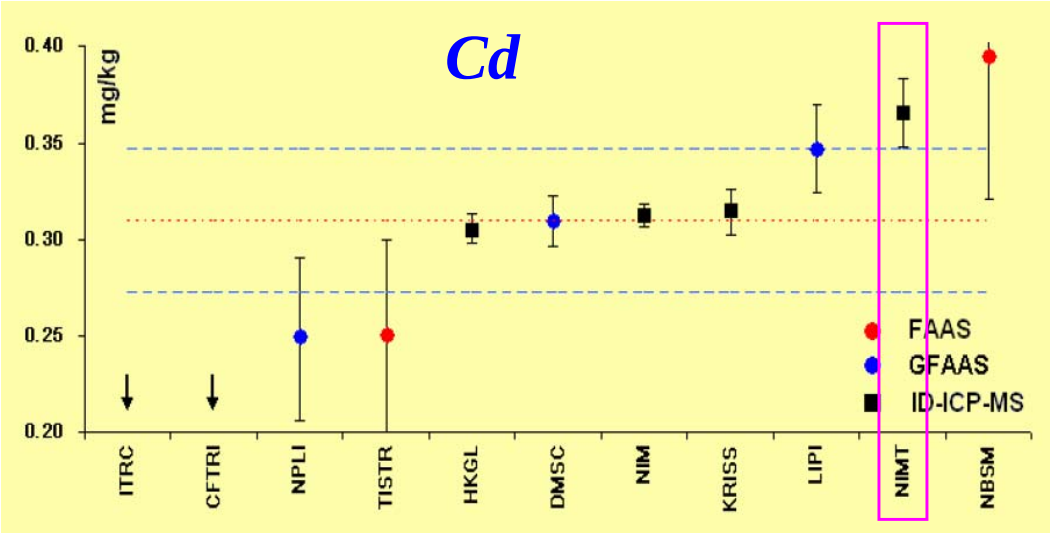


2007

▷**CCQM-P97: Cadmium (Cd) and Lead (Pb) in Herb**

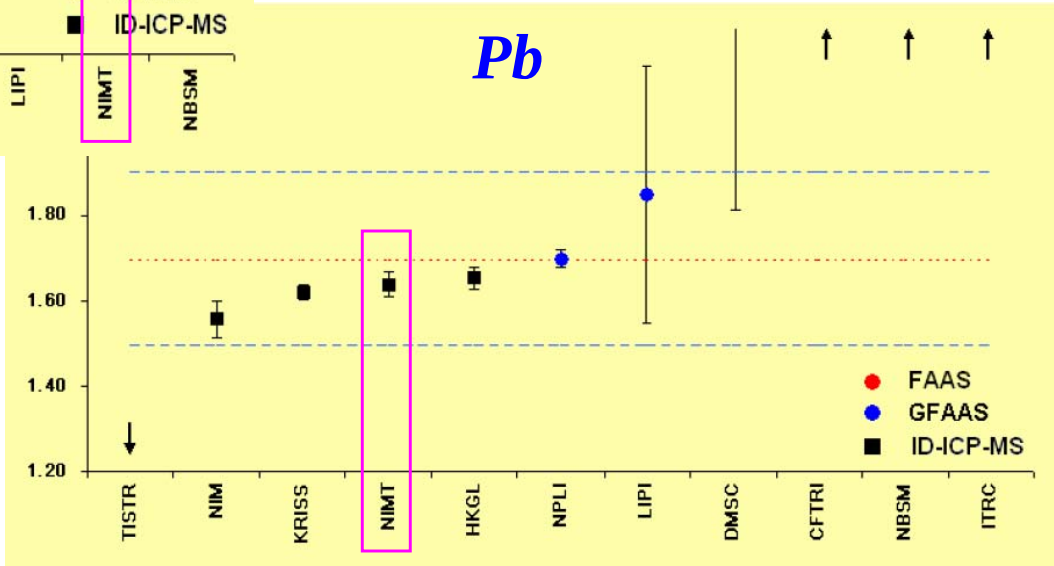


The result of inter-laboratory comparison and proficiency test



2007

▷APMP.QM-P10: Cadmium (Cd) and Lead (Pb) in Herb

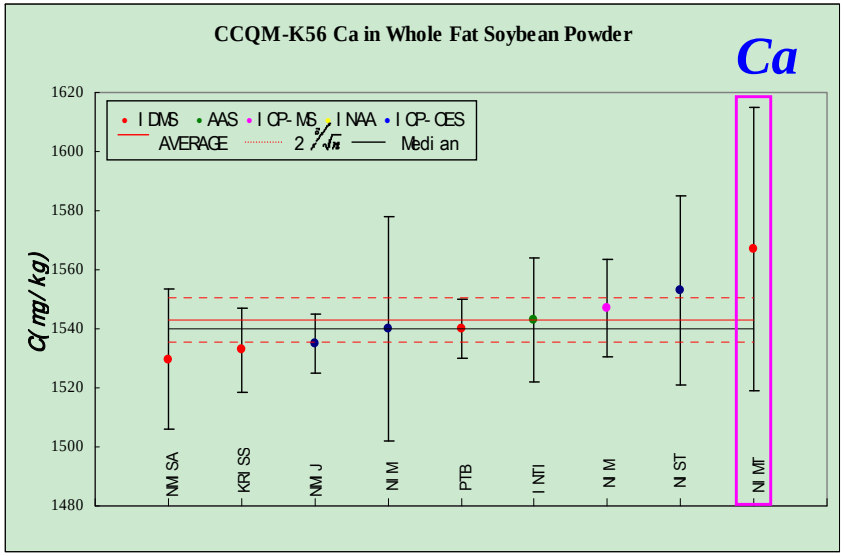


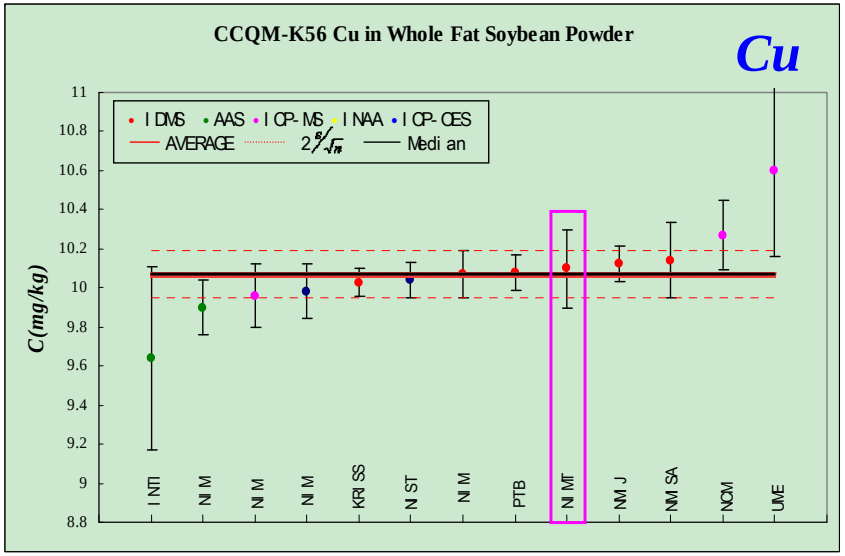
Chemical Metrology and Its Impact on Industry and Quality of Life

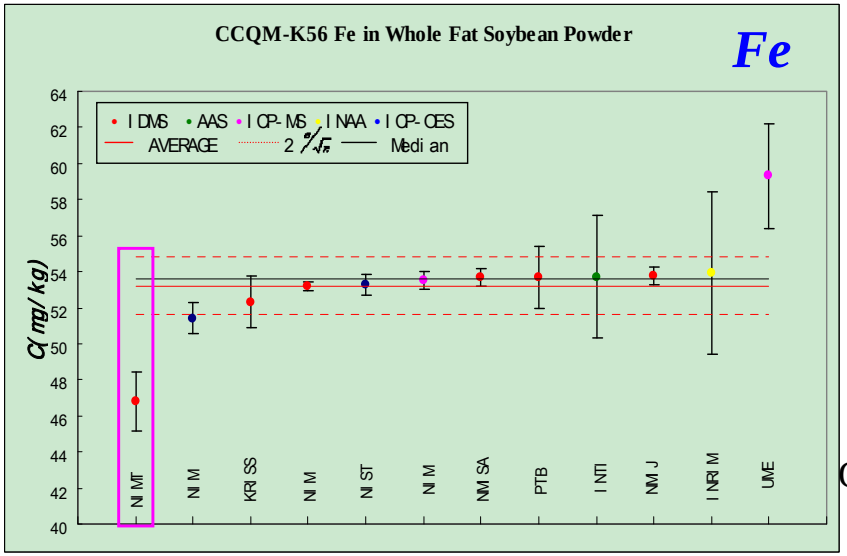
The result of inter-laboratory comparison and proficiency test

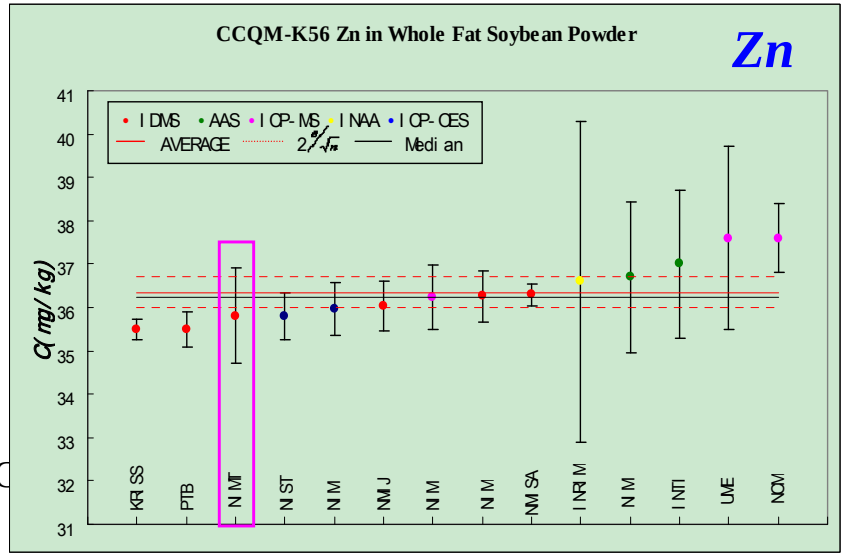
▷ **CCQM-K56: Calcium (Ca), Copper (Cu), Iron (Fe) and Zinc (Zn) in Soybean**

2007



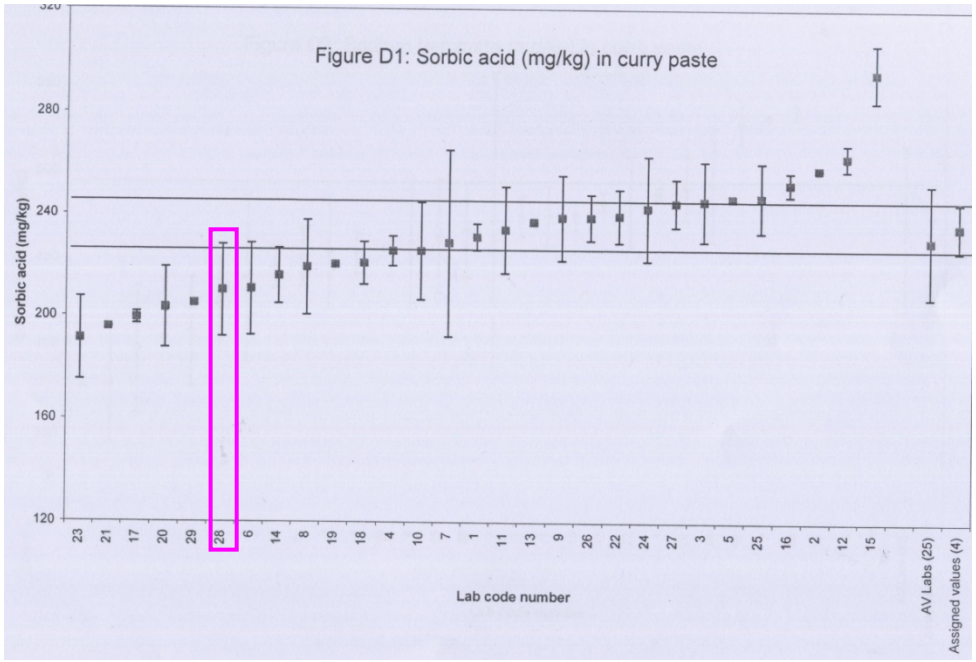






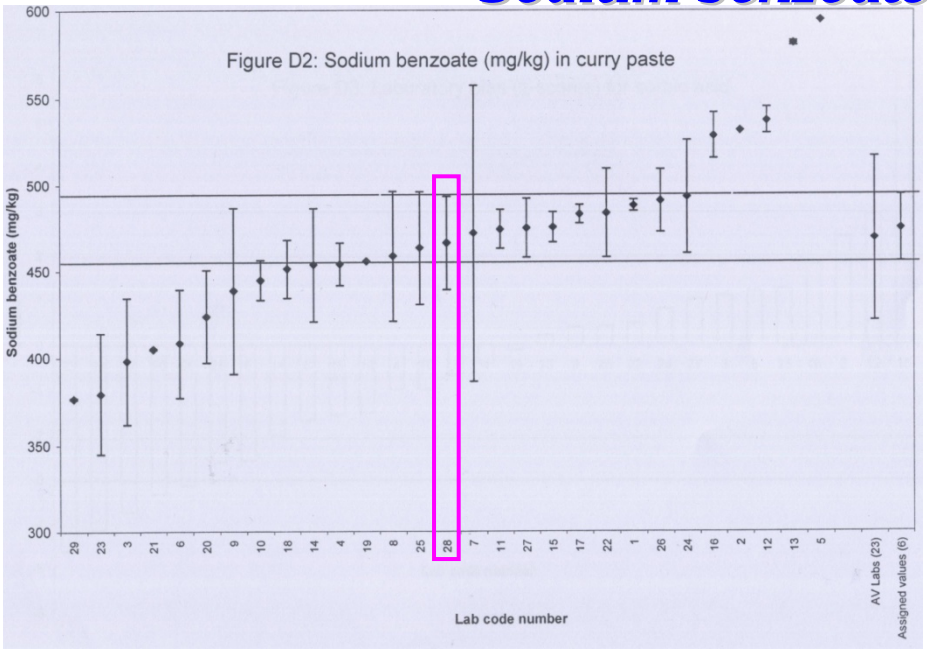
The result of inter-laboratory comparison and proficiency test

▷ **Proficiency testing: Analysis of preservatives in curry paste**



Sorbic acid

Sodium benzoate



2007

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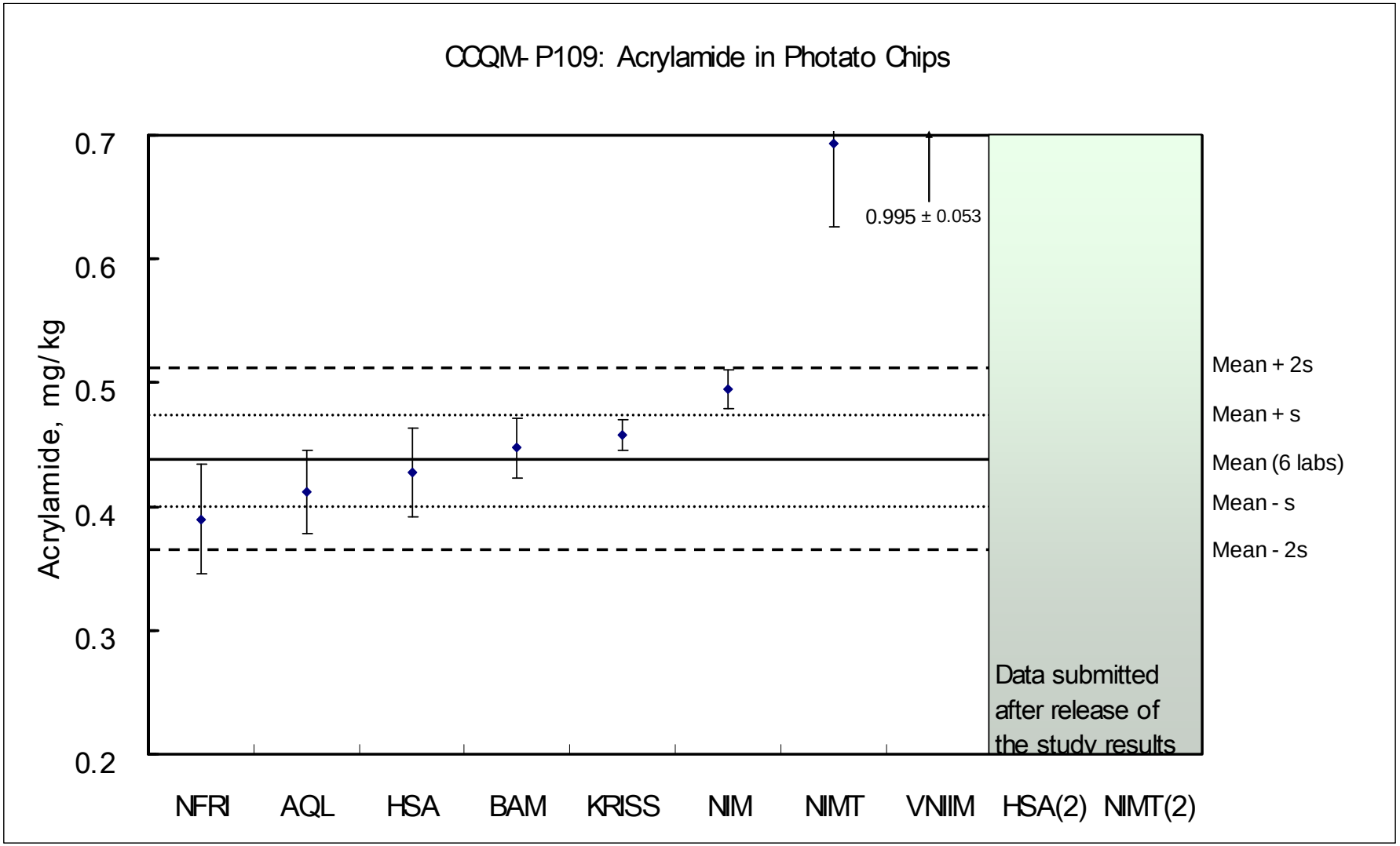
Results of CCQM-P109 Acrylamide in Potato Chips

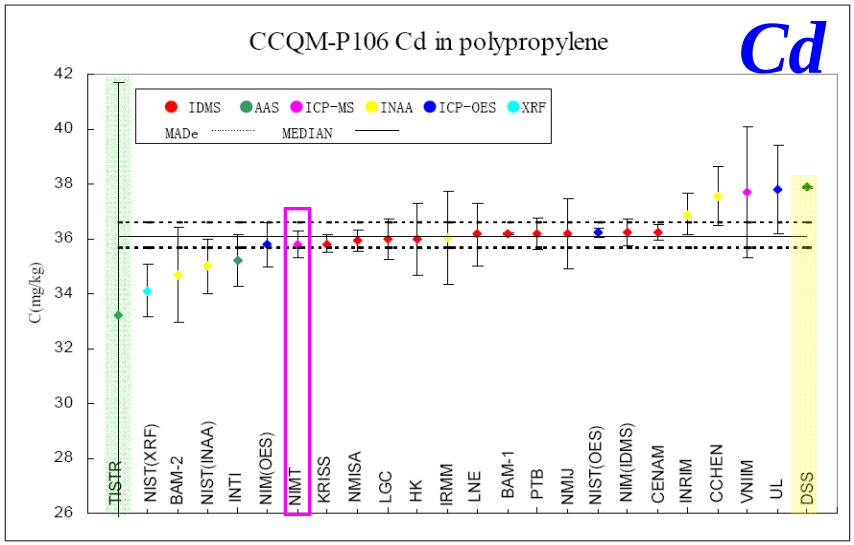


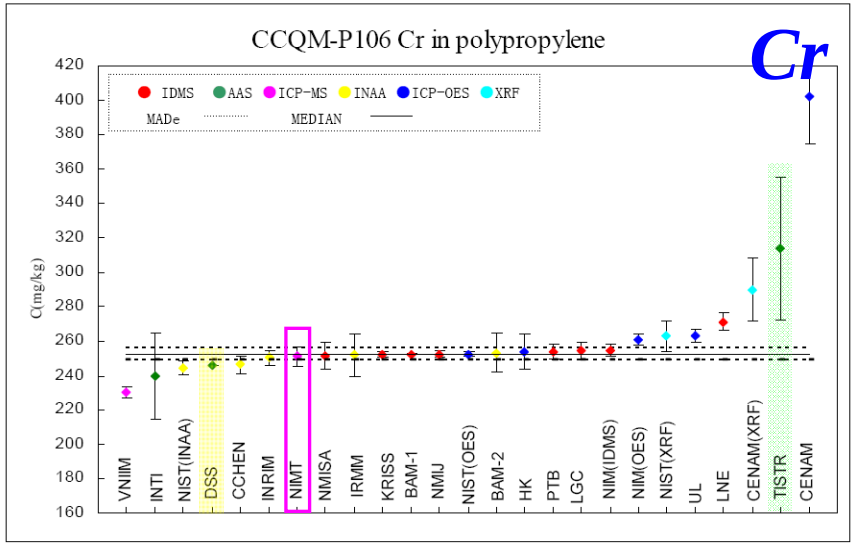
Chemical Metrology and Its Impact on Industry and Quality of Life

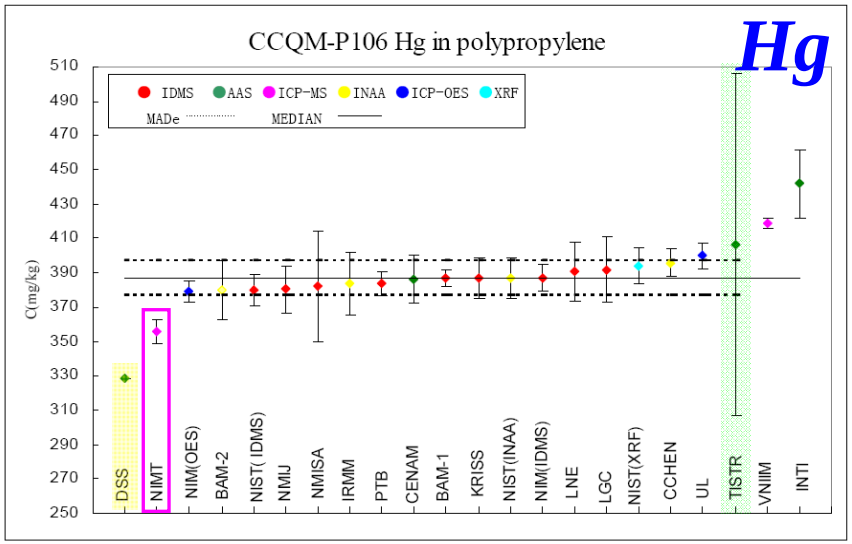
The result of inter-laboratory comparison and proficiency test

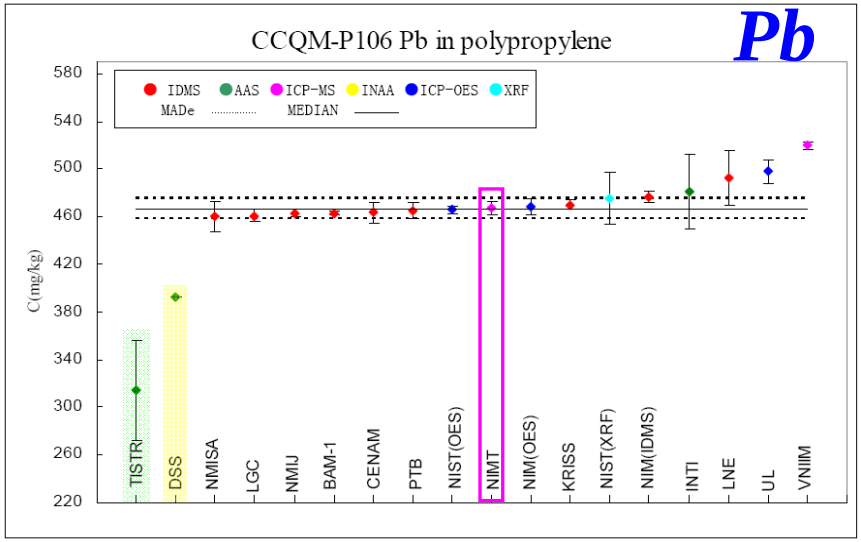
▷ CCQM-P106: Cd, Cr, Hg and Pb in Polypropylene

2008





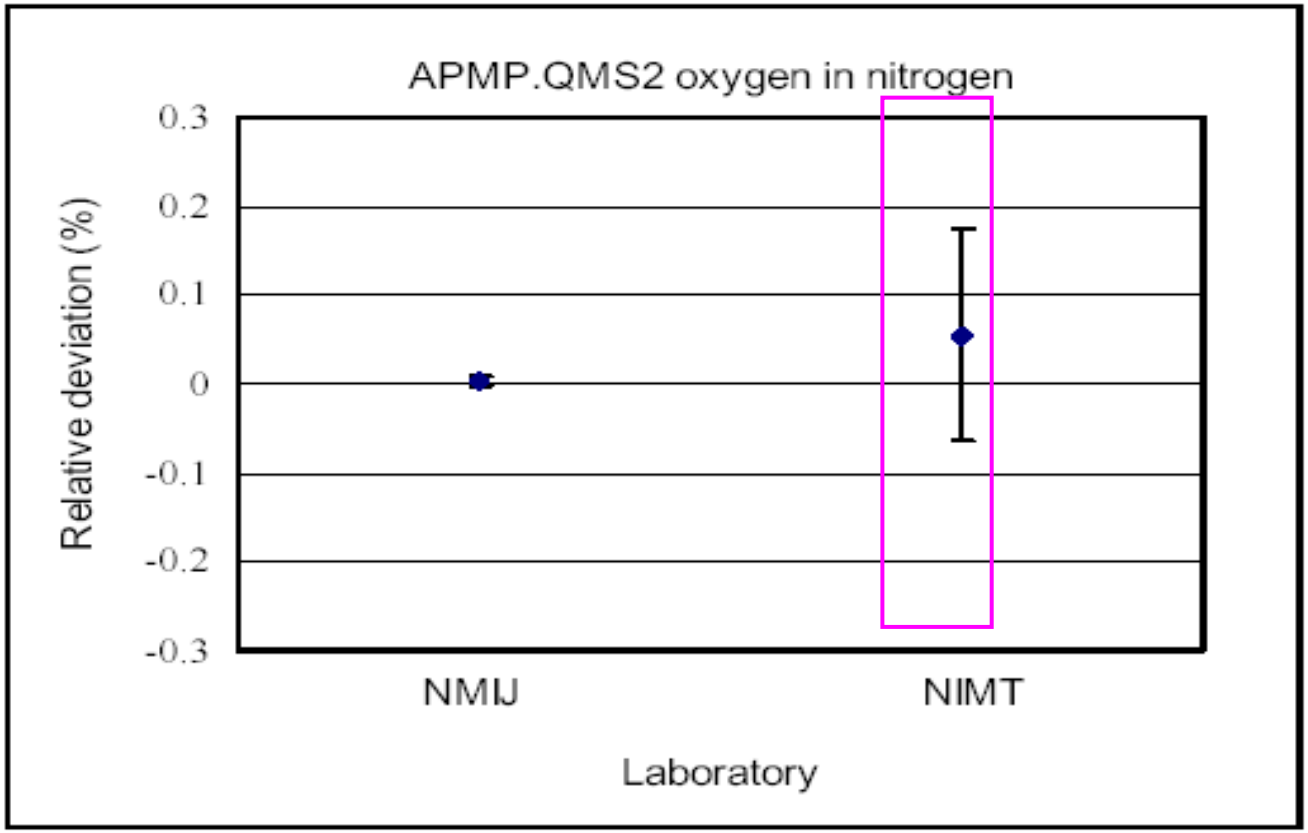




The result of inter-laboratory comparison and proficiency test

▷ **APMP-QM-S2: O2 in N2 (Bilateral NIMT & NMIJ)**

2008



Business Development for Shrimp Viral Diagnostic Kits

Shrimp Biotechnology Business Unit under BIOTEC

Licensing to Farming Intelligene Technology Corporation, Taiwan

Distributor in Philippines Continental Pacific Agritrade Co.

- **manufacture and market test kits for shrimp diseases**

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Eastshrimp association with shrimp domesticated larvae performance testing

Suratthani Shirmp Club with shrimp domesticated larvae performance testing

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Production of good quality strawberry runner

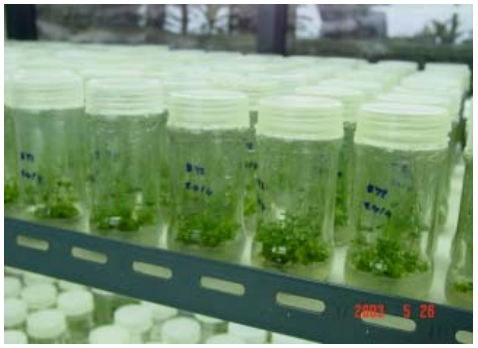
Stock culture from tissue culture (disease free)

high quality runner 100 farmers in 2006

Runners in green house

Fruit production

Yield increase from 3,000 to 3,500 kg/rai



Conventional technique

Coconut fubre + soil + organic fertilizer

Green house

New technique

Courtesy by Dr Nataporn Chanvarasuth, BIOTEC, Thailand

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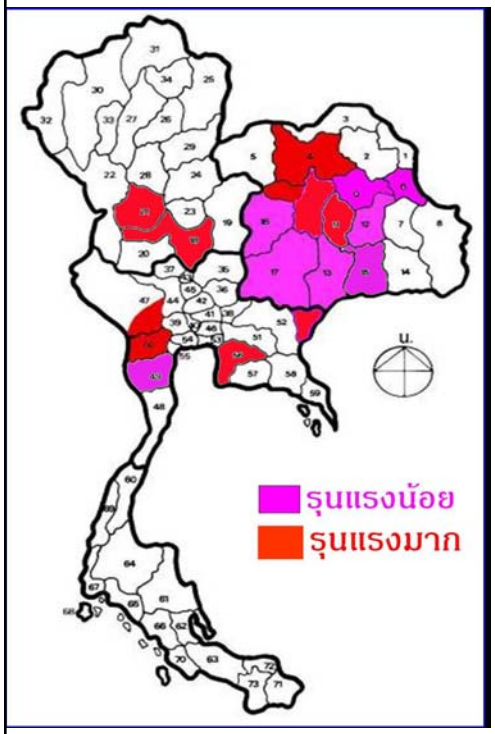

Sugarcane : White Leaf Disease

Tissue cluture

INNOVA Biotechnology

MITR PHOL

Disease test kit

Chemical Metrology and Its Impact on Industry and Quality of Life

World's First Commercial Biosensors for Avian Influenza H5

Acknowledgement

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- Derek Craston, LGC
- Gutler Berndt, PTB
- Clemens Sanetra, PTB
- Ulrich Diekmann, PTB
- Andrea Ulbrich, PTB
- NMIJ

THANK YOU

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