ANNUAL REPORT 2019

Thailand Institute of Scientific and Technological Research

Message from the Governor

Dr.Chutima Eamchotchawalit

Governor, Thailand Institute of Scientific and Technological Research (TISTR)

The year 2019 was prosperous for the Thailand Institute of Scientific and Technological Research (TISTR) when we achieved in developing a service model as a partner for the vital success of SMEs and OTOP entrepreneurs. The infrastructure necessary for strengthening those industries was also provided in order to fill the gap that entrepreneurs had encountered of both in commercial and social issues. The more focus of research, development, technology transfer and industrial services was concentrated based on the 4 guiding principles: bio-based economy, area-based projects, appropriate technology, and total solution.

Partner towards success of startup entrepreneurs

• Share Service - minimizing the risk of entrepreneurs

TISTR created the Share Service Model for enhancing food product innovation in order to minimize the risk of startup entrepreneurs on the way from research to commercialization. The Food Innovation and Service Plant (FISP) was opened for the purpose of transforming innovative food products into the commercial ones. FISP provided most services to the processing of agricultural produces, making them into the innovative products of higher value that met international quality standards and ready for marketing.

Another model of Share Service is production of bio-based material for sustainable development. In 2019, the Algal Excellent Centre (ALEC) was founded on the ground of knowledge and expertise of TISTR personnel for maximizing the use of fresh water algae. Later, the service scope was extended to production of both marine and freshwater algae for industrial use, making them higher value raw materials to be utilized in food, pharmaceutical and cosmetic industries. So far, TISTR's ALEC is the 3rd largest centre in Asia having more than 2,000 species of algae in collection.

• Solution Provider - Creating trust in quality and standard of products

TISTR launched the 6 Quality Marks (Q Marks) to certify products and services according to ISO/IEC 17065, focusing on these following categories: agricultural products in compliance to GAP, inorganic agricultural products, electricity and electronic products, biodegradable plastic products, transport and rail system products, and services in tourism. This certification process could enhance Thai industry's products and services to be well accepted in the trade liberalization. Moreover, the testing services for medical appliances in the new S-curve industries were initiated by TISTR, which had been certified by AAALAC International of Full Accreditation. TISTR's services were also certified as the the 9th organization having certified in Thailand according to the OECD GLP Guideline.

Achievements in 2019

• **Income and Socio-Economic Results** TISTR could create revenues from commercialization of research and development (R&D) and industrial services more than 220 million baht in 2019, increasing approximately more than 10% of 2018. In this regard, sixty-two R&D projects were commercialized, 53 patents and petty patents were filed, and knowledge in science, technology and innovation were transferred to more than 5,000 entrepreneurs in the agricultural sector. About 25% earnings of the target population in the 10 provinces of low income were increased from the Big Rock Project, of which the ratio of Social Return on Investment (SROI) accounted for 1:7.

• **Sustainable development** TISTR received 2 Public Sector Excellent Awards (PSEA) 2019 in Public Sector Services, one from the operation of Food Innovation Service Plant (FISP) that could minimize risks and create business opportunities for entrepreneurs, and the other from the One Tambon One Agro-Innovation Program where science, technology and innovation were promoted to strengthen local wisdom in order to increase efficiency, reduce production cost, and develop sustainability of agricultural occupations.

• **Digital technologies for improving work process** TISTR received the award from the Office of National Digital Economy and Society Commission (ONDE) and was recognized as the government organization providing basic services in the Internet that accommodated the IPv6 in 3 types: DNS, Mail and Web. TISTR also supported the Zero Copy Policy of the Thai Government in order to offer more convenience to clients.

• **Corporate governance** With transparency policy in the workplace, TISTR received the high score of 90.22 in 2019 according to the criteria of the Integrity & Transparency Assessment (ITA) prescribed by the National Anti-Corruption Commission (NACC).

• **Awareness of the environment** TISTR kept striving toward the Green Office policy and implementing it concretely. Sakaerat Environmental Research Station (SERS) was the first location that won the Green Office Excellent Award in 2019 under the Green Office Project of Department of Environmental Quality, Ministry of Natural Resources and Environment.

On behalf of TISTR's executives and staff, I would like to express my deepest gratitude to all stakeholders who always support us. Please be ensured that we shall continue to develop the quality of our work system to meet the ultimate needs, collaboratively overcome any obstacles, enhance production, and create innovation for entrepreneurs, communities, the society and the country with all our efforts in research and development.

Dr.Chutima Eamchotchawalit
Governor, Thailand Institute of Scientific and Technological Research (TISTR)

Board of TISTR

Gen. Takerngkarn Sri-am-pai
Board Chairman
(23 May 2017-22 May 2019)

Prof. Sirirurg Songsivilai
Board Member
(30 Dec 2016-Present)

Ms.Duangjai Assawachintachit
Board Member
(1 Oct 2017-Present)

Dr. Thosaporn Sirisumphand
Board Member
(29 June 2018-Present)

Asst.Prof.Dr. Tanawan Sinthunawa
Board Member
(23 May 2017-22 May 2019)

Assoc.Prof. Supot Teachavorasinskun
Board Member
(23 May 2017-22 May 2019)

Mr. Aphichat Todilokwet
Board Member
(23 May 2017-22 May 2019)

Mr. Nakah Thawichawatt
Board Member
(23 May 2017-22 May 2019)

Mr. Permsuk Sutchaphiwat
Board Member
(7 Aug 2017-22 May 2019)

Ms. Kanittha Sahamethapat
Board Member
(4 Jan 2019-22 May 2019)

Mr.Wirach Chantra
Board Member and Secretary
(12 Aug 2018-1 Nov 2018)

Dr. Chutima Eamchotchawalit
Board Member and Secretary
(2 Nov 2018-Present)

TISTR Executives

Dr. Chutima Eamchotchawalit
Governor

Dr.Aparat Mahakhant
Deputy Governor Research & Development Group for Sustainable Development

Mr.Wirach Chantra
Deputy Governor Industrial Services

Mr. Sayan Tanpanich
Deputy Governor Research & Development Group for Bio-industries

Dr. Apakorn Supanya
Deputy Governor Strategies and Innovation Management Group

Dr. Jittra Chaivimol
Deputy Governor Administration Group

Dr. Teerapat Srinorakut
Chief Expert

Mr.Anun Rungporntavewat
Special Executive

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PART 1

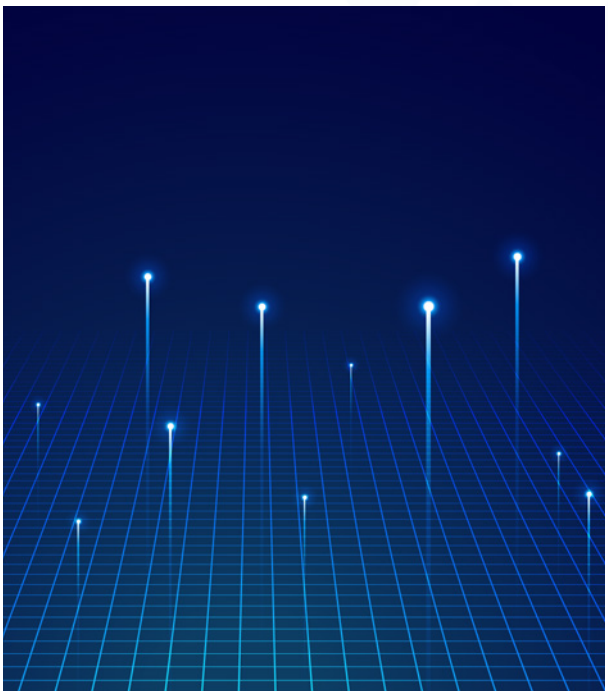
Annual report 2019

Important Changes in 2019

In 2019, TISTR faced significant changes in both internal and external factors, especially, government policy factors which is considered as an opportunity and a major challenge for TISTR's operations.

- **Establishment of Ministry of Higher Education, Science, Research and Innovation (MHESI)**

Ministry of Higher Education, Science, Research and Innovation (MHESI) was established according to "Reorganization of Ministry, Sub-Ministry, and Department Act (No.19), B.E. 2562 (2019)" and related laws, which was announced in Government Gazette on 1 May 2019 and become effective on 2 May 2019. The new ministry was set by the merger of Ministry of Science and Technology (MOST), Office of the Higher Education Commission (OHEC), National Research Council of Thailand (NRCT), and Thailand Research Fund (TRF). In this regards, the role of MHESI is responsible for promoting and supervising higher education institutions in order to strengthen manpower's skills consistently with country development guideline in the context of science, technology and social science. The ministry has authority and function to set policies and action plans regarding higher education separated from the Ministry of Education. In addition, research and innovation development is under supervision and responsibility of the ministry according to Science Promotion Act Research and Innovation 2019, section 7(3), and TISTR's role is to perform research and innovation works.



At the ministry level, Minister of Higher Education, Science, Research and Innovation, Dr. Suvit Maesincee has set a policy which is considered to be a framework for operation and driving MHESI in 4 dimensions which are (1) Creating and enhancing Thai people capacity development towards the 21st century (2) Creating and developing knowledge (3) Creating and developing innovation, and (4) Reforming higher education.

• Master Plan under National Strategy: Research and Innovation (B.E. 2018 – 2037)

As announced by the Office of the Prime Minister on 18 April 2019, the government has set up master plan under National Strategy on Research and Innovation (B.E. 2018 – 2037), which targeted Thailand to have higher national competitiveness on technological and scientific infrastructure, and to increase the value of investment on research and development, as well as the value of innovations towards gross domestic product continuously. However, Thailand is facing several significant challenges on innovative research and development such as defining research topics that meet people need in both the manufacture and service sectors, including social problems, integration of research, development and innovation agencies, the number of researchers that do not meet expected requirements and demands of the market, and also the problem on utilization of research results. Hence, the government aimed to solve the mentioned issues by using the master plan that focused on driving on national innovative research and development. The sub – plans consist of 5 contexts including economic, society, environment, basic knowledge, and supporting factors for research and innovation.

• State Enterprise Assessment Model: SE-AM

State Enterprise Policy Office (SEPO) has improved the state enterprise performance evaluation system and has changed the system from (State Enterprise Performance Appraisal: SEPA and Enterprise management systems (3) to State Enterprise Assessment Model: SE-AM. The new system has been divided into 2 parts which are Key Performance Area and Core Business Enablers. Core Business Enablers consist of 8 aspects evaluation including; (1) Corporate Governance & Leadership: CG, (2) Strategic Planning: SP, (3) Risk Management & Internal Control: RM&IC, (4) Stakeholder & Customer: CSM, (5) Digital Technology: DT, (6) Human Capital Management: HCM, (7) Knowledge Management & Innovation Management: KM & IM (8) Internal Audit: IA.

Industry Situation and Future Trend

• National Science Technology and Innovation Trends

Referring to performance evaluation result based on key indicators, especially, in the area of science, technology and innovation competitiveness and ranking from international management organizations such as International Institute for Management Development (IMD) World Economic Forum (WEF) and Global Innovation Index (GII), IMD survey result in 2019 shown that Thailand was ranked at 38th in technological infrastructure ranking which is lower comparing to 2018 ranking. In the meanwhile, Thailand's ranking of scientific competency in 2019 increased from the year 2018 from 42nd to 38th Besides, GII reported that Thailand's innovation competency ranking increased from 44th to 43rd which was in accordance with the results of Bloomberg survey that indicated rising rank from 45th in 2018 to be 40th in 2019.

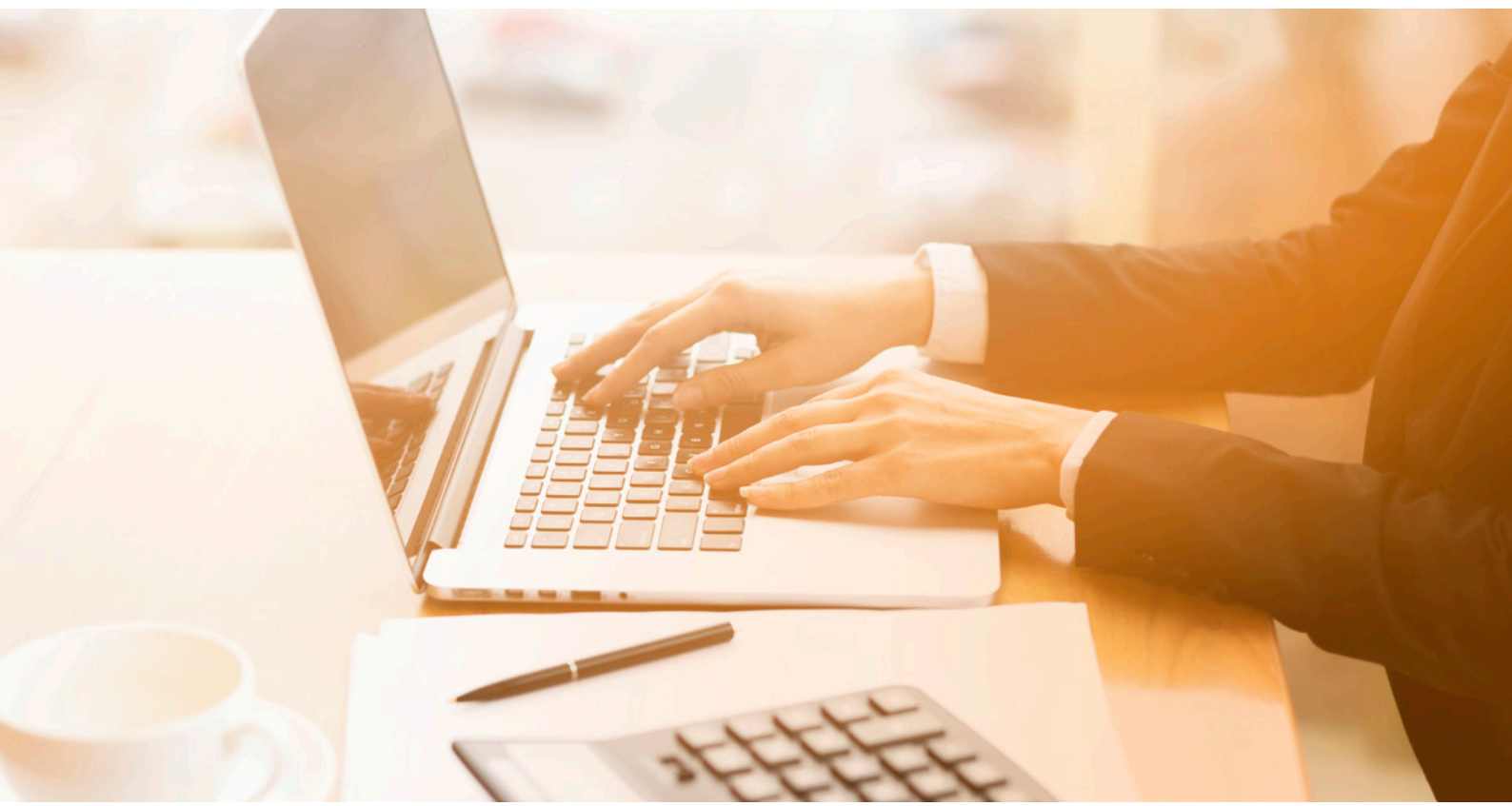
For research investment dimension, the WEF survey result in 2018 found that research and development costs in Thailand are was at 54th (surveyed from 140 countries), while research and development expenditures on gross domestic product surveyed by Bloomberg in 2019 ranked at 48th, down from the 45th in 2018. In addition, survey result from Science, Technology and Innovation Information Center, National Council for Higher Education, Science, Research and Innovation Policy (NRCT) found that research and development expenditures tend to be increased from 2008 to 2017 in 2018 survey round. The research and development expenditures were increased as 155,143 million baht or 36% from previous survey round. Percentage of R&D expenses per Gross Domestic Product was 1.0%. For private sector, research and development expenditures accelerated from 82,701 million baht in 2019 to 123,942 million baht in 2018. On the other hand, research and development expenditures in public sector were 31,201 million baht. The proportion of public and private is approximately 80% and 20% respectively. In addition, a significant indicator was that the research and development personnel (FTE) per 10,000 populations also tend to increase since 2015-2017 with the proportion of 13.6, 17, and 21 respectively.

NRCT has planned to enhance the competitiveness of higher education, science, research and innovation in 2022 by targeting Thailand competitiveness ranking (IMD World Competitiveness Center) as 20th from 63 countries, and aiming to be 30th from 63 countries for scientific competitiveness ranking. NRCT is expected to have a proportion of research and development expenditures per national GDP increased to 1.5% per GDP or approximately 280,000 million baht. The investment was divided into two parts which are 70% from the private sector or 196,000 million baht and 30% from the government or 84,000 million baht. NRCT also has set the target of 50 effective patents per population 1,000,000 persons, and has aimed to produce 40% bachelor's degree of STEM graduates in Science, Technology, Engineering and Mathematics in 2020.

Main Risks of Business Operation

Currently, world and business change situation is in "VUCA" condition which V stands for Volatility, U is for Uncertainty, C is for Complexity, and A is for Ambiguity. The VUCA situation was caused by uncertainties in various fields including consumer demands, technology and innovation, completion, international politics, and other aspects. Thailand Institute of Scientific and Technological Research (TISTR) has analyzed and evaluated the risks that may occur and hinder the implementation of the TISTR's main mission as follows:

- Uncertainty in research integration policy and merger of the ministry.
- According to government policy in establishing Ministry of Higher Education, Science, Research and Innovation, TISTR operational plan was directly affected by this policy.
- Government and Budget Bureau policies for reducing budget allocations and returning revenue



These policies have resulted in high competition on the operation and budget allocation of agencies within the Ministry. Moreover, there are the overlapping roles and frameworks of operation problems among agencies. On the other hand, this was considered as an opportunity for TISTR and other agencies in building and developing potential cooperation.

• Policy formulation, role and operation framework of research agencies prioritized on budget allocation for large research projects rather than small research projects. TISTR may disadvantage other research units because of the readiness for supporting a large research program.

When compared with other research agencies, TISTR may have some disadvantages in the aspect of its readiness to conduct a large research program.

• The fluctuation of the global economic conditions caused by a trade war between China and the United States negatively affected global economy including exports, industrial sector, and also manufacturers who related to each industry. TISTR was affected on this issue since it could not achieve organization metrics and targets from service operation for industrial sector. In addition, in the dimension of business competition, TISTR may be disadvantaged in the market competition when compared with international technology manufacturers that are equipped with technology, cost, and continuously created value added of products.

• Law and regulation related to budget control and auditing.

As TISTR's operations are relevant to many aspects of the law, which affected on delaying of TISTR operation including durable goods process, building construction and recruitment. In this case, the institute had to follow every related law and regulation, which the workers lack of sufficient knowledge and understanding which may cause operational errors and affect the overall performance of TISTR.

Achievements

1. "Helios Facial Serum"

TISTR by its Expert Centre of Innovative Herbal Products (InnoHerb) conducted research and development facial serum from Pigeon Pea's extract, the local peas in Tak province. It was the value added product or facial serum having different textures. The serum can easily absorb into skin. Outstanding in anti-aging and collagen booster,the product was tested and approved on safety and efficiency by 20 Asian female volunteers aged during 35 – 65 years old. The result after using product twice a day in 8 weeks found none of allergy or irritation, 72.7% of wrinkle reduced, 70% of mean depth reduced, 60% of total wrinkle length reduced, 65% of eye wrinkle reduced, and significant reduce of melasma compared to those faces not using the product.

TISTR commercialized this technology of Helios Facial Serum to Super Seyo Company Limited. The product was awarded at 2nd runner up at AGRI PLUS AWARD 2019 in the category of innovation from Thai non-food agricultural product hosted by Institute for Agricultural Product Innovation – API Department of Foreign Trade, Ministry of Commerce. It was the success case of TISTR's technology transfer and commercialization.


KOREA INVENTION PROMOTION ASSOCIATION

SPECIAL PRIZE

presented to

Supawat Sakkayawong, Supersayo Co. Ltd., Ubon Ratchathani
Thailand Institute of Scientific and Technological Research

from

THAILAND

in recognition of excellent and creative efforts to invent

Cajanus cajan (L.) Millsp. Peptide Serum: Helios face serum

exhibited at

2019 International Trade Fair "Ideas-Inventions-New Product" (iENA 2019)

Nürnberg, Germany

Oct 31st – Nov 3rd, 2019

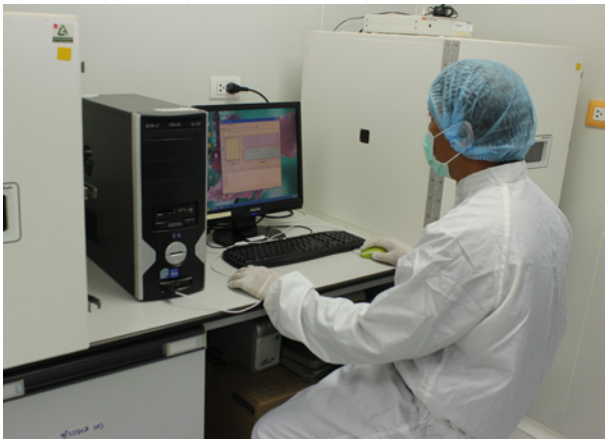
2. Cosmetic from Cartilaginous Fish Bone Extract

TISTR conducted research and development in biological activity testing of extracts and quantitative analysis of active compounds especially hyaluronic acid, biological analysis of fish bone extract, formula development for beauty products having salient feature in anti-aging on face, eyes, and nostril. The product can soften skin, tighten pores, and moisture lock. TISTR transferred its technology to Pinmisa Co. Ltd., Samut Sakhon. The product was named HYA Beauty Seacret Solution Set and awarded at 5-star OTOP 2019 by the Community Development Department.

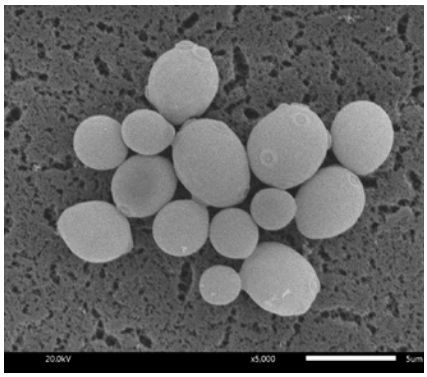
3. Germ Capsules Product

TISTR developed and tested efficiency of anti-oxidant and chemical quality control of germs for the development of organic processed rice product and in powder form for value added. It helped generate better income to farmers. Especially, the innovative group of Nakhon Si Thammarat that needed the product to be developed into capsules, including packaging development for export to oversea markets. The germ capsules product of the said innovative group was achieved in international award.

4. Testing Services for Dietary Supplement, Medicine, Medical Material/Equipment accredited by AAALAC International or the Association for Assessment and Accreditation of Laboratory Animal Care International



Expert Centre of Innovative Herbal Products (InnoHerb), TISTR enhanced its standard of animal care for scientific experiments in order to increase credibility of research results. InnoHerb, TISTR is ranked as the ninth organization of the country that had been fully accredited by the Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC International) of Full Accreditation categories (the highest level of accreditation for a new applicant institutions) on 2 November 2018. InnoHerb is ready to provide effectiveness and safety in animal testing for food products, dietary supplement, medicine, and medical devices. InnoHerb adopted cell testing for cosmetics such as skin allergies and irritation testing. Then, entrepreneurs can bring a product and a testing result to register with the Food and Drug Administration (FDA) because TISTR is listed in FDA's testing and analysis acceptance.



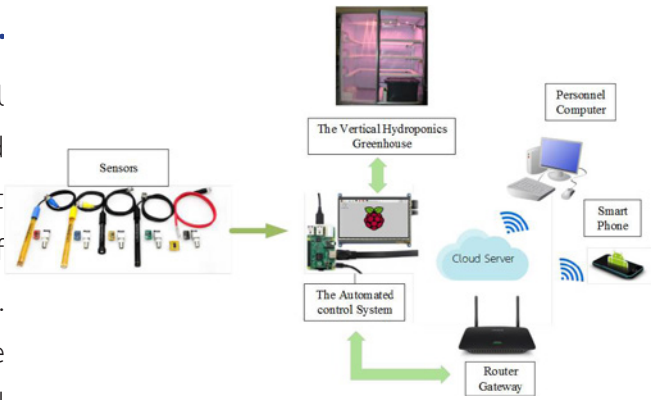
5. Project on the Productivity Increase of Ethanol from Molasses, the Success in the Development of Thai Yeast Strains Equivalent to the Characteristics of Industrial Yeast Imported from Overseas

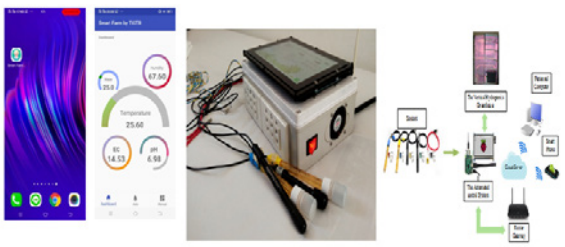
TISTR together with the Department of Alternative Energy Development and Efficiency, Ministry of Energy, successfully conducted research and technology development in biotechnology and production process to increase productivity of ethanol from molasses funded by the Energy Conservation and Promotion Fund. The project was designed for high gravity fermentation and yeast strain development suitable for raw materials in which molasses are composed of single molecules such as glucose and fructose and double molecules such as sucrose. The researchers used *Saccharomyces Cerevislae* yeast in Thailand that can withstand the heat temperature to 40 degree Celsius and ethanol highest to 18% during production. The yeast is effective in producing ethanol 88-90% equivalent to industrial yeast in case of using molasses not more than 25 degree Brix. The ethanol production using high gravity fermentation can increase the capacity as well as reducing cost of production. Thailand has several biological resources, the investment in research and development would create great value from biological resources to industrial commercialization in the country.

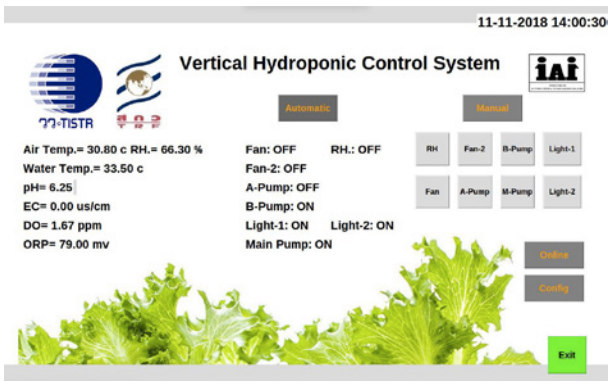



6. Automatic Control System for Hydroponic Vegetable Production House, Smart Agricultural Innovation for Urban Society

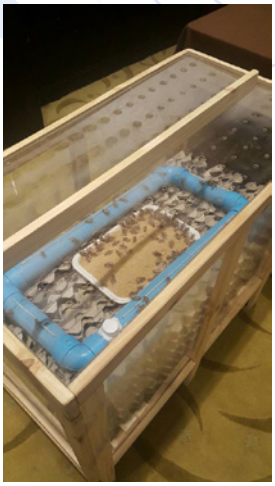
Expert Centre of Innovative Industrial Robotics and Automation (InnoRobot) designed the automatic control system through Internet of Things (IoT) to track growing conditions of hydroponic vegetables in production house. The system could control air temperature and humidity, acidity and base of water, and concentration of nutrient solutions in water in order to balance the environment conditions. Data was sent via smart phone application, tablets, and computers. The users could adjust the conditions and send the order to the automatic control box. The system was applied by Industrial Automation and Innovation Co.,Ltd. The automatic control system







for hydroponic vegetable production house was one of the smart agricultural innovations for urban society which helped resolve labour shortage issue. This was a success of transferring scientific knowledge, technology, and innovation to commercialization that fulfilled entrepreneurs' needs.



7. Green & Sustainable Health Food Products

TISTR brought science, technology, and innovation to conduct research and develop health food products. Green and sustainable health food products in the forms of food, beverage, and ingredients was launched, suitable for consumers of all ages. Green and sustainable health food products created a good quality of life for everyone in the society and increased the competitiveness in food industry for entrepreneurs as well as fostered economic value and growth. Moreover, TISTR focused on research processes and operations that were environmentally friendly, zero waste, and helped reduce carbon dioxide (CO2). There were many examples of successful green and sustainable health food products as follows:

Gluten-free Cricket Processed Products – TISTR transferred cricket culture and product processing technology with minimal CO2 to entrepreneurs which enabled the products to be non-toxic, gluten-free, high protein, and meat substitute. Cricket had been processed into cookies, chili paste, sweet fish sauce, and crispsy cricket.

High Gaba Dietary Supplement–Raw materials with high gaba such as melon, dried tea leaves, gaba rice, and tomato which contained neurotransmitters for insomnia had been processed into food products and dietary supplement such as melon tea, purple sweet potato yoghurt, and snack from Thai jasmine rice and rice berry.

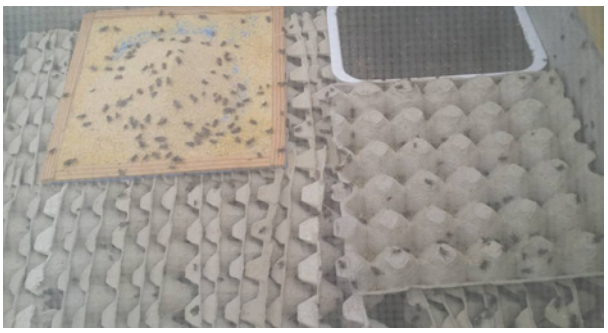
Herbal Jelly Products – Plant and herb ingredients contained natural Melatonin, which helped reduce stress and induce relaxation. The herbal jelly product had a soft texture and good taste. The product was designed for consumers of all ages, especially for elderly and working people with stress. As the body mechanism of the elderly produces less Melatonin when they are getting older and they often encounter with insomnia; therefore, it is essential to get more melatonin from the food taken. The product was in the form of a jelly with a small amount of water, so it can be eaten before bedtime without having to worry about going to the restroom at nighttime.

Beta Glucan Dietary Supplement from Mushrooms in the form of tablet, helped alleviate joint pain and inflammation caused by gout. Beta glucan was extracted from shitake mushroom (reducing genes related with inflammation stimulation), phoenix mushroom (expressing the effect of gene related to anti-inflammatory), and oyster mushroom (stimulating immune system).

Products from Chong Cao TISTR supported entrepreneurs in Lamphun province in mushroom species proof, substance analysis, mushroom production house, and dietary supplement factory.

Instant Food Products from Mushroom such as instant mushroom soup, mushroom spicy soup, coconut milk from mushroom, crispy mushroom, mushroom nuggets, and mushroom drink.

Russula Functional Beverage was made from indigenous mushroom in Northeast region of Thailand. Its benefits were to enhance immune system, reduce the risk of cancer, and possess high antioxidant.



8. InnoAgri Project, TISTR in Agricultural Product Processing in Kamphaeng Phet Province

InnoAgri Project executed by TISTR, aimed to enhance farmers' scientific knowledge, technology, and innovation in order to promote safe agriculture in the Northern region of Thailand – Kamphaeng Phet Province including Kluai Khai banana community group in Sa Kaeo Sub-District and Tha Phutsa Sub-District, Soisuwan rice products community enterprise. TISTR researchers utilized and transferred STI knowledge to InnoAgri famers and entrepreneurs to add value to indigenous fruit - Kluai Khai banana by product development, product processing, and packaging development such as Kluai Khai banana juice, products developed from agricultural wastes (organic fertilizer from the stems of Kluai Khai banana), plant

Chili sauce from Kluai Khai banana flour

Chili paste
from Kluai Khai banana blossom

Chili crushed powder
from Kluai Khai banana blossom

Cereal cookies from
Kluai Khai banana flour

Doughnuts from
Kluai Khai banana flour

Spaghetti from
Kluai Khai banana flour

Egg custard from
Kluai Khai banana flour

Kluai Khai banana juice

Kluai Khai banana jam

Kluai Khai banana pollen tea

Kluai Khai banana blossom tea

Crisp snack from Kluai Khai banana flour

propagation (tissue culture and rhizome cutting), agricultural technology utilization for improving quality and quantity of Kluai Khai banana in a demonstration farm, sesame snack products, tea made from pollens and banana blossom, and animal feed made from banana leaves. Hence, the project fostered InnoAgri sustainability and villages to increase Kluai Khai banana productivity throughout the value chain. As a result, farmers could reduce 30% of plant and animal production cost, had higher employment rate, created 40% value addition to products, and generated 10% increase of income. There were 350 InnoAgri farmers, 120 InnoAgri entrepreneurs, 16 products had been developed, and 3 pilot communities had been learned about product value chain.

9. Project on Product Certification and Total Solution Services

The Office of Certification Body (OCB) enhanced the capability of being a product and service certification body following ISO/IEC 17065, which promoted certified products and services of the country's industrial and service sectors, opened for trade liberalization, and minimized the effects from non-tariff measures (NTMs) and technical barriers to trade (TBT). The success of the project was to launch TISTR product and service certification mark in six categories such as agricultural products following GAP, organic products, electrical and electronic products, biodegradable plastic products, railway transportation system, and tourism services. The certification mark and evaluation helped guarantee the quality of products and services according to international standards. It is also one of the factors that influences customer decision to select certified products and services as it could build customer trust and loyalty. Hence, the evaluation and certification according to international standards supported and enhanced entrepreneurs in production and service industries which increased the potential and competitiveness domestically and internationally, generated higher income from export products, and stimulated community and country's economy. The OCB coordinated with relevant departments

such as Ministry of Industry, Ministry of Transport, Ministry of Agriculture and Cooperatives, and Ministry of Tourism and Sports to support national strategy Thailand 4.0 and the fourth industrial revolution (4IR).

The OCB is the quality system certification body which is managed in accordance with ISO/IEC 17021 and ISO/TS 22003, providing evaluation and quality certification services such as quality management systems (ISO 9001), environmental management system (ISO 14001), occupational health and safety assessment series (OHSAS 18001), hazard analysis and critical control points (HACCP), and food safety

management (ISO 22000) in order to support entrepreneurs to compete in a business market by manufacturing quality products that meet certified and reliable standards at national and international levels.

PART 2

Annual report 2019

Honorable Awards and Achievements 2019





The Public Sector Excellence Award (Lert-Rat) 2019

On behalf of Thailand Institute of Scientific and Technological Research (TISTR), Dr. Chutima Eamchotchawalit, Governor, together with Mr. Sayan Tanpanich, Deputy Governor of Research and Development for Bio-Industries, received the Public Sector Excellence Award (Lert-Rat) 2019 on the improvement of the public services with convenience, promptness, transparency, fairness, and satisfaction given by the Deputy Prime Ministry Wissanu Krea-ngam on 13 September 2019 at Impact Muang Thong Thani, Nonthaburi. The Food Innovation Service Plant (FISP), Expert Centre of Innovative Health Food (InnoFood) and One Tambon, One Innovative Agriculture, Expert Centre of Innovative Agriculture (InnoAg) had been proved TISTR's excellent operations, service quality, and satisfaction.

The 2nd runner up of Pigeon Pea Extracted Serum on AGRI PLUS AWARD 2019

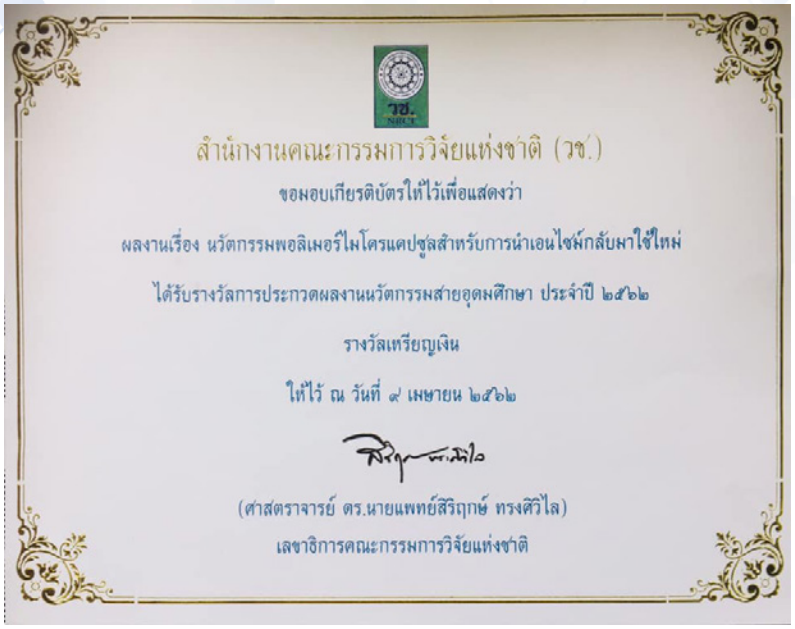
Pigeon Pea Extracted Serum under the brand “Helios Face Serum”, the research on cosmeceutical products from Thai indigenous beans developed by the Expert Centre of Innovative Herbal Products (InnoHerb), won the 2nd runner up on AGRI PLUS AWARD 2019, organized by the Institute for Agricultural Product Innovation, Department of Foreign Trade, and Ministry of Commerce. This successful research and technology had been transferred to Super Seyo Co.,Ltd. for commercialization. In this regard, the company representative and Ms. Ubon Rerk-am, Senior Research Officer from InnoHerb received the award on 16 May 2019 at Renaissance Hotel, Bangkok.

Research on "Modern Agriculture for National Sustainability" won the gold award in Thailand Research Expo 2019

The research on Modern Agriculture for National Sustainability proposed by the Expert Centre of Innovative Industrial Robotics and Automation (InnoRobot), won the gold award on outstanding research presentation and exhibition booth contest in Thailand Research Expo 2019. On behalf of TISTR, Dr.Aparat Mahakhant, Deputy Governor of Research and Development for Sustainable Development received the award from Prof. Sirirurg Songsivilai, M.D., Ph.D., Secretary-General of National Research Council of Thailand (NRCT) on 10 April 2019 at Centara Grand and Bangkok Convention Centre at Central World, Bangkok.

Outstanding Research Oral Presentation Award

Dr. Rujira Jitrwung, Senior Research Officer from the Expert Centre of Innovative Clean Energy and Environment (InnoEn) received the outstanding research oral presentation award in the 3rd ASEAN Bioenergy and Bioeconomy Conference (ABB2019) on 6 June 2019 at Bangkok International Trade and Exhibition Centre (BITEC), Bangkok.



สำนักงานคณะกรรมการวิจัยแห่งชาติ (วช.)

ขอมอบเกียรติบัตรให้ไว้เพื่อแสดงว่า

ผลงานเรื่อง นวัตกรรมพอลิเมอร์ไมโครแคปซูลสำหรับการนำเอนไซม์กลับมาใช้ใหม่

ได้รับรางวัลการประกวดผลงานนวัตกรรมสายอุดมศึกษา ประจำปี ๒๕๖๒

รางวัลเหรียญเงิน

ให้ไว้ ณ วันที่ ๙ เมษายน ๒๕๖๒

(ศาสตราจารย์ ดร.นายแพทย์สิริฤกษ์ ทรงศิวไล)

เลขาธิการคณะกรรมการวิจัยแห่งชาติ

สำนักงานคณะกรรมการวิจัยแห่งชาติ (วช.)

ขอมอบเกียรติบัตรให้ไว้เพื่อแสดงว่า

ดร.พงศธร ประภักรางกูล

ได้เข้าร่วมกิจกรรมการประกวดผลงานนวัตกรรมสายอุดมศึกษา ประจำปี ๒๕๖๒

ระหว่างวันที่ ๗ – ๑๐ เมษายน ๒๕๖๒

ณ โรงแรมเซ็นทาราแกรนด์และบางกอกคอนเวนชันเซ็นเตอร์ เซ็นทรัลเวิลด์ กรุงเทพฯ

ให้ไว้ ณ วันที่ ๑๐ เมษายน ๒๕๖๒

(ศาสตราจารย์ ดร.นายแพทย์สิริฤกษ์ ทรงศิวไล)

เลขาธิการคณะกรรมการวิจัยแห่งชาติ

Silver Medal Achievement in Higher Education Innovation Competition 2019

The research on "Innovation on Microcapsule Polymer for Enzyme Reuse" conducted by Dr. Pongsaton Phapugrangkul, Acting Director of Biodiversity Research Centre (BRC), won the silver medal in Higher Education Innovation Competition 2019, National Research Council of Thailand (NRCT) on 9 April 2019 at Centara Grand and Bangkok Convention Centre at Central World, Bangkok.

PART 3

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Highlight Activities in 2019

Cooperation Network

Cooperation Network
Cooperation on Technology Transfer ‘Therapeutic Heat Pad’

Dr.Aparat Mahakhant, Deputy Governor R&D for Sustainable Development and Mr. Vilas Saokaew, MD to Unity Meditec Company Limited, together attended a signing ceremony for technology transfer agreement on production technology for therapeutic heat pad, held on 9 January 2019 at TISTR HQ, Technopolis, Pathum Thani province. For the project, TISTR had continuously conducted further research to develop powder and sheet for the heat pad products from natural materials.

‘White Paper’ Submitted to PM

TISTR, along with many representatives from agricultural sector (the National Farmer Federation, working group of community-water management, groups of Thai farmers, Thai SMEs, Thai young farmers and Thai scholars), participated in event ‘PM Meet Thai Farmers and Thai SMEs: Local Economy in Action’, to present and submit ‘White Paper: Local Economy in Action’ to PM, held on 31 January 2019, at the Secretariat of the Cabinet, the Royal Thai Government, Bangkok.

Cooperation on Community-water Management with Rajamangala University of Technology Network

As a part of event 'Leverage OTOP Entrepreneurs and SMEs with STI', TISTR and Rajamangala University of Technology Network joined together to sign agreement on 'Community -water Management: Royal-initiated Sustainability Project on the National Natural Resource and Environment Reformation', held on 31 January 2019, at the Secretariat of the Cabinet, the Royal Thai Government, Bangkok, with the presence of PM, as a witness of the event.

Cooperation on Value-added Agriculture Products with Chaipattana Foundation

Dr. Sumetra Tantivejkul, Secretary to Chaipattana Foundation, Assoc. Prof. Soranit Siltharm, Permanent Secretary to MHESI, and Dr.Chutima Eamchotchawalit, Governor to TISTR, joined together to sign agreement on 'STI for Value-added Agricultural Products at Chatpattana Foundation', held on 19 March 2019, at Chaipattana Foundation Office Building, Bangkok.

Cooperation on Cannabis R & D for Medical Benefits

Dr. Chutima Eamchotchawalit, Governor to TISTR, and Dr. Sitthichai Dangprasert, MD to JSP Pharmaceutical Manufacturing (Thailand) Public Company Limited, joined together to sign agreement on 'Research and Development on Cannabis for Medical Benefit', held on 27 Mary 2019, at Permanent Secretary Office of MHESI, Bangkok, with the presence of Mr. Permsuk Sutchaphiwat, Chief Inspector General to MHESI, as a Chairperson of the event.

MOU signed between CP All Research and Development Plc. and TISTR for the preparation of extracts from waste pieces of holy basil

Dr. Chutima Eamchotchawalit, Governor of TISTR, and Mr. Wiset Wisitwinyu, Managing Director, CP All Plc., also the founder of 7-11 stores in Thailand, signed a Memorandum of Understanding (MOU) for cooperation in research and development on preparation of extract from waste pieces of holy basil in the selection process (flowers / chives and stalks) in the CPRAM ready-to-eat food factory, and also the study of fat reduction effect to protect liver cells and kill cancer cells. This pursued CP ALL's aspiration to create and share opportunities for everyone, for the everlasting community and society. The event took place in May 17, 2019 at Room 1102, C.P. Tower Building, Silom, Bangkok.

Cooperation on Public Communication with MCOT Public Company Limited

Dr. Chutima Eamchotchawalit, Governor to TISTR, and Mr. Kematat Paladesh, MD to MCOT Public Company Limited, joined together to sign agreement on 'Public Communication on STI Beneficial to People, Society and the Nation', held on 18 June 2019, at MCOT Office Building, Bangkok.

‘Fi (Food Ingredient) Asia 2019’ Event

TISTR jointly participated in exhibition event ‘Fi Asian 2019’ to display its successful research showcase under theme ‘Green and Sustainable Foods’, by providing with protein from cricket, high melatonin/GABA from plants, ‘Sustainable Foods’, with products from micro-algae in Thailand, food and cosmetic products from mushrooms, ‘Ingredient’, with ingredients from plants (*Passiflora foetida* L, mulberry, *Momordica cochinchinensis*, Chrysanthemum, mushrooms, ginger, onion, etc.), and ‘Freeze Dry’, with products from agricultural crops (fruits and vegetable), held on 11 – 13 September 2019, at BITEC Bangna, Samut Prakan province.

Cooperation on Technology Transfer ‘4 GRAINE’

Dr. Chutima Eamchotchawalit, Governor to TISTR, and Mr. Paisan Vejpongsa, MD to Sangsawang Tra Kangkao Company Limited, together attended a signing ceremony for technology transfer agreement on production technology for migraine-headache relief ‘4 GRAINE’, held on 25 September 2019, at TISTR HQ, Technopolis, Pathum Thani province.

Cooperation on Innovation Management for Sustainable Development with National Housing Authority

Dr. Chutima Eamchotchawalit, Governor to TISTR, and Dr. Tachapol Kanjanakul, Governor to National Housing Authority, joined together to sign agreement on 'Innovation Management for Sustainable Development', held on 11 October 2019, at National Housing Authority Office Building, Bangkok. The purpose of agreement was to build up innovation-based society for National Housing Authority, aligning with the nation policy 'Thailand 4.0'.Thailand 4.0

Exhibition

'Moving Thailand 4.0 with STI: Thailand in the Making' Event

TISTR jointly participated in exhibition event 'Moving Thailand 4.0 with STI: Thailand in the Making' organized by MHESI and its alliances, held on 21 – 25 November 2018, at Siam Square and Park@Siam, to drive the national policy on 'Thailand 4.0', and achieve in four missions: 'Sciences for People's Competence, Sciences for Poverty Solution, Sciences for National Strength, and Sciences to Regions', to strengthen national economy economy in short-term and long-term, and to prepare Thai people's readiness to the 21st century era.

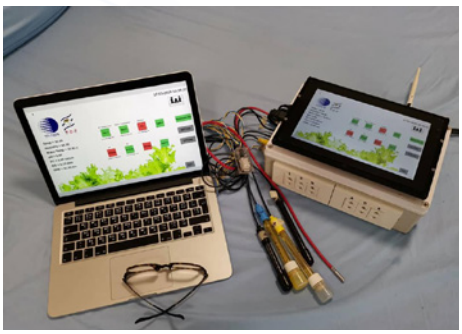
Press Conference

'Products and Service Certificate Mark' Launched

TISTR organized press conference to launch products and service certificate marks for six groups of products and service, including agricultural product with GAP, organic agricultural products, electrical and electronic products, biodegradable plastic products, products for railways, and products for tourism. In this occasion, TISTR, Thailand Environment Institute, and other alliances, joined together to sign an agreement on certification of products and service, held on 11 December 2019, at Pullman Bangkok King Power Hotel.

'TISTR's ALEC' Launched

Dr. Apichai Somboonpakorn, Consultant to MHESI, presided as a Chairman over an opening ceremony of 'TISTR's Algae Excellent Centre (ALEC)'. At the ceremony, Dr. Chutima Eamchotchawalit, Governor to TISTR and Mr. Dittapon Soothi-O-Soth, Senior Vice President to Safety, Security, Health and Environment Division, PTT Exploration and Production Public Company Limited (PTTEP), joined together to publish a statement of R&D cooperative project between TISTR and PTTEP, focusing on biotechnology research implemented for all levels of sustainable agriculture and industry activities, held on 25 January 2019, TISTR HQ, Technopolis, Pathum Thani province.



'Automatic Control System for Hydroponic Vegetable Cultivation Plant' Launched

TISTR organized press conference to launch automatic control system for hydroponic vegetable cultivation plant, for chemical-free vegetable cultivation in limited agricultural field, and labor substitution in agricultural activities, at the event 'Thailand Research Expo 2019', held on 19 March 2019, at Bangkok Convention Center, Centara Grand at Central World Hotel, Bangkok.

'Rest Area in Songkran Holiday Festival at Flora Tale@Lamtakhong' Launched

TISTR organized opening ceremony to launch rest area at Flora Tale@Lamtakhong, serving as car park and restroom stop for the tourists and travelers in the national long holiday of Songkran festival. In this occasion, Dr.Chutima Eamchotchawalit, Governor to TISTR, Mr. Charuschai Chotreangsakul, Provincial Governor Nakhon Ratchasima province, and MHESI's Executives together joined the opening ceremony, held on 10 May 2019, at TISTR's Lamtakhong Research Station, Nakhon Ratchasima province, with the presence of Mr. Permsuk Sutchaphiwat, Chief Inspector General to MHESI, as a Chairperson of the event.

‘Flora Tale’ Brand Launched

TISTR organized press conference to launch product series of cosmetic and drinking under brand ‘Flora Tale’, held on 24 April 2019, at Permanent Secretary Office of MHESI, Bangkok. The products included sun protection and facial treatment from *Centella asiatica*, cosmetic product with *Coprinus imetarrius* extract, herbal gel product for muscle pain, and instant lemon juice.

Open House 'the 30th Anniversary Technopolis toward Innovation'

Assoc. Prof. Soranit Siltharm, Permanent Secretary to MHESI, as a Chairman, presided over the Open House 'the 30th Anniversary Technopolis toward Innovation', held on 21 May 2019, at Technopolis, Pathum Thani province. The purposes of the event was to celebrate of the 30th anniversary of the establishment of Techonopolis, and publicize its products and services to its target groups (Thai people, Thai entrepreneurs, Thai SMEs and local communities), in order to strengthen Thai business and competitiveness. At the event, there were 7 agencies/institutions joined together to sign collaboration agreement on 'Power Synergy to Drive Technopolis', as the national STI, energy and environment conservation hub for achieving sustainable development goals.

‘Environmental Crisis Talk’

As a part of ‘World Environment Day 2019’, TISTR held an event ‘Environmental Crisis Talk’, on 5 June 2019, at Permanent Secretary Office of MHESI, Bangkok. The event aimed to provide guideline for dealing with climate change crisis, present scientific and technological products and service for solving environmental crisis, highlight STI as main tools for driving BCG economy model ‘Bioeconomy-Circular Economy-Green Economy’, and activate social behavior and social awareness for dealing with global warming crisis.

PART 4

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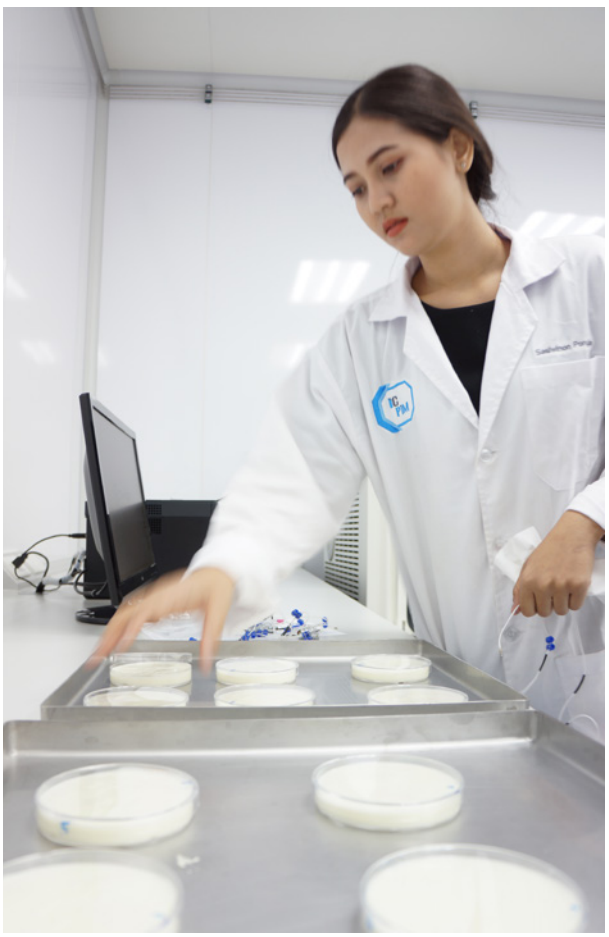
Flagship Projects

1. Project on Establishment of Innovation Center on Effective Microorganisms for Industries



TISTR has continuously developed the probiotic and prebiotic pilot plants by bringing advanced technology and equipment, as well as, strictly complying with the biological safety in accordance with the international standards in order to enhance the quality of research, technology and innovation, starting from knowledge creation, technology application, prototype production to product commercialization. Moreover, TISTR has provided quality analysis and validation of probiotic, prebiotic and synbiotic products for supporting clinical testing results and developing prototype production process to meet the demands of local communities and SMEs. There were several remarkable projects in 2019 as follows:

- Producing probiotics and developing microbial production process of tooth decay prevention products for SMEs
- Developing product prototypes for technology transfer and commercialization such as PRO FRUIT product transferred to Greater Pharma Co.,Ltd., ProHerb Tea product transferred to Research X Co.,Ltd. and Lycon Co.,Ltd., ProHerb-L product transferred to Lycon Co.,Ltd., and More Milk product transferred to Dairy Home Co.,Ltd.

- Establishing the international collaboration in science, technology, and innovation (STI) under ProHerb joint research contract (JRC) on the topic: "Whole genome sequencing: from DNA preparation to bioinformatics" at Biomedical Research Institute (BMRI), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan.

2. Project on Potential Development of Food Research

TISTR has utilized STI knowledge to develop shelf stable technology in which food products can be stored at the room temperature without deterioration. This technology had been transferred to develop the potential of SMEs and OTOP community enterprises in food processing, increase production capacity, create market opportunities, and raise business competitiveness. There were many successful projects as follows:

- Entrepreneurship Development: 180 entrepreneurs were developed. For example, crystallized and dried lemon products were developed for Panaraya Fruit and Fruit Co.,Ltd. and whey protein products in strawberry and lemon flavours were developed for APT Professional Co.,Ltd.
- Shelf life extension technology had been transferred to 213 sustainable agricultural consumer community enterprise and farming in Surin Province, and mushroom cultivation community group in Nakhon Ratchasima province.
- Food product preservation technology such as ready-to-drink mango juice had been transferred to TCT Intertrade Co.,Ltd.
- Snack shelf life extension technology such as fried chicken, seasoned crispy dumplings, vacuum fried vegetable, and crispy beans had been transferred to entrepreneurs and community enterprises in Chantaburi province.
- Bakery and bun shelf life extension technology
- Chili paste shelf life extension and heat sterilization technology
- Ready-to-eat food shelf life extension technology with cooking and heat sterilization techniques

3. Project on Industrial Capacity Development and Food Safety Innovation

TISTR supported SMEs and OTOP community enterprises by providing food safety testing services and analysis with well-equipped infrastructure and advanced technology in accordance with the ASEAN and world standard levels to food entrepreneurs/ producers in order to get ready and be able to compete in the ASEAN and world markets. Furthermore, TISTR encouraged entrepreneurs to apply for standard certifications such as GMP/ HACCP which helped reduce non-tariff barriers when exporting products to overseas. With the goal to upgrade the quality of testing services, TISTR has developed seven standardized testing methods with validation including 1) food testing method and analysis of free amino acids and dipeptides, 2) substance testing method for aroma extraction of essential oil from Thai plants with pharmacological effects in high concentration, 3) sample preparation method for phytonutrients analysis such as Curcumin substance, 4) natural extraction testing method and analysis of phytonutrients such as Isoquercetin, 5) dissolvable sample preparation method for free amino acids and dipeptides analysis, 6) natural polyphenol extraction analysis such as Ergosterol substance, and 7) sample preparation method for natural polyphenol extraction analysis such as active substances for oxidation and immune system booster. Besides, TISTR enhanced the potential of 23 entrepreneurs which could be divided into 3 groups which were rice and rice products, fruit and tea products, and dietary supplement. TISTR also provided 750 product testing services i.e. improving quality standards of new product development to comply with the regulations of Food and Drug Administration (FDA), the Notification of the Ministry of Public Health No. 182 B.E.2541 (1998) Re: Nutrition Labelling, No. 355 B.E.2556 (2013) Titile: Food in a Hermetically Sealed Container, and No. 356 B.E.2556 (2013) Re: Beverages in Sealed Container.

4. Pineapple Technology Transfer Centre, Ao Noi Sub-district, Muang District, Prachuap Khiri Khan Province

Pineapple Technology Transfer Centre in Prachuap Khiri Khan Province is the first fresh pineapple selection and packing manufactory with modern machinery and qualified production standards in Thailand. It has production capacity of three tons per hour. The pineapple manufactory is a learning and technology transfer center for pineapple farmers and producers. The STI knowledge and technology helps solve economic crop issues throughout the supply chain which is in accordance with the national strategy in pineapple oversupply management and one of TISTR's guiding principles - Area Based. Moreover, they can also be applied to other fruits planted in Prachuap Khiri Khan and nearby provinces. The Pineapple Technology Transfer Centre has continuously improved GMP standards and prepared essential tools and equipment such as sizing, cutting, screening, cleaning, waxing, coating machines, conveyor belts, packaging, forced air cooling, and freezers in order to maintain product quality with a beautiful package and sell at a reasonable price. In addition, farmers could receive useful advices, recommendations, knowledge, and technology transfer. This was one of TISTR's successful projects to increase the potential of farmers as well as strengthen the country's economy for stability and sustainability.

PART 5

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Completed research and development projects

TISTR conducts research and development according to the mission in line with the approach of integrating three dimensions of economy development which comprise: Bio economy - focusing on the cost-effective use of resources; Circular economy - taking into account the most utilization of materials; and the Green economy - concentrating on solving pollution problems. In fiscal year 2019, there are 72 research and development projects having been undertaken and completed by 6 Expert Centres of Innovation, together with Biodiversity Research Centre. Material Properties Analysis and Development Centre, and Thai Packaging Centre. These operations can be described as follows:

1) Expert Centre of Innovative Agriculture (InnoAg)

InnoAg aims at being a Centre of excellence in agricultural technology for community, integrating research and development (R&D) which can solve the real problems of the country, making the most of these R&D projects into practices of both social and commercial dimensions, and developing the infrastructure necessary for social and economic development of the country. InnoAg has its expertise in organic agriculture, and focuses the research on promoting the cultivation of medicinal plants, local crops and new economic crops, mushroom strain improvement and cultivation, fertilizer technology, Biocontrol, microbial and biopesticides, post-harvest technology, plant breeding and tissue culture, and plant genetics conservation.

In fiscal year 2019, there are 21 projects completed as shown in the following list:

InnoAgri
Innovative Agriculture

1.1) Research and development of species and production technology of Bastard Oleaster fruit *(Elaeagnus latifolia L.)* for commercial cultivation;

1.2) Post-harvest management to maintain the quality of Bastard Oleaster fruit *(Elaeagnus latifolia L.);*

1.3) Research and development of utilization of Bastard Oleaster fruit *(Elaeagnus latifolia L.)* to produce pesticide products;

1.4) Greenhouse and nutrient management to increase the yield and quality of melon;

1.5) Development of a production system of Sam Roi Yot Yellow Pineapple seedlings to reduce genetic variability.

1.6) Control of sweet potato weevil *(Cylas formicarius)* with a bio-intensive system using a substance extracted from plants in combination with milk cow's urine

1.7) Control of potato tuber moth *(Phthorimea operculella)* with a biointensive system using plant extracts in combination with cow's milk urine;

1.8) Research and Development of integrated plant nutrient management for organic Arabica coffee production;

1.9) Research and development of physiological process adjustments to increase quality and productivity;

1.10) Pollination ecology for sustainable increase of quantity and product quality of Arabica Coffee;

1.11) Research and development of biological products to prevent rot in Arabica coffee with chemical-free agricultural system;

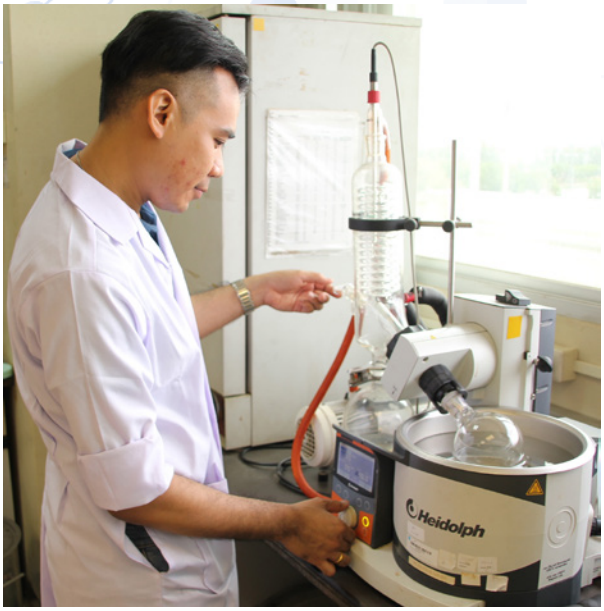
1.12) Development of a model of indigenous vegetable cultivation in the community forest to strengthen the sustainable economy in the community;

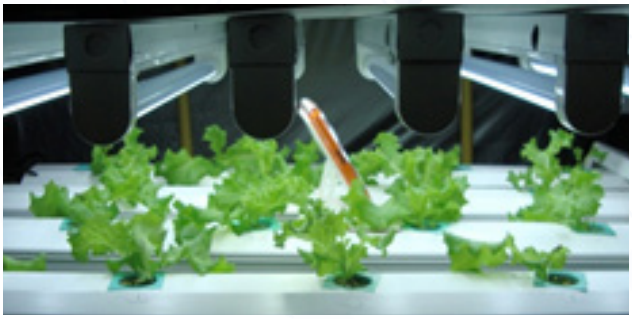
1.13) Research and development of sustainable natural mushroom production in the model community forest;

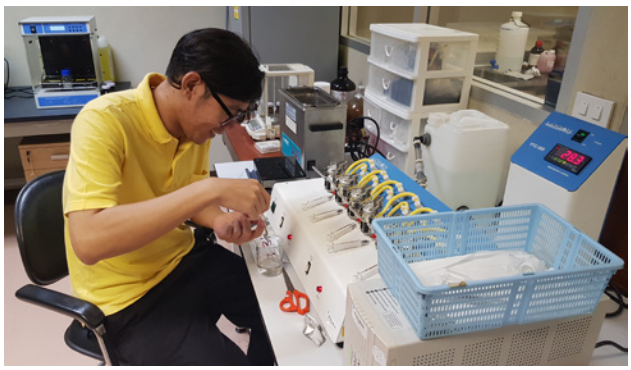
1.14) Production of Gros Michel banana (Hom Thong) with selenium supplement;

1.15) Research and Development of white jasmine rice 105 high selenium;

1.16) Creation of a soil selenium database for selenium fortified plant production;







1.17) Development of suitable forms of selenium fertilizers for the uptake of plants;

1.18) Farmers Development Project with science, technology and innovation to increase the value of agricultural products in the North (Kluai Khlai - *Musa sapientum,* Linn.*);*

1.19) Farmers Development Project with science, technology and innovation to create new agricultural products according to the potential of the Northeast area;

1.20) Farmers Development Project with science, technology and innovation to create new agricultural products according to the identity of Southern area;

1.21) Development of innovative agriculture via science and technology.

2) Expert Centre of Innovative Health Food (InnoFood)

InnoFood focused on research and development to add value to domestic raw materials and health food products, developing infrastructure to support entrepreneurs, and commercializing research. InnoFood has its expertise in conducting research and development of food and beverage products, food supplement, major food substances from nature and design of food manufacturing equipment.

In fiscal year 2019, there are 12 projects completed as shown in the following list:

2.1) Development of melon extract by freeze drying method and its application in protein-based functional drink products;

2.2) Development of innovative health food from melon (Genus Cucumis) supplemented with probiotics to adjust balance of gut flora;

2.3) Research and development of riceberry rice products using extrusion process;

2.4) Development of products from riceberry rice for health enhancement of children and the elderly;

2.5) Research and development of syrup products and fermented vinegar / cider from riceberry rice;

2.6) Research and development of butter-like products from riceberry bran oil.

2.7) Research and development of candy and fast dissolving film containing high melatonin from plants and Thai herbs;

2.8) Research and development of health products from nature to relieve stress from plant sources and Thai herbs;

2.9) Developing food potential for the private sector;

2.10) Research and development of food coloring from nature in compliance with Halal standards;

2.11) Research and development of health products From organic Arabica coffee beans;

2.12) Development of coffee slime washing machine and energy-saving coffee bean dryer.

3) Expert Centre of Innovative Herbal Product (InnoHerb)

InnoHerb has its expertise in herbal medicine and herbal medicine products. It is the center of research, development, service and innovation which provides full cycle of herbal health products recognized worldwide. InnoHerb has high potential inn extraction technology from herbs and extensive base of research on pharmacological and toxicological effects.

In fiscal year 2019, there are 3 projects that have been completed, namely:

3.1) Research and development of co-enzyme Q10 production from microorganisms to be an active ingredient for nanoparticles in cosmetic products thay uses for skin clarification and youth-restoring.

3.2) Research and development of polymeric proanthocyanidins from grape and tamarind seeds and proof of properties as an active ingredient in nanoparticles cosmetic products for skin radiance and youth-restoring.

3.3) Research and Development of Alpha Tocopherol (α-tocopherol) from gac and proof of properties as an active ingredient in the cosmetology products for skin redience and youth-restoring.

4) Expert Centre of Innovative Clean Energy Environment (InnoEn)

InnoEn focuses on excellence in renewable energy and environmental management for integration into the economy and sustainability of nation's green society, together with infrastructure development for knowledge transfer of technology and innovation. InnoEn has expertise in the field of clean energy from biomass and environmental management and energy-related resources in various development projects, climate change, measures / mechanisms on carbon footprint and water footprint.

In fiscal year 2019, there are 15 projects that have been completed as follows:

4.1) Carbon dioxide reforming process from biogas for production of bio-methanol.

4.2) Development of bio-methanol production process from pretreated biogas.

4.3) Potential assessment of bio- methanol technology from carbon dioxide in biogas.

4 .4) Environmental Impact Assessment Research on community waste management.

4.5) Research and development on production technology for community waste odorants together with additives for recycled plastics.

4.6) Biogas energy using organic community waste as raw materials and their uses for fuel cells.

4.7) Environmental Impact Assessment of the surrounding communities in the waste management area.

4.8) Construction of a double gear low -pressure steam engine.

4.9) Design and simulation prototyping of production of cellulosic ethanol from agricultural wastes.

4.10) Integration of biogas production process in high pressure conditions with Anaerobic Phased Solids (APS) using agricultural wastes and waste water with highly contaminated solids as raw materials.

4.11) Development of post-treatment processes for biogas production that can reduce air and water pollution as well as struvite buildup.

4.12) Evaluation of economic suitability, environmental risks and health status of biogas production process in high pressure

4.13) Tar removal in fuel gas using the adsorption process of char from biomass gasification process in high pressure condition.

4.14) Research on the utilization of tar from biomass gasification process by re-using water as fuel in combination with biomass.

4.15) Water Footprint and Carbon Footprint of the model community forest area for cultivating local mushrooms and local vegetables for education and sustainable tourism.

5) Expert Centre of Innovative Materials (InnoMat)

InnoMat focuses on research and development of material innovation and technology transfer and innovation to serve the aims of promoting and supporting industrial development as well as

boosting jobs and generating sustainable income for the community. InnoMat has expertise in developing materials for healthcare, energy and environment, and natural materials to increase the value and standard of products.

In fiscal year 2019, there are 2 projects that have been completed:

5.1) Research on the utilization of coal and ash from biomass gasification process by using as a mixture of concrete blocks.

5.2) Non-thermalplasma for jewelers SMEs.

6) Expert Centre of Innovative Industrial Robotics and Automation (InnoRobot)

InnoRobot focuses on research and development for industry by developing a production process to be semi-automatic or automation to solve cost problems in the production process and raise the standard of products. InnoRobot has expertise in fully automatic mechanical technology and can provide consultancy services in the conduct of research and development regarding design and manufacture of machinery and automatic control systems according to customer requirements.

In fiscal year 2019, there are 5 projects that have been completed:

6.1) Development of an external combustion engine cyclone to generate small electricity.

6.2) Development of external combustion machine with wheel rotates around the axle for small power generation.

6.3) Research and development of production processes for high-concentration sugar from rice using membrane technology.

6.4) Research and development of bacteria cellulose for medical use.

6.5) Development project for a sorting machine of fresh coffee cherries and a coffee bean size sorter for coffee production systems at community level.

7) Biodiversity Research Centre (BRC)

BRC is a center for conservation and research and development focusing on sustainable use of the country's biological resources in order to enhance national increase competitiveness in the biological industry and the regional and global biological economy. BRC has expertise in collection, storage and management of biological resource-based systems such as microorganisms, plants and animals, and research and development of biological innovation in biological substances and microbial pesticides.

In fiscal year 2019, there are 9 projects that have been completed:

7.1) Effects of modification on changes of melatonin in development of new products.

7.2) Development of the contamination test kit for pork in raw materials and food products.

7.3) Research and development for contaminant removal of freshwater fish according to the Halal standard.

7.4) Establishment of Innovative Center for Production of Industrial used Micro-organisms (ICPIM).

7.5) Microorganism Development of TISTR Culture Collection for transfer to the community to add value of local products.

7.6) Research and development of recombinant enzyme to increase the degradation potential of biomass for biogas production.

7.7) Research and development of cellulase enzyme production from genetically modified microorganisms to develop sustainable ethanol production industry.

7.8 Research and development of oligosaccharides from Thai rice.

7.9) Research and development of production processes of dietary fiber for boosting immune system from cellulose bacteria.

8) Material Properties Analysis and Development Centre (MPAD)

MPAD provides services and consultation for testing, analysis and inspection of raw materials parts and products according to International standards and requirements. The consultancy scope also includes technical consultation for material improvement and development through the complete process from upstream, midstream, and downstream. Moreover, there is a service on biodegradation testing of materials that are available both domestically and globally.

In fiscal year 2019, there are 2 projects that have been completed:

8.1) Assessment of degradation potential for hazardous substances from waste residues in the environment of microbial groups in the area.

8.2) Establishment of Biodegradation Testing Centre.

9) Thai Packaging Centre (TPC)

TPC is the packaging technology center of national standards in compliance with international standards to help maintain product quality, reduce the loss of products from the use of packaging lower than standard quality, and develop packaging that helps increase export efficiency. TPC has expertise in packaging development and packaging testing.

In fiscal year 2019, there are 3 projects that have been completed as follows:

9.1) Development of green packaging for inpatient meals.

9.2) Moth-proof edible film packaging for ready-to-cook organic brown rice.

9.3) Research and development of commercial packaging for Malot (Bastard Oleaster) products.

Patents and Petty Patents

In fiscal year 2019, TISTR filed 63 projects as registered with Department of Intellectual Property, accounting for 20 patents and 33 petty patents as follows:

Patents-20 projects

No.	Patents
1	Biogas treatment by hydrogen sulfite absorption process with iron EDTA (Fe-EDTA) in base solution of multi packed bed absorption tower)
2	Fixed bed reactor of multi-pipe with baffle and multiple gas feeder tubes to dissipate heat for methanol
3	Wet steam twin gear low-pressure steam engine
4	Sorting machine of fresh coffee cherries of horizontal belt conveyor model
5	Coiled tubular steam generator
6	Isomalto-oligosaccharides (IMO) production from rice
7	Alumina thin film coating process on semi-precious stone
8	Increasing naphtha octane value with methanol or equivalent by methaforming reaction
9	Bagasse trays (product design)
10	Bagasse cover (product design)
11	Drawer boxes (product design)
12	Treatment process for biogas contaminated with hydrogen sulfide using automatic sulfur sludge removal
13	Grain dehumidification dryer for storing
14	Closed organic waste digestion accelerator
15	Continuous sugar production machine from rice with reusable enzymes
16	Prototype of multi- photobioreactor using carbon dioxide as raw material for production of food and pharmaceutical materials from algae

No.	Patents
17	Prototype of algae production system using high concentration carbon dioxide in Closed System- Counter Current Mass Transformation Chamber (CCMTC)
18	Formula and production methods of cold brew tea from Chiangda vegetable (Gymnema - *Gymnema inodorum* (Lour.) Decne., supplemented with probiotics to reduce blood sugar
19	Model of tubular spiral algae cultivation using highly concentrated light source
20	Set of DNA primers for genetic identity of pigs using DNA increase technique at a single temperature

Petty patents - 33 projects

No.	Patents
1	Fresh pineapple cleaning machine with wind tunnel to get rid of ants and insects
2	Methods for producing zeolite from plant ash
3	Formula and processing for crispy melon with *Lactobacillus paracasei* lm2TISTR2733
4	Alpha tocopherol retention process (α-tocopherol) from gac extract technology using Nanostructured Lipid Carriers (NLC)
5	Nano-emulsion formula and manufacturing process that contains grape seed extract as a component in cosmetics
6	Formula and production process of concentrated syrup from riceberry rice-grain
7	Methods for producing plant pots from agricultural waste
8	Concrete blocks from charcoal and biomass ash
9	Double absorption chamber, polypropylene on stainless steel surface for biogas treatment with absorption system of hydrogen sulfide
10	Ready-to-brew beverage products with coarse extract from melon in gel-alginate form
11	Production process of fragrance-emitting rubber products from natural rubber blend fragrance-containing compound
12	Formula and process for making margarine from rice bran oil
13	Paint from natural latex

No.	Patents
14	Preparation of bacterial cellulose powder using non-chemical mechanical method
15	Extraction process of carmine-like natural red pigment for use in the food industry
16	Recipes and production process of ready-to-drink riceberry juice mixed with Goji berries
17	Cutting Machine for weaving handicrafts from *Cyperus involucratus Roxb.*
18	Production process of beta-glucan from *Saccharomyces cerevisiae* yeast
19	Nano-capsule formula containing coconut oil as an ingredient for use in cosmetic products and manufacturing processes
20	Hydrogel ginger salad dressing and processing
21	Nano-capsule formula containing coconut oil as an ingredient for use in cosmetic products and manufacturing processes
22	Hydrogel ginger salad dressing and processing
23	Enzyme endo1,4-beta-xylanase GH11 from *Penicilliumoxalicum* genetically modified by the addition of family 6 CBM
24	Formulas and physical conditioning methods in the margarine production process from rice bran oil
25	Selenium-based fertilizing in Gros Michel banana at flag-leaf period
26	Low-temperature glaze formula for pottery from ash and local soil
27	Rice bran dryer
28	Recipes for producing Kaempferia juice with honey and lemon juice for reducing the risk of intestinal cancer
29	Formula of nutrient solution for the production of mineral fortified salad vegetables using nutrient film technique hydroponic system
30	Carbonate soft drinks from decaffeinated coffee with no alcohol
31	Formula and production process of soybean extract solid candy products
32	Production process of Zeolite 4A from lignite ash
33	Formula and production process of breakfast from riceberry cereal with extrusion process

National and International Publications

There were a total of 45 publications as follows:

National publications -13 articles

No	Article title	Journal
1	Interspecific Hybrid Plants (*M. tomentosa* x *M. sirikittiae*) in Genus *Mitrephora* of Annonaceae Family	Thai Journal of Science and Technology (7)3 (September-December 2018) pp. 223-230
2	Pollination Approaches to Atemoya Fruit's Growth (*Annona atemoya* Hort. cv. Petchpakchong) and Suitable Harvesting Period	Thai Journal of Science and Technology (7)3 (September-December 2018) pp. 262-271
3	Effects of Bioextract from Waste of Fish Meal Factory on Growth and Marketable Yield of Head Lettuce and Marigold	Thai Journal of Science and Technology (8)1 (January- February 2018) pp.43-53
4	Morphology Study of Various Asiatic Pennyworth	Thai Journal of Science and Technology (8)1 (January- February 2019) pp.54-65
5	A Study of Chemical Compositions and Shelf Life of Ready to Drink Nom Chang (*Uvaria codata* L.) Juice	Thai Journal of Science and Technology (8)2 (March- April 2019) pp.154-161
6	Effect of Storage Temperature on GABA Content and Quality of Soursop (*Annona muricata* L.).	Agricultural Sci. J. 2018, (49)4 (Suppl.), pp. 35-37
7	A study of natural red extraction for use in the food industry in compliance with Halal Standards	4th National Symposium of Fatoni University 2018 on "Interdisciplinary Integration with Islamization: Building Peace and Sustainable Moral Society"

No	Article title	Journal
8	Characterization of exopolysaccharide from *Lactobacillus fermentum* TISTR 2514 and its potential prebiotic properties	Asia-Pacific Journal of Science and Technology,2019, 24(1), pp.1-8
9	Expression of the Endoglucanase gene in *Escherichia coli* for the second-generation bioethanol production	Food and Applied Bioscience Journal, 2019, special issue on agriculture and agro-industry, pp.27-35
10	The prototype of automatic control system for the vertical hydroponic	11th Conference on Application Research and Development of the Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology Association of Thailand (ECTI Thailand) (ECTI-CARD 2019), Sirindhorn International Institute of Technology (SIIT), 4-7 June 2019, Baan Suan Khun Ta Golf and Resort, Ubon Ratchathani Province
11	Reduction of GHG emission using Zeolite 4A under different fertilizer usages in rice cultivation	Applied Environmental Research, 2019, 41(1), pp.70-82 12
12	Turmeric drying using closed system dryer	Proceeding of the 15th Conference on Energy Network of Thailand. Greenery resort, Nakhon Ratchasima, Thailand. 21-23 May 2019. pp.825-831
13	Effects of the revolution speed on yield of crude Jatropha oil from the Jatropha squeezing machine	Journal of Science and Innovative Technology,2019, 2(1), pp.10-17

International publications -32 articles

No	Article title	Journal
1	Fabrication of ultrafiltration PLA hollow fiber membrane for surface water treatment applications	Proceeding of the Regional IWA International Conference on Water Reclamation and Reuse, 30 Oct-2 Nov 2018, Phuket, Thailand, pp.248-254
2	The Influence of pH, NaCl, and the deacidifying yeasts *Debaryomyces hansenii* and *Kluyveromyces marxianus* on the production of pigments by the cheese ripening bacteria *Arthrobacter arilaitensis*	Foods, 2018, online publication
3	Analysis of the fatigue performance of elastic rail clip	Engineering Failure Analysis, 2018, 92(10), pp.195-204
4	Characterization of fusing CBM6 within *Cellvibrio Japonicus* Endo-b-1,4-mannanase-enzyme in Pichai pastoris expression	Proceeding of the 30th Annual Meeting of the Thai Society for Biotechnology and International Conference, 22-23 November 2018, Bangkok, Thailand. pp.1-12
5	Screening of potential probiotic lactic acid bacteria for swine industry	Proceeding of the 30th Annual Meeting of the Thai Society for Biotechnology and International Conference, 22-23 November 2018, Bangkok, Thailand. pp.1-9
6	*Pseuderanthemum palatiferum* (Nees) Radlk extract induces apoptosis via r*eactive* oxgenspecies-mediated mitochondria-dependent pathway in A549 human lung cancer cells	Tropical Journal of Pharmaceutical Research,18(2), pp.287-294
7	Anaerobic degradation of sulfated polysaccharides by two novel *Kiritimatiellales* strains isolated from black sea sediment	Frontiers in Microbiology, 2019, 10, pp.1-16 published Online 18 Feb 2019
8	Microbial diversity and organic acid production of guinea pig faecal samples	Current Microbiology, 2019,76, pp.425-434

No	Article title	Journal
9	Novel biodegradable hydrogel based on natural polymers: synthesis, characterization, swelling/reswelling and biodegradability	European Polymer Journal, 2019, 112, pp. 678-687
10	Effects of alternative fillers on the propeties of rubber compounds	Key Engineering Materials, 2019, 798, pp. 316-321
11	Thermoelectric properties of $YBa_2Cu_3O_7$-x -Na_yCoO_2 segmented oxide ceramics	Materials Letters, 2019, 236, pp. 378-382
12	Thermoelectric properties of $YBa_2Cu_3O_7$-x -$Ca_3Co_4O_9$ segmented oxide ceramics	Journal of Electronic materials, 2019, 48, pp. 3514-3518
13	Evaluation of total phenolic content and *in vitro* antioxidant activity of edible mush-room	Proceeding of the 35th International Annual Meeting in Pharmaceutical Sciences & CU-MPU International Collaborative Research Conference, pp. 239-242
14	Effects of potassium chloride-induced stress on the carotenoids Canthaxanthin, Astaxanthin, and lipid accumulation in the green *Chlorococcal Microalga* strain TISTR 9500	Journal of Eukaryotic Microbiology, 2019, 66 first published online 10 March 2019
15	Nutrient deprivation-associated changes in green microalga *Coelastrum* sp.TISTR 9501RE enhanced potent antioxidant carotenoids	Marine Drugs, 2019, 17(6), pp. 328-339
16	Isomalto-oligosaccharides production from rice flour and cassava starch	The 3rd International conference on Agriculture and Agro-industry (ICAAI2018), Mae Fah Luang University, 15-17 November 2018
17	Two new species of the genus *Echinopla* Smith, 1857 (*Hymenoptera: Formicidae: Formicinae*) from Thailand	Far Eastern Conference, 2018, 370, pp. 1-11
18	Resource use among sympatric *Callosciurus* spp. (Sciuridae) in tropical seasonal forests during the dry season in Northeastern Thailand	Mammal Study, 2019, 44, pp. 23-32

No	Article title	Journal
19	Hits close to Home: repeated persecution of King Cobras (*Ophiophagus hannah*) in Northeastern Thailand.	Tropical Conservation Science, 2018, 11, pp. 1-14
20	Profiling and catalytic upgrading of commercial palm oil-derived biodiesel fuels for high blend fuels	Catalysis Today, 2019, 332, pp. 122-131
21	The removal of tar in producer gas using bio-char derived from biomass gasification	Proceedings of the 2019 Pure and Applied Chemistry International Conference (PACCON2019), Bangkok, Thailand. 7-8 February 2019. pp. EE24-EE29
22	Investigation of high-quality palm biodiesel production using batch type	Proceedings of the 2019 Pure and Applied Chemistry International Conference (PACCON2019), Bangkok, Thailand. 7-8 February 2019, pp. RE136-RE141
23	Preparation of coloured thin films on glass and stainless steel using RF Magnetron Sputtering	Proceedings of the 2019 Pure and Applied Chemistry International Conference (PACCON2019), Bangkok, Thailand. 7-8 February 2019, pp. MN127-MN132
24	Improvement of natural rubber composite properties using silica/carbon black hybrid filler	Proceedings of the 2019 Pure and Applied Chemistry International Conference (PACCON2019), Bangkok, Thailand. 7-8 February 2019, pp. PO35-PO40
25	Development of green concrete using solid residues from biomass gasification	Proceedings of the 2019 Pure and Applied Chemistry International Conference (PACCON2019), Bangkok, Thailand. 7-8 February 2019, pp. RE70-RE74
26	A new species of the ant genus *Myrmecina Curtis*, 1829 (*Hymenoptera: Formicidae, Myrmicinae*) from Thailand	Far Eastern Entomologist, 2019, 383, pp. 1-7

No	Article title	Journal
27	Characterization and *Bifidobacterium* sp. growth stimulation of exopolysaccharide produced by *Enterococcus faecalis* EJRM152 isolated from human breast milk	Carbohydrate Polymers, 2019, 206, pp. 102-109
28	Physical stability of astaxanthin from *Haematococcus pluvialis* loaded in microemulsion as a cosmetic ingredient for melanogenesis inhibition	Key Engineering Materials, 2019, 819, pp. 157-162
29	A competitive colorimetric immunosensor for detection of Tyramine in fish samples	Food Analytical Methods, 2019, 12, pp. 1886-1894
30	Biological activities and dermal penetration of liposome-containing *Coprinus atramentrarius* extract	Key Engineering Material, 2019, 819, pp. 124-129
31	Determination of shelf life of Durian chips at room temperature (real condition for sale)	The 3rd International Conference on Agriculture and Agro-industry (ICAAI2018), Mae Fah Luang University, 15-17 November 2018
32	Effect of different types of packaging and temperature on the quality of Angelica (*Angelica sinensis* Oliv.) during storage	The 3rd International Conference on Agriculture and Agro-industry (ICAAI2018), Mae Fah Luang University, 15-17 November 2018

PART 6

Annual report 2019

Customer and marketing performance

Commercial technology transfer

In fiscal year 2019, TISTR conducted memorandums of agreement and understanding with government and private agencies, totaling of 31 projects. Details are as follows:

List	Subject	Agencies
1	Memorandum of understanding on the collaboration in research, development and technology transfer	Rambhai Barni Rajabhat University, Chanthaburi
2	Memorandum of collaboration agreement “Promotion and support on Science, Technology and Innovation for creating value added to agricultural commodities	Chul Thai Silk Co., Ltd.
3	Science, Technology and Innovation for utilization and value added creation in sustainable community waste management	Chiang Rai Provincial Administrative Organization
4	Memorandum of understanding	Thailand Environment Institute
5	Memorandum of collaboration agreement in the development of central data for integrated SME promotion (web portal) or SME ONE website	Office of Small and Medium Enterprise Promotion
6	Memorandum of understanding “Common pool resources of state enterprise for maximizing benefits in operation”	Metropolitan Waterworks Authority
7	Memorandum of understanding “Common pool resources and academic collaboration for maximizing benefits in operation”	Thammasat university
8	Memorandum of understanding on the collaboration in research and development	PTT Exploration and Production Public Co., Ltd.

List	Subject	Agencies
9	Memorandum of understanding	Cooperative Promotion Department
10	Memorandum of understanding in the project "San Phalang Pracharat for promoting community enterprises' entrepreneurs, community enterprise network and community cooperatives by Science, Technology and Innovation	Siam Kubota Corporation Co., Ltd.
11	Memorandum of collaboration agreement in bringing Science, Technology and Innovation into value added creation and supporting management administration of technology transfer center and innovative processed foods, Phrae province	Phrae province
12	Memorandum of understanding "Research and development for creating value added products and agricultural produce of Chaipattana Foundation by Science, Technology and Innovation	Chaipattana Foundation
13	Memorandum of collaboration agreement "Promoting capacity and supporting small and medium enterprise entrepreneurs (SMEs)"	Export-Import Bank of Thailand and Bank for Agriculture and Agricultural Cooperatives
14	Memorandum of understanding	JuiceInnov8 Co., Ltd.
15	Memorandum of understanding	JSP Pharmaceutical Manufacturing (Thailand) Public Co., Ltd.
16	Memorandum of understanding in the promotion of Science, Technology and Innovation for provincial development	Lampang province
17	Memorandum of framework agreement in the development and promotion in innovative artificial intelligence in agriculture machinery	The Federation of Thai Industries and Thai IoT Association
18	Memorandum of understanding in enhancing One Tambon One Product entrepreneurs and small and medium enterprises by Science, Technology and Innovation	Rajamangala University of Technology network

List	Subject	Agencies
19	Memorandum of collaboration in promoting and supporting ECO industrial town development and enhancing local products manufacturers, local economy group by Science, Technology and Innovation for sustainable development in EEC area	Puen Chumchon Association
20	Memorandum of collaboration in promoting and supporting ECO industrial town development and enhancing local products manufacturers, local economy group by Science, Technology and Innovation for sustainable development in EEC area	Noen Phra Subdistrict Municipality, Rayong province
21	Memorandum of collaboration in promoting and supporting ECO industrial town development and enhancing local products manufacturers, local economy group by Science, Technology and Innovation for sustainable development in EEC area	Na Ta Khuan Subdistrict Administration Organization, Rayong province
22	Memorandum of collaboration in promoting and supporting ECO industrial town development and enhancing local products manufacturers, local economy group by Science, Technology and Innovation for sustainable development in EEC area	Industrial Estate Authority of Thailand
23	Memorandum of collaboration	MCOT Public Company Limited
24	Memorandum of collaboration agreement in the promotion of research and development in Science and Technology for innovative business development and value addition for Thai industry	Department of Industry Promotion (DIP)
25	Memorandum of collaboration agreement in research and development of cosmetic products and cosmeceuticals from plants	Mitr Phol Sugarcane Research Center Co., Ltd.

List	Subject	Agencies
26	Memorandum of understanding	King Mongkut's University of Technology North Bangkok
27	Memorandum of understanding	Rajamangala University of Technology Suvarnabhumi
28	Memorandum of academic collaboration	Silpakorn University
29	Memorandum of collaboration agreement in research and development in Science and Technology	National Science and Technology Development Agency
30	Memorandum of academic collaboration in the development of agriculture and agro-industry in Lamphun area	Lamphun province and Pracharath Rak Samakkee (Social Enterprise) Co., Ltd.
31	Memorandum of understanding	Naraesuan University, Phitsanulok

Social technology transfer

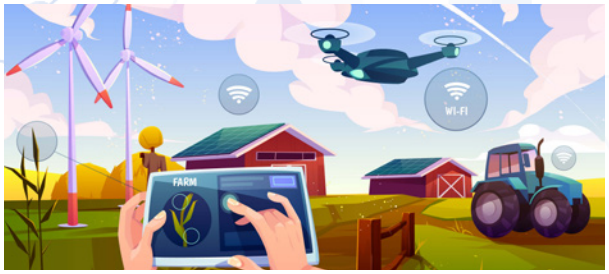
TISTR conducted social technology transfer to farmer groups and people in bringing science, technology and innovation (STI) to utilize in the way of life, to improve competencies of farmers and people in local areas and communities in problem solving skills, along with to add more value to local produces. There were projects in technolology transfer as follows:

1) Technology transfer on food processing to add value of local vegetables and fruits in the area of 5 southern border provinces (Pattani, Yala, Narathiwat, Satun, and Songkhla)

TISTR organized a workshop to transfer knowledge on production process for food processing tocommunities and farmers. The knowledge and technology transfer activities were as follows: 1) recipe and processing of longkong processed products to housewives and farmers groups in order to solve the problem of oversupply raw material at Princess of Naradhiwas University, Narathiwat province; 2) processing of mangosteen juice and mangosteen jam to Tai Rom Boon group, Hat Yai, Songkhla province; 3) production of Khao Yam (rice salad) mixed with longkong to Ban Thon A-man group, Narathiwat province; 4) production process of longkong-mangosteen juice to Budo Cooperative Group, Yala province. Moreover, the knowledge on production process of food processing using Hom Kradang Nga rice abundantly found in Narathiwat, modified into healthy Hom Kradang Nga rice flour and black sesame crisp Hom Kradang Nga rice flour to Bang Khun Tong farmer-housewives community enterprise group in Tambon Bang Khun Tong, Amphoe Tak Bai, Narathiwat province.

2) Technology transfer on biotechnology for developing model farms on the Royal initiated project in Pattani

TISTR conducted survey in Pattani to transfer biotechnology used in farms by transferring technology on production and use of pesticides made from herbs and microorganisms, bio-extracts, organic fertilizer, starter culture for soil improvement in dried and liquid form, training on production of liquid organic fertilizer from golden snails (*Pomacea canaliculata*), low-cost production process of layer diet, pasteurization method of palmyra palm vinegar production, production process of lotion from gac fruit and cold pressed coconut oil, including purchasing of materials/ equipment for each model farm to use for producing pesticides, bioextracts,



starter culture, animal feeds by following TISTR's production processes. There were also efficacy test of liquid culture and herbal extracts for pesticide, in collaboration with Rajamangala Univeristy of Technology Tawan-ok. The results of technology transfer could enhance the target groups to produce liquid and dried organic fertilizer, as well as liquid and dried starter culture, in a total model farms about 100 ton/month.

3) Development of agricultural community innovation by Science and Technology in collaboration with Bank for Agriculture and Agricultural Cooperatives (BAAC)

TISTR in collaboration with Bank for Agriculture and Agricultural Cooperatives (BAAC) implemented the STI research outputs into actions with the objectives to increase the quantity and qualityof productivity, cost reduction, value addtion of agricultural produces and product development to meet the quality standards. Moreover, other types of action consisted of marketing system for creating one-stop innovative agricultural community business, an increase of knowledge and skills in S and T to personnels in agriculture and BAAC staff and building of a rural network for supporting continuous operation of the community. Three communities from 2 provinces were included in this program, namely, Nakhon Nayok and Chachoengsao by transferring knowledge and technology as follows: business development for community enterprise, property analysis of pig placenta extract and distilled pig placenta extract, packaging development of pig placenta extract for market trial, irrigation system development for Madan *Garcinia schomburgkiana* Pierre plantation, study on off season production of Madan, Madan herbal tea product and production process development of mulberryherbal drink, including technology transfer of organic chemical fertilizer for jackfruit production in Tambon Krasae Bon, processing jackfruit and residues from peeled jackfruit, food products from jackfruit seeds, spicy jackfruit chili paste and jackfruit seeds in syrup and biomass stove, development and knowledge transfer on mangosteen harvesting equipment to protect the damage of graded mangosteen, method for reducing fungal occurrence on surface of durian paste, thermal production from biomass for longan drying process, etc.

4) Development of microorganisms of TISTR culture collection for community transfer on value addition to local products

TISTR achieved, from this project, food microorganisms as product prototype, which is readily available for farmers and communities, can be used for processing local raw materials, such as microorganisms in vinegar production from fruits, production process of ready to drink fruit cider and production process of coconut jelly, etc.

Besides, TISTR conducted knowledge transfer in microorganisms from this project, which was suitable for processing raw materials on value creation to local products by training 265 farmers. There were also technology transfer activities in the use of microorganisms in coconut jelly production at Phetchaburi, training farmers for Ban Pa-sang, Amphoe Muang, Chiang Rai, Samut Sakhon, and Chachoengsao.

5) Technology transfer of interlocking bricks to community for creating social innovation

TISTR is well-experienced in technology transfer of interlocking block production to communities, and so far, those communities are capable of producing the good quality blocks comparable to marketing standards. Moreover, TISTR's construction technology using interlocking blocks have been transferred to many communities. Thus a collaborative network has been created and helps promote more collaboration among both urban and regional entrepreneurs through continuous learning and development. As a result, job opportunities have been promoted with higher rate of employment and social innovation concerning interlocking block technology, leading to new rising of housing projects for communities and a better way of living for people.

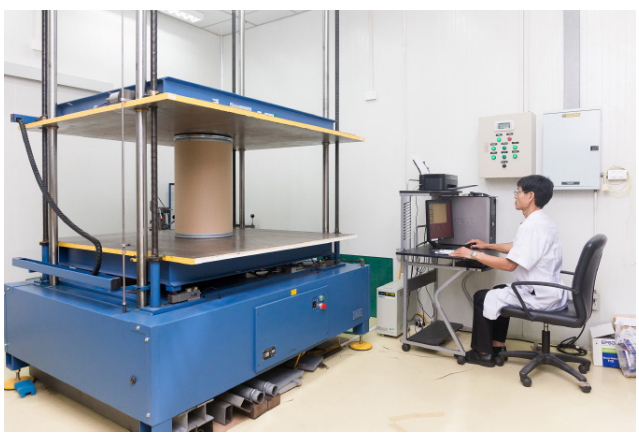
The interlocking block production technology was transferred in 16 provinces of northern region, namely, Chiang Mai, Mae Hong Son, Lampang, Lamphun, Chiang Rai, Phrae, Tak, Phitsanulok, Nakhon Sawan, Uttaradit, Nan, Phayao, Phetchabun, Sukhothai, Kamphaeng Phet and Phichit. In the northeast, the training courses on interlocking block production were provided to 54 participants of interested communities from 18 provinces, namely, Kalasin, Khon Kaen, Chaiyaphum, Nakhon Phanom, Buri Ram, Sakon Nakhon, Surin, Roi Et, Srisaket, Loei, Maha Sarakham, Nongbua Lamphu, Yasothon, Nong Khai, Bueng Kan, Udon Thani, Ubon-Ratchathan and Amnat Charoen.

Science and technology service

Industrial Services Group (ISG), TISTR focuses on providing science and technology services to raise the quality of the domestic industrial sector up to international standards and increase competitiveness in the world market. In fiscal year 2019, there were 2,759 customers using services of ISG, 380 of which were certified under the quality assessment systems whereas other customers applied for analysis, testing, and calibration services, accounting for 186,500 requests which is 5% higher than last year. In case of training, there were 2,047 participants from private and government sectors who had been improved and developed of their quality skill via 33 science, technology, and innovation training courses organized by ISG. Moreover, ISG also provided consulting services on quality system for establishment of certified laboratories to 26 customers. There were 139 participants in the project for product certification, of which 48 participants had been

certified covering the product and service standards as follows: Thai tourism standard 10 cases, agricultural products standards according to GAP 22 cases, organic agricultural product standards 16 cases, respectively.

In fiscal year 2019, TISTR upgraded the ability to provide services by expanding the scope of application for certification of the new ISO / IEC 17025 standard in 10 items such as TIS 1039-2547



- Electric rice cooker, 7 scopes in safety sector, upgrade of ISO/IEC 17025 towards the new version 2017, solar reflectance test for home paint, analysis of amino acid content in milk and dairy products such as aspartic acid, serine, glutamic acid, proline, and valine, analysis of potassium sorbate calculated as sorbic acid in milk powder, good manufacturing practices (GMP) for fresh fruit and vegetable collection plants (TAS 9047-2017), and performance test for railway fastening system according to BS EN 13481 and BS EN 13146.

TISTR provided services to support the manufacturing and service sectors of the country with science and technology services that are certified according to International Standards ISO 9001, ISO/IEC 17020, ISO/IEC 17021, ISO/IEC 17025, ISO/IEC 17043, ISO/TS 22003 which could meet the following industrial needs:

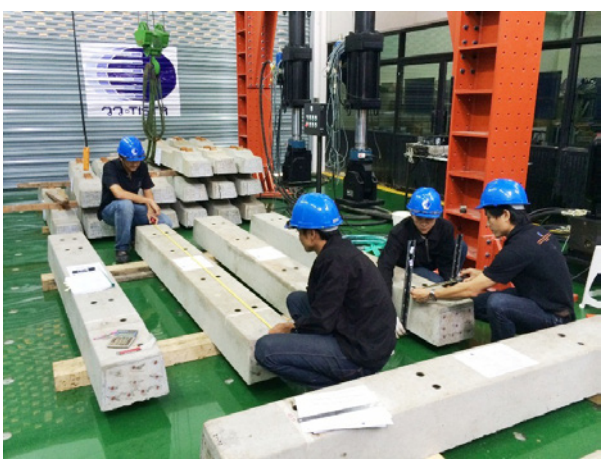
1. Testing and Analysis (ISO/IEC 17025 Accredited)

- Analyze and test materials and products in physical, chemical, metallurgical, mechanical, biochemical and biological.
- Analyze and test the ingredients and nutritional value of food, food products and beverages to be approved by the Food and Drug Administration (FDA).
- Analyze and test for certification of industrial product standards (TIS), such as industrial paint, electrical appliances, and hard PVC pipe.
- Test plastic and paperboard packaging for quality control and select proper packaging including both consumer and transport packaging in order to prolong the shelf life and reduce product damage. Packaging test for transport of dangerous goods to obtain 'UN mark' certification for export is also conducted.

- Test for biodegradable plastics according to ISO 17088.
- Test medical devices to verify the correctness and safety in use.
- Railway fastening system test according to BS EN 13481 and BS EN 13146.
- Test rail system materials and products, such as materials in concrete railroad sleepers, welding, fasteners to assess compliance with Terms of References (TOR) and international standards such as ISO, UIC, EN, AS, AREMA, etc.
- Test and assess for safety such as strength, vibration, fatigue, durability, service life, etc. During the use of railway products and in land transport vehicles.

2. Calibration (ISO/IEC 17025 Accredited)

- Calibrate of industrial metrological devices covering all branches both in site and off site.
- Calibrate medical devices.



3. Assessment and Certification for Quality Management Systems ISO/ IEC 17021 and ISO/TS 22003

- Assessment and certification for quality management system according to International standard, including ISO 9001, ISO 14001, ISO 45001 GMP (CODEX), HACCP (CODEX), ISO 22000 GMP (Law), etc.

4. Assessment and Certification for Products and Service

- Products and services such as organic and GAP agricultural products, electrical and electronic items, biodegradable plastics, rail system and service standards for Thai tourism.
- Test for quality assurance of rail system products such as concrete sleepers, railway turnouts, and fasteners according to product standards such as ISO, EN, AREMA, etc.

5. ISO/IEC 17020 Inspection (ISO/IEC 17020 Accredited)

- Product manufacturing in compliance to industry standards to be certified by ISO/IEC 17020 in the category of equipment, lighting, electrical power, electrical appliances and electronic appliances.
- Non-destructive testing of parts, equipment, and products
- Inspection of boilers and pressure vessels.
- Check for defect in rail products and rolling stocks such as rail, bogie and train body.
- Inspection during the train operation with modern inspection and monitoring technologies.

6. Proficiency Testing Provider (ISO/IEC 17043 Accredited)

- Proficiency Testing Provider (ISO/IEC 17043 Accredited)

PART 7

Annual report 2019

International Cooperation in 2019

During fiscal year 2019, TISTR collaborated with many foreign countries to conduct international projects and activities in many fields, to promote STI capabilities, to achieve United Nations' Sustainable Development Goals (SDGs) and to cope with global crisis and challenges together. We work together in the forms of written agreements and global network association (WAITRO). TISTR work on bilateral cooperation through research projects with 7 ASEAN member states, 22 projects with countries in Asia, 1 project with country in Oceania, 2 projects with countries in Europe and 1 project with country in North America, including 1 multilateral cooperation (the Asia-Pacific Metrology Program – APMP).

Highlight Activities

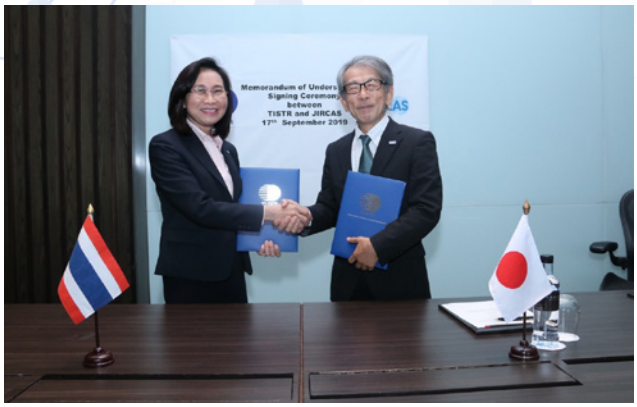
ASEAN Network of Excellence Centre of Biomass Conversion Technology (ANEC)

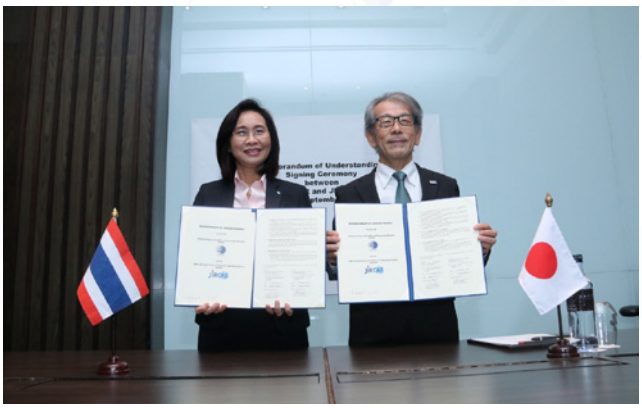
To continue ASEAN Network on Biomass Open Research (ANBOR) (2015 - 2018), TISTR worked for ANEC (2019 – 2020), under supervision of ASEAN Sub-committee on S&T Infrastructure and Resource Development (SCIRD) and financial support by ASEAN Science Technology and Innovation Fund (ASTIF). ANEC aims to facilitate collaborative activities to exchange and transfer knowledge of renewable energy technology, focusing on biomass conversion technologies, among ASAEN State Members. On 29 - 30 May 2019, 'Initiative Meeting for ANEC' was conducted and successfully

Initiative Meeting for ANEC to brainstorm ideas for project collaboration plan and guideline, held on 29 - 30 May 2019, at TISTR Technolopolis.

gathered representatives from research and educational sectors from 7 ASEAN State Members, including representatives from SCIRD, ASEAN Sub-committee on Biotechnology (SCB), and ASEAN Sub-committee on Sustainable Energy Research (SCSER). Pilot knowledge exchange under ANEC included high-quality biodieel production, gasification technology and algae technology for energy. Counterpart also included Universiti Kebangsaan Malaysia (UKM) - Malaysia, Renewable Energy and New Materials Institute (REMI) - Lao PDR, and University of Science and Technology of Hanoi (USTH) - Vietnam.

'TISTR and JAIMA Conjoint Conference on Application of Ingredient for Functional Food and Cosmetics 2018', at Rama Gardens Hotel Bangkok

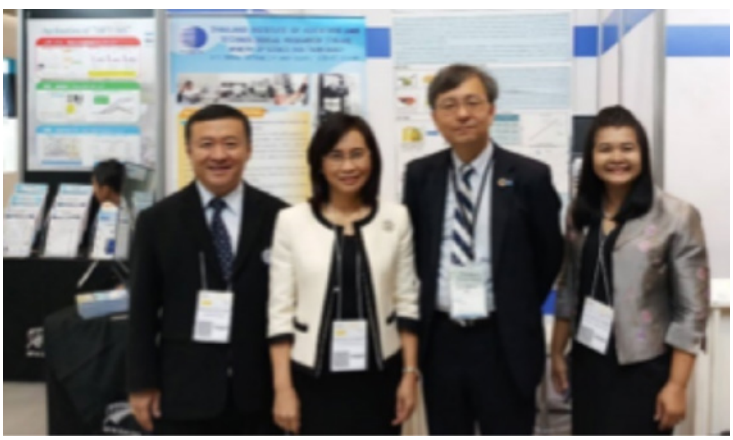




Japan Analytical Instruments Manufacturers' Association (JAIMA))

TISTR and JAIMA jointly organized the event 'the 1st TISTR and JAIMA Conjoint Conference on Application of Ingredient for Functional Food and Cosmetics 2018' on 13 November 2018, at Rama Gardens Hotel Bangkok and TISTR Technopolis. The event aimed to share knowledge of ingredients extract for functional food production and for cosmetic production, with modern tools, equipment and technologies.

In September 2019, TISTR Executives visited Japanese private companies, which are members of JAIMA, including HORIBA Tokyo Office, JEOL and Agilent, to study progress of equipment for testing and analysis. After that, TISTR's Executives attended 'Japan Analysis & Scientific Instruments Show (JASIS 2019)' held by JAIMA, in Japan. We also send researchers to join exhibition to publicize complete services of testing and analysis services for industrial products provided by TISTR, to give an academic presentation in the event 'Asia Technical Forum 2019' and to give a poster presentation in the event 'The RSC Tokyo International Conference 2019', as parts of JASIS 2019.



TISTR attended 'JASIS 2019', in Japan.

Dr. Chutima Eamchotchawalit, Governor to TISTR, attend WAITRO Regional Focal Point (RFP) & Board Meeting 2019, on 10 – 12 July 2019, at Fraunhofer IZB Zentrum Schloss Birlinghoven, Sankt Augustin, Germany

World Association of Industrial and Technological Research Organization (WAITRO)

TISTR was appointed as a 'Regional Focal Point (RFP) for Asia and the Pacific (2019 - 2020)', by WAITRO Executive Board, to support work operations of WAITRO Secretarial (Fraunhofer-Gesellschaft - Germany, and the Jiangsu Industrial Technology Research Institute - China), as a regional liaison to Asia and the Pacific. In this occasion, TISTR is responsible for information exchange of upcoming events, activities and research funding scheme (e.g. WAITRO's Water Campaign, WAITRO Innovation Award, WAITRO Fellowship Program, and Horizon 2020) among member researchers and member institutions within the region, publicizing information on benefits of

membership in order to seek for new members, and introduction to the use of SAIRA database which is an Open Innovation Hub for Sustainable Development to research agencies both in the country and abroad. TISTR distributed this information concerning organizational background and benefits to various government agencies in Thailand such as Office of Atoms for Peace, Thailand Institute of Nuclear Technology, Thailand International Cooperation Agency, and Metropolitan Waterworks Authority (Thailand).

Research and Development on Functional Agriculture: Selenium distribution in Thai agricultural land and Se-enriched crops production

In cooperation with Suzhou Setek Co., Ltd. (SETEK) and Jiangsu Bio-engineering Research Centre of Selenium (JBRCS), TISTR conducted agricultural technology project of Se-enriched crop production for health, through many forms of activities, which are brainstorming session, consultation meeting with Chinese researchers, workshop event for Thai researchers, information exchange regarding Selenium distribution in Thai agricultural land, successful case Thai crop production (Golden Banana and Jasmine Rice 105), and development of Selenium-analysis standard for agricultural land and crop production. The project was successful at small-scale experiment in pilot plant and was expected to be successful at the next step for larger-scale experiment in agricultural field of which mass crop production was used for commercialization.

With financial support by MHESI, TISTR extended cooperation under this project to Suzhou Institute of Advanced Technology, University of Science and Technology of China (USTC-Suzhou) for conducting a field study and establishing a 'TISTR-USTC Suzhou Joint Lab and Demonstration Base for Functional Agriculture', in Suzhou, Jiangsu Functional Agriculture at Suzhou province, China, and Shanxi Agricultural University (SXAU) for conducting collaborative research projects regarding bio-fortification, drought

Dr. Chutima Eamchotchawalit, Governor to TISTR, attend MOU signing ceremony between TISTR-USTC (Suzhou), and TISTR-SXAU in China

'TISTR researcher team attended 'the 6th International Conference on Selenium in the Environment and Human Health' in China

management, food ingredients, botanical extraction for food and feed, and horticultural cultivation, in Shanxi Province, China.

In October 2019, TISTR researcher team attended 'the 6th International Conference on Selenium in the Environment and Human Health' to provide four topics of academic presentation (Selenium Distribution in Thailand,

Selenium Accumulation in Grand Rapids Lettuce (*Lactuca sativa*), Effect of Selenium Application Timing on Selenium Accumulation in Hom Thong Banana (*Musa acuminata* AAA group "Gross Michel"), Effect of Selenium Application on Selenium Content of Jasmine Rice (*Oryza sativa* KDML 105)), held in Xi'an, Shanxi province, China.

Thailand Institute of Scientific and Technological Research