ANNUAL REPORT 2022

Thailand Institute of Scientific and Technological Research (TISTR)
Ministry of Higher Education, Science, Technology and Innovation (MHESI)

Content

	A
Message from the Governor	1
Business Risk	4
Business Condition, Business Plan and Strategies	8
Research Highlight	10
Highlight Activities	17
Achievement Awards	29
Important Projects	34
Completed Research and Development projects	38
Patents and Petty Patents	45
National and International Publication	50
Technology transfer for Commercialisation	66
Technology transfer for Social Benefit	70
Science and Technology Services	75
International Cooperation	79

Message from the Governor

The operation of Thailand Institute of Scientific and Technological Research (TISTR) in 2022 was extremely challenging due to the impact of the spread of the COVID-19 that has caused a slowdown in the economy around the world, especially small and medium enterprises (SMEs), community enterprises and the One Tambon One Product group (OTOP) that relies on trade in products linked to tourism. In addition, the export problem caused by the conflict between Russia and Ukraine resulted in an energy crisis and high production costs which greatly affected SMEs and OTOP that are customers of TISTR.

TISTR has, therefore, focused on strengthening SMEs and OTOP to be able to operate continuously after the COVID-19 outbreak by using science, technology, and innovation (STI) to create value-added innovations that will result in new business opportunities through the BCG model. The BCG model is an important mechanism for driving the new economy according to the government's policy that relies on the advantages of the country's biodiversity. The BCG model contributes to cost-effective resource circulation and promotes environmentally friendly operations, reducing greenhouse gas emissions for SMEs and OTOP, which is a global trend.

TISTR focuses on creating an innovation ecosystem by using STI to develop innovative products through total solutions operations and promoting the use of scale up plant such as "Innovative Centre for Production of Industrially used microorganisms: ICPIM 1" to create High-value microbial products available in Culture Collection, which such products are certified by the Food and Drug Administration (FDA). ICPIM1 supports large and small businesses to use STI to create new products that are superior to traditional agricultural processing, such as probiotic drink products (Pro Herb), cosmetics made from probiotic (Pro Skin). In addition, the Innovative Centre for Production of Industrially used microorganisms: ICPIM 2 has been developed as an infrastructure to promote the production of safe agricultural products using bio-products. ICPIM 2 has potential to produce quality bio-products for the community to use in the production of organic agricultural products on an area over 100,000 Rai. It also provides industrial cosmetic production services under the Innovative Cosmetic Services Centre (ICOS) that has been assessed and certified for cosmetic production facilities from FDA.

In terms of enhancing the capabilities of the industry and SMEs, TISTR has expanded the scope of various testing/calibration analysis services to support the government's New S-curve industry, such as the development of medical device testing services according to OECD/GLP standards, providing testing services for rail system parts, and providing testing services for aircraft parts according to international standards. This is to help reduce the cost of testing for operators and build credibility for products in the country. In terms of business transformation in accordance with environmental requirements in increasing the proportion of biodegradable plastic used for exports to Europe, TISTR has increased biodegradable plastic certification services by providing comprehensive product testing and certification services. As a result of such services, TISTR received the Public Sector Excellence Award 2022 . TISTR has been registered as a product inspection unit under Section 5 of the Thai Industrial Standards Institute (TISI), Ministry of Industry. It is a mandatory and voluntary industrial product standard covering consumer and medical products. Moreover, TISTR has received a Section 1 juristic person license to provide inspection services for machinery, cranes, and boilers. TISTR is also a host organisation of the Council of Engineers that continually participates in the development of the country's engineering profession.

For the social aspect, TISTR has supported important communities in 39 provinces across the country to increase incomes, reduce expenditures, upgrade agricultural products, and create new jobs. TISTR has operated under various projects such as the provincial-level grassroots economy project with science, technology and innovation, the Innovative Identity Community Development Project, and the project to raise the standards of tourist attractions and product standards from Thai wisdom in the region. This project is linked and integrated with Rajabhat University (MRP) throughout the country, which leads to the creation of innovative products from local raw materials, creating a circular economy in the country.

For foreign affairs, TISTR has been working with European countries to drive environmental education together with leading international organisations, such as collaborating with WAITRO to conduct researches according to the SDG guidelines in two projects, namely SMARTinFOOD: Insect-based Food Sources to Supplement Nutrient Deficiencies in Vulnerable Areas and the Strengthening Food Sustainability in Southeast Asia by Utilisation of Local Tuber of Amorphophallus Muelleri Blume Project. TISTR was also responsible for co-hosting APEC in organising an online international conference to create a network of cooperation and promote the application of STI to increase productivity in the ornamental plant business and the capacity of municipal solid waste management at the regional level of the APEC economic zone. Furthermore, TISTR also contributed to the creation of international cooperation networks and promoted the BCG model.

TISTR has also received outstanding awards in many areas such as the Outstanding State Enterprise Award on Strategic Cooperation for Outstanding Development 2021, Public Sector Excellence Award 2022, Human Rights Award 2022 : Outstanding Organisational Model, the Best Business Service Provider Award for building business networks both domestically and internationally, etc.

As a result of the determination of executives, researchers, and staff, TISTR has achieved its goal as a mechanism to help drive the country. The results of TISTR's operations have positive impacts on the economy, society and environment, especially in reducing production costs and enhancing the competitiveness of start-up entrepreneurs and SMEs, enabling them to develop new products with higher value and the products are certified according to international quality standards. In society, TISTR helps to raise household incomes in the grassroots economy, especially farmers and community enterprises in various areas by transferring agricultural technology, which results in increased income and reduced household expenditures. TISTR's projects also have a positive effect on the environment. It contributes to the efficient use of natural resources and helps reduce greenhouse gas emissions. Moreover, it supports balanced economic development with conservation of natural resources and the environment in line with sustainable development. The operation of TISTR in 2022 generates economic and social value of 16,770.7416 million Baht or 17.69 times compared to the allocated national budget.

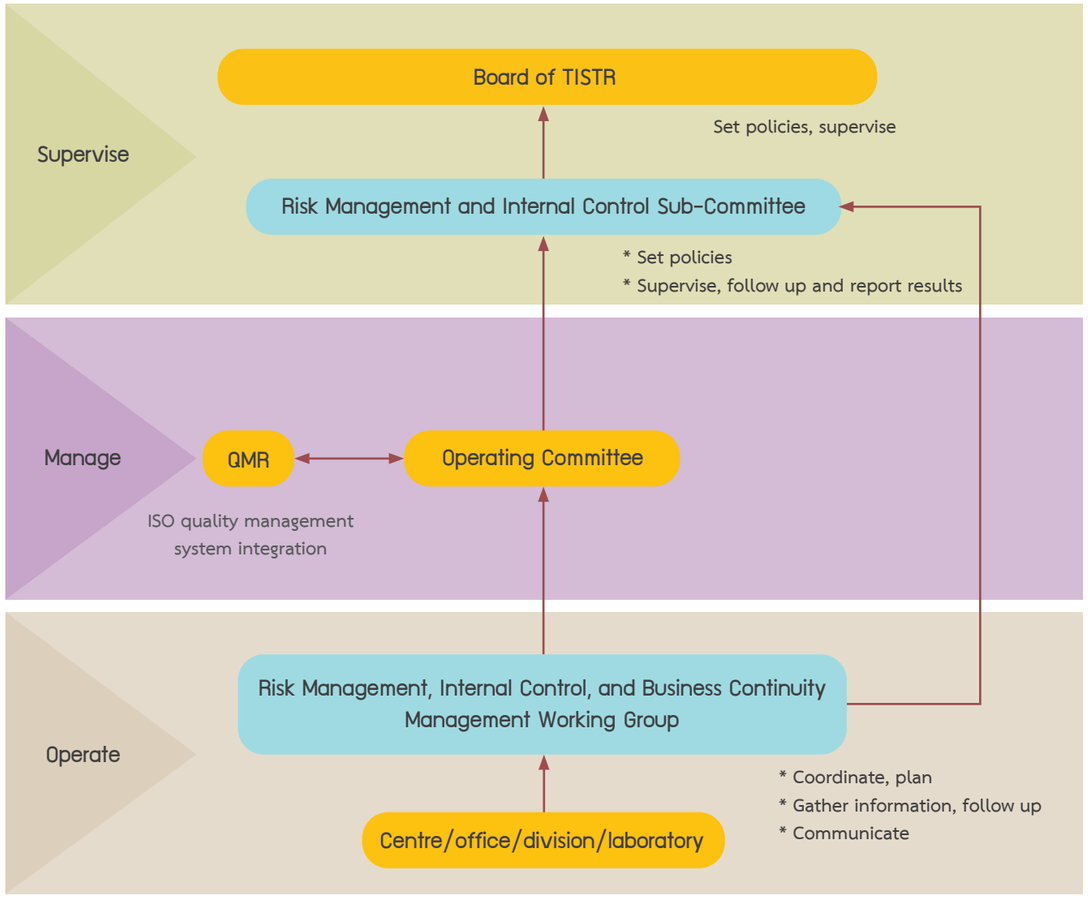
TISTR believes in maintaining quality standards in operations and further development and is ready to stand alongside all sectors in Thai society for sustainable success.

Dr. Chutima Eamchotichawalit
Governor

Business Risk

TISTR determines the structure of risk management and internal control according to the risk management and internal control sub-committee, which is responsible for setting policies, supervising, monitoring, and reporting results to the Board of Directors of the Thailand Institute of Scientific and Technological Research (Board of TISTR).

At the unit level, TISTR has appointed a risk management, internal control, and business continuity management working group to coordinate and drive operations with the centre/office/division/laboratory and quality management representative (QMR) of the ISO 9001 to achieve the integration of risk management and internal control according to ISO requirements.



Risk management guidelines for 2022

Risk Factor	Cause of Risk	Effect	Management Approach
R-01: Existing methods of promoting the utilisation of the research results may not be flexible enough (S)	• The development of methods for utilising research results is insufficient • Cooperation with external agencies is not encouraged enough	Existing research outputs are not utilized, and performance cannot be significantly enhanced	• Develop methods for utilising research results • Promote cooperation with external agencies in distributing intellectual property
R-02: Implementation of core business enablers may not be effective enough. (O)	• Follow up on the progress of the implementation of the feedback report is not enough • Implementation of the criteria is insufficient • Lack of improvement and development according to the suggestions from the assessors	Inability to maintain standards of assessment results and meet stakeholder expectations	• Organise a meeting to monitor the progress of the implementation of the feedback report • Set up a plan to improve the operation according to the criteria
R-03: Relationships with stakeholders may not meet expectations. (O)	• The process of monitoring the status of cooperation projects is inadequate • Lack of development of the VOS System to improve the stakeholder database	Failure to respond to the needs of stakeholders and desired outcomes	• Follow up on the status of cooperation projects every quarter • Develop the VOS System to improve the stakeholder database into a digital format
R-04: Income may not be as expected (F)	• The marketing and public relations of TISTR is still insufficient Service scope is not comprehensive enough	Lack of liquidity in financial management, which affects the sustainability of the organisation	• Proactive marketing/ public relations • Expanding the scope of services

Risk Factor	Cause of Risk	Effect	Management Approach
R-05: Existing work processes may not comply with the Personal Data Protection Act (C)	• Lack of preparation for the important database of TISTR Governance process and communication of information is inadequate	Causing damage to the image and credibility, including being prosecuted with civil, criminal, and administrative penalties	• Conducting surveys and preparing important databases of TISTR • Carry out communications regarding data governance
R-06: The disbursement of the capital budget may not be in accordance with the disbursement plan (O)	• Lack of readiness for the procurement process (document/ location) • Implementation of the contract management system has not been used sufficiently • Communication on preparation of receipt and disbursement documents is insufficient	Delays in the procurement process that affect the disbursement of the investment budget	• Increase readiness in the procurement process. (document/ location) • Implement a contract management system to record contract data, reduce defects, and check return of contract collateral • Communicate with vendors/contractors about preparing documents for receipt and disbursement
R-07: Existing digital systems may not be sufficient to support the organisation/ operation in the digital era (O)	• Digital systems for external services are not enough. • Digital systems for internal use are not enough	Failure to support operations in the digital age and unable to meet the needs, expectations of customers and stakeholders	• Develop a digital system for use with external services • Develop a digital system for internal use
R-08: Personnel competency development may not be sufficient to drive important missions (O))	• Personnel lack of digital literacy • Personnel do not have marketing skills. Not enough high- performing personnel in the organisation	Lack of personnel with sufficient competence to drive important missions of the organisation	• Develop digital literacy • Develop marketing skills Increase high performance personnel

Risk Factor	Cause of Risk	Effect	Management Approach
R-09: Allocated state budget money may continue to decrease (F)	• Budget allocation policy emphasizes self-reliance • TISTR Act has restrictions on the scope of earning and receiving income • TISTR's income earning plan is not comprehensive enough	Lack of liquidity management that affects the sustainability of the organisation	• Revise the TISTR Act to be able to expand the scope of earning and receiving income, including expanding the roles and responsibilities of TISTR operations to be a full-scale research-based business platform • Develop an action plan to earn income for TISTR
R-10: Increasing organic/safe farmland is not as expected (S)	• Poor tracking of progress through key indicators • The COVID-19 situation has caused limitations in operations	Unable to increase organic/ safe farmland as expected	Implement quarterly progress tracking through key indicators
R-11: There is a large amount of information in TISTR, making it difficult to link and manage data (O)	• Lack of database updates • Lack of development and improvement of systems for linking data	Unable to link and manage data systematically, resulting in inability to utilise existing data	Update the database, test/ update the system, and prepare to link with external agencies
R-12: Personnel are at risk of being infected with COVID-19, resulting in them not working to their full potential (O)	• The monitoring of epidemic control measures is insufficient • Personnel have insufficient protection for themselves and their families	The ability to operate continuously, quickly and respond to customer and stakeholder needs is decreased	Follow up on epidemic control measures

*** Note:**

S = (Strategic Risk)

O = (Operational Risk)

F = (Financial Risk)

C = (Compliance Risk)

Business Condition, Business Plan and Strategies

For more than 55 years, TISTR still operates according to its vision, “to be a research and development organisation in science, technology and innovation for sustainable changes in the economy, society and the environment.” This operation is based on the availability of science, technology and innovation infrastructure, as well as the cooperation of more than 300 qualified professionals in research, development, technology transfer and service to the industry, including comprehensive training in various industries responding to both economic and social sectors. TSTR focuses on driving the economy according to the BCG model in the group of microorganisms and herbs, concerning safe agriculture, food, extracts, and the environment. It also aims to create businesses for SMEs and the grassroots economy. TISTR places emphasis on operational guidelines according to the four principles, consisting of 1) Bio-Based Operations, 2) Appropriate Technology Operations, 3) Total Solution Operations, and 4) Area based Operations. TISTR has set target groups and customers into three groups as follows: 1) Government organisations, namely, central government agencies/regional/local/state enterprises/organisations public sector, 2) private sector, i.e., large enterprises, small and medium enterprises (SMEs), and 3) social/individual sectors, i.e., people include community enterprises, farmers, and the general public. TSTR promotes integrated work through customer and market plans linked to the national strategy that adapts to situations and major global trends by applying science and technology to develop innovative products, technologies, and sustainable service with two operational strategies as follows:

Strategy 1: Promoting research and innovation utilisation for economic and social benefits. TISTR serves as an agency to support targeted industry development (S-Curve) and enhance business competitiveness for new entrepreneurs and SMEs by focusing on results in new services as well as intellectual property that has been applied for commercial purposes. Operations under this strategy integrate development from a variety of biological and cultural resources by using knowledge of science, technology, and innovation for value creation which leads to the creation of careers and sustainability for the community. TISTR is also involved in the creation of new products and the development of existing local products from technologies that TISTR has expertise in such as cosmetics, food, beverages, agriculture, rubber, and packaging.

Strategy 2: Customer Relationship Building and Sales Promotion. This year, TISTR has increased the efficiency of customer service in three areas: accessibility, responsiveness, and quality of service, which are important factors in building a good relationship with customers through a better services system by creating an “online customer service system under the project of JUMP (Joint Unit Multi-Task Platform)”. This system uses customer databases to make predictions and work proactively to increase efficiency and create value of services, such as improve services, increase or decrease products, product offering, promotional items that affect specific target groups with better directions. As for the concept of product offering, TISTR focuses on facilitating customers and allowing them to use a comprehensive range of services to create quality and competitive products. This is done by organising a promotional package, for example, providing product manufacturing services together with analysing and testing to verify product safety at the same time, which will make the cost cheaper than using individual services. Moreover, TISTR has worked according to research, development, and industrial services to further develop industries driven by technology and innovation in 5 groups and will continue to do so in the future. Such actions are important and challenging to drive the country’s economic system. The five sectors mentioned are: 1) Food, Agriculture and Biotechnology, 2) Health and Medical Technology, 3) Intelligent Devices and Robotics, 4) Digital Technology, 5) High value Creative Industries and Services. This is to keep pace with the changes of the world into the era of digital transformations. In every work according to TISTR’s main mission, digital technology is used to reduce time, labour, expenses, and travel constraints. It also helps to facilitate entrepreneurs to be able to use services from researchers and access to knowledge and infrastructure of TISTR quickly and easily. In addition, in the post-COVID-19 economy, industries are implementing digital technology and innovation to enhance their services and productivity with higher value and complexity. Appropriate and up-to-date logic and innovation are therefore essential to cope with disruptive changes in technology.

Research Highlight

TISTR brings expert knowledge and science, technology, and innovation to drive the BCG economic policy and meet the needs of the country and the people sustainably in order to raise the economy, increase the gross national product, distribute income to the community, and build a strong and environmentally friendly community. TISTR pushes forward the three main economic drives as follows: Bio Economy, a bio-economy system that focuses on cost-effective use of biological resources in conjunction with Circular Economy, and Green Economy, to solve and reduce environmental impact.

"TERRY", A COSMETIC PRODUCT BASED ON TORCH GINGER (*ETLINGERA ELATIOR*) EXTRACT

TISTR by Expert Centre of Innovative Herbal Products (InnoHerb) developed and transferred TERRY production technology to TERRY PERFECT CO., LTD. TERRY is a cosmetic product based on Torch Ginger *(Etlingera elatior)* extract. It is effective in reducing wrinkles, stimulating collagen, reducing redness, inflammation, irritation on the skin. It is also reducing hyperpigmentation caused by acne and inhibiting *P. acnes*, *S. epidermidis* and *S. aureus* that are the main causes of acne. Besides, it inhibits tyrosinase and skin pigment synthesis, brightens skin, antioxidants, smoothes skin and tightens pores. It is a herbal product that is effective, safe and meets international standards. It is a combination of Thai wisdom and science and technology which is unique and has a selling point for the natural cosmetics business.

SERUM FROM RED WATER LILY (*NYMPHAEA RUBRA*) EXTRACT, INTEGRATED RESEARCH BY TISTR IN COLLABORATION WITH UDON THANI RAJABHAT UNIVERSITY (UDRU)

TISTR cooperates with Udon Thani Rajabhat University in cosmetic research and development to add value to cosmetic products using "Red Water Lily'' as the main raw material. Red Water Lily is an identity plant in Kumphawapi district, Udon Thani province, which has been developed into an innovative serum from Red Water Lily extract. The serum has outstanding performance in facial skin, inhibits melanin production, reduces inflammation and acne. In research and development of such products, TISTR and UDRU have worked together to complete the value chain in order to bring research into commercial production and help stimulate the economy as well as to promote community enterprises of the Port Chalae Group that has more than 22,500 rai of Red Water Lily planting areas.

"PROSKIN SERIES", COSMETICS FROM PROBIOTIC EXTRACTS

From the integration of internal centres, namely Expert Centre of Innovative Herbal Products (InnoHerb), Biodiversity Research Centre (BRC) and Innovative Centre for Production of Industrially used microorganisms (ICPIM), TISTR has successfully developed "ProSkin Series", which are cosmetics made from extracts of probiotic, contains active ingredients from fermented probiotic in food that have prebiotic properties. The obtained extracts can strengthen and moisturise the skin, reduce dullness, protect the skin from germs and pollution. Performance testing of the product found that it is safe and does not cause irritation. When tested in volunteers for 25 days, 90% of volunteers have over 50%

lower rate of transepidermal water loss (TEWL), than placebo group. Thereby, TISTR is ready to transfer "ProSkin Series" production technology to commercialisation for consumers to use quality products that are suitable for Thai people.

"PROHERB PRODUCTS" WON FIRST PRIZE IN THE CATEGORY OF SMEs FOR HEALTHY FOOD PRODUCTS FROM THE 3RD FI ASIA STARTUP PRODUCT COMPETITION

TISTR by Expert Centre of Innovative Herbal Products (InnoHerb) jointly researched with RESEARCH EXPLORE CO., LTD., successfully developed Functional Food "ProHerb" in the form of freeze-dried tea powder for brewing in cold water. ProHerb contains two active natural active ingredients, probiotics, and herbal extracts, which are effective in reducing the risk of non-communicable diseases (NCDs), especially in the control of diabetes and hypertension from dyslipidemia. From the strengths of the product, it won the first prize in the category of SMEs for Healthy Food products in the 3rd Fi Asia Start-up Product Competition for food and beverage innovation projects. Pro-Herb products have successfully researched and developed and have already filed patents and petty patents for formulas and production processes for two products: 1) ProHerb-G which is in the form of a tea for brewing in cold water; and 2) ProHerb-L in ready-to-eat powder form.

HIRCUS, PERFUME INNOVATION FROM "GOAT HAIR", SUCCEEDED FOR THE FIRST TIME IN THAILAND AND ASIA

TISTR by Expert Centre of Innovative Herbal Products (InnoHerb) has successfully developed perfumes from innovative goat hair extraction for the first time in Thailand and Asia. The extraction and study of male pheromone from waste goat hair and its use in the perfumery and cosmetic industries to create value-added products from goats. The goat hair extraction was successfully developed into perfumes that have a unique scent, distinctive and difficult to imitate. It is mainly extracted from Boer goat hair due to its strong aroma and long lasting. The perfume has already been tested. It is ready to be used as a component of cosmetics and fragrance-related products, or in aromatherapy and high-value products for niche markets. It is currently being developed into seven scents for women, three for men, and it is being developed for coffee, smoke, and PF-1 (agarwood) scents, which are popular among people in the Middle East. TISTR is ready to provide technology transfer or be a consultant to create personalised perfumes. This innovation is the result of TISTR's fieldwork at Krabi province in using science, technology, and innovation for community development according to the area-based policy of TISTR.

"HERBAL RICE WITH CORDYCEPS ESSENTIAL SUBSTANCES", ANTIOXIDANTS AND BUILD IMMUNITY

TISTR by Industrial Metrology and Testing Service Centre (MTC) together with farmers in Phitsanulok province have developed rice that contains the important substance of cordyceps in order to add value to rice to become an innovative agricultural product. TISTR has tested the substance content and has registered a petty patent in the field of rice cultivation to contain the essential substances of cordyceps and rice products. It is now available in the market under the name Cordy Power Rice. TISTR has also conducted an analysis to test the amount of important substances which are

cordycepin and adenosine that efficiently increase blood flow and help with irregular heartbeat, strengthen the body's immunity and protect against current pathogens. Besides, other important substances were also tested including gamma oryzanol, an antioxidant that stimulates the release of endorphins to relieve stress. In addition, TISTR has helped develop products to be certified by the FDA and supporting health claims on the label so that the products can be extended and added value to be healthy herbal drink products which can help create jobs, generate incomes for farmers and strengthen the country's economy.

TISTR RECEIVED A SYSTEM CERTIFICATE AS THE ONE AND ONLY THAI TOURISM STANDARD ACCREDITATION BODY IN THAILAND

TISTR by Office of Certification Body (OCB) received a certificate of TIS 17065-2565 (ISO/IEC 17065-2012) for inspection and certification - requirements for certification bodies for products, processes and services: Thai Tourism Standards Certification Body. This certification is a collaboration of government agencies, namely the Thai Industrial Standards Institute (TISI) and the Department of Tourism (DOT) which TISTR is an agency that has been accepted by TISI and DOT to be the one and only tourism accreditation agency in Thailand. The scope of accreditation includes the Thai Tourism Standard, Ecotourism Tourism Standard, Natural Hot Springs Health Tourism Quality Standard, Natural Tourism Quality Standard, Historical Tourist Attractions Quality Standard, Quality Standards for Cultural Attractions and Quality Standards for Recreational Attractions. This accreditation aims to raise the quality of Thailand's tourist attractions to a standard, reassure both Thai and foreign tourists, enhance Thailand's tourism image and help support the Thai tourism industry which is a very important business to generate income for the country.

"ICPIM 2" BIO-BASED ECONOMIC DEVELOPMENT

The Innovative Centre for Production of Industrially used microorganisms (ICPIM 2) under the Expert Centre of Innovative Agricultural (InnoAg) has bio-product production lines covering both fungal and bacterial production. ICPIM 2 plays an important role in creating careers in the agricultural sector. ICPIM 2 has a comprehensive operation to support the complete range of biological products. It is a result of the integration of several parts of TISTR. For example, TISTR Culture Collection that has more than 11,000 strains of microorganisms for research and development of new strains and provide microbial strains storage services for entrepreneurs, and Expert Centre of Innovative Herbal Products (InnoHerb) that has a laboratory accredited according to OECD GLP Guideline for microbial toxicity analysis services. Therefore, ICPIM 2 brought more than 1.3 million liters of biochemicals produced to support the local organisation "Plant Protection Group, Office of Provincial Agriculture" in pest control, substitute for agricultural chemicals. This is to reduce pesticide residues, increase safety, improve the quality of life for farmers, users, consumers and the environment, and reduce the importation of chemicals from abroad.

PACKAGING INNOVATION, "OZONE" SCENT LOCK BOX, EMERALD CUT MODEL

TISTR by Thai Packaging Centre (TPC) succeeded in developing packaging innovations, "OZONE" scent lock box - Emerald Cut model, which meets the needs of entrepreneurs. It has the same standards as imported packaging and has a unique feature of 100% odor locking. It can prevent the odor of strong-smelling foods such as processed seafood, dried squid, and salted mackerel. It can prevent the ingress of gas and steam, anti-spill, and has anti-fog properties. It has a clamshell structure which is strong and reduces production costs. It can help entrepreneurs increase distribution channels, especially online channels.

Highlight Activities

OPENING CEREMONY OF THE NATIONAL SCIENCE AND TECHNOLOGY FAIR 2021

The Ministry of Higher Education, Science, Research and Innovation (MHESI) organised a hybrid exhibition under the concept of "Art – Science – Innovation and Creative Economy" during 9-19 November 2021 at Impact Arena, Muang Thong Thani, Nonthaburi. On this occasion, General Prayut Chan-o-cha, Prime Minister, presided over the opening ceremony of the 2021 National Science and Technology Fair and presented the Prime Minister's Science Award 2021. TISTR itself has exhibited its research and development work at this event under the "TISTR in Wonderland" activity at Hall 9, through an online exhibition. www.tistr-science2021.com under the concept "TISTR develops grassroots economy by using biocontrol agents and ornamental plants"

TISTR LAUNCHED NEW INNOVATIVE PACKAGING IN "OZONE SERIES ODOUR LOCK BOX"

On December 26, 2021 at Challenger Hall 1-3, Impact Muang Thong Thani, Nonthaburi, TISTR by Thai Packaging Centre (TPC) launched the second generation in "OZONE series odour lock box". The 2nd generation "OZONE" odour lock box is 100% effective in keeping unwanted odours to the outside, which perfectly meets the needs of consumers/entrepreneurs and can also reduce production costs. The box covers most foods with strong odours. It is stronger and wider so it can contain more goods. Besides, the design is environmentally friendly and can be stacked more conveniently.

TISTR WELCOMED MHESI MINISTER TO VISIT THE EXHIBITION AND PRODUCT FAIR OF OTOP ENTREPRENEURS

On December 26, 2021, at Challenger Hall 1-3, Impact Muang Thong Thani, Nonthaburi, Prof. (Special) Dr. Anek Laothammathat, Minister of Higher Education, Science, Research, and Innovation (MHESI) visited OTOP exhibitions and product fair. Thailand Institute of Scientific and Technological Research (TISTR) under MHESI and its allies have brought science, technology and innovation (STI) to develop the potential to increase competitive opportunities for OTOP entrepreneurs. The entrepreneurs have brought their products to be exhibited and sold at the OTOP Thailand event to fight the threat of COVID-19 which the Community Development Department under the Ministry of Interior organised to promote the economy of the grassroots community to be strong and sustainable. On this occasion, Dr. Wiparat De-ong, Director of the National Research Council of Thailand (NRCT) and Executive Director of TISTR, along with Prof. (Research) Dr. Chutima Eamchochawalit, Governor of TISTR, including executives, employees, and entrepreneurs jointly welcomed the Minister.

OPENING CEREMONY OF “BCG AGRICULTURAL WAY OF LIFE DRIVES THE SUFFICIENCY ECONOMY “

On December 28, 2021, at TISTR Technopolis, Khlong Ha, Khlong Luang, Pathum Thani, H.E. General Kampanat Ruddit, a Privy Councilor and a Committee Chairman of the Royal Project Foundation, presided over the opening ceremony of “BCG agricultural way of life drives the sufficiency economy” and chaired a meeting to discuss academic support cooperation between the Royal Project Foundation and TISTR during the year 2023-2027 along with a visit to the industrial biological production process under the principles of safe agriculture. This event was organised by Thailand Institute of Scientific and Technological Research (TISTR) to showcase research and development achievements that meet the needs of the country’s agricultural sector through the project that enhance the economy in the Central Western Economic Corridor with the BCG model according to the government policy under the project Loan Act. Furthermore, this event also aimed to strengthen the grassroots economy of the flower and ornamental plant community with agricultural innovation using the Malai Wittayasatarn approach which was supported by research grants from the National Research Council of Thailand (NRCT).

TISTR SIGNED A COOPERATION AGREEMENT WITH THE NAKHON PHANOM PROVINCIAL ADMINISTRATIVE ORGANISATION TO SOLVE WATER HYACINTH PROBLEMS AND CREATE SUSTAINABLE CAREERS

On March 1, 2022, at TISTR Technopolis, Khlong 5, Pathum Thani, Prof. (Research) Dr. Chutima Eamchotchawalit, Governor of TISTR, and Ms. Suppanee Phosu, Chief Executive of Nakhon Phanom Provincial Administrative Organisation, has signed a cooperation in the project to bring research and development in science, technology, and innovation to solve water hyacinth problems and create jobs for people in Nakhon Phanom province. This project covers an area of 855 rai where water hyacinth removal in the watershed caused problems, resulting in shallow water channels, and causing flooding problems that affect water transportation and aquaculture.

TISTR PRESENTED FRESH LINGZHI MUSHROOM SLICER TO THE CHAIPATTANA FOUNDATION

On February 25, 2022, at the Chaipattana Foundation, Bang Phlat, Bangkok, Prof. (Research) Dr. Chutima Eamchochawalit, TISTR's Governor, presented fresh Lingzhi mushroom sliders, which was the result of research funding support from Office of the National Research Council of Thailand (NRCT), for Dr. Sumet Tantivejkul, Director and Secretary General of the Chaipattana Foundation, to help reduce the production process of fresh Lingzhi mushroom. This machine also helps make mushroom slices consistent, clean, safe, and up to standard.

TISTR JOINED THE LAUNCH OF COSMETIC PRODUCTS “TERRY TIME TO SHINE SERUM IN CREAM” FROM TORCH GINGER (*ETLINGERA ELATIOR*) EXTRACT

On February 19, 2022, at the Basilica Building, Phothalai Laser Park, Bang Kapi, Bangkok, Mr. Sayan Tanpanich, Deputy Governor R&D Groups of Bio-industry of TISTR, presided over the product launch event “TERRY TIME TO SHINE SERUM IN CREAM”. This event was the result of the successful production technology transferred of TISTR by the Expert Centre of Innovative Herbal Products (InnoHerb). InnoHerb has transferred production technology of herbal cosmetics from Torch Ginger *(Etlingera elatior)*, with executive rights, to TERRY Perfect Company Limited. In this occasion, Mrs. Sirinan Tubtimthet, Director of InnoHerb, and Dr. Rotjana Tangkulboriboon, Director of InnoAg, and Ms. Ubon Rerk-am, senior researcher of InnoHerb, joined the product launch event.

TISTR JOINED THE EVENT “RUAM JAI PHAK RAK LANG NAM 2022” IN NAKHON PHANOM

On 10 March 2022, at iHotel, Nakhon Phanom, H.E. Admiral Pongthep Nhuthep, a Privy Councillor and a Committee Chairman of Rajaprajanugroh Foundation Under Royal Patronage, presided over the opening ceremony of Ruam Jai Phak Rak Lang Nam 2022 and the symposium on sustainable weed control in water resources of Thailand. This event was organised by the Nakhon Phanom Provincial Administrative Organisation to bring the royal initiative of His Majesty King Bhumibol Adulyadej, the Great Borommanathbophit, King Rama IX, on the management of public water sources to solve water hyacinth and weed problems in natural water sources in Nakhon Phanom. On this occasion, Prof. (Research) Dr. Chutima Eamchochawalit, TISTR’s Governor, together with the executives and researchers, attended the ceremony as an honour partner agency. TISTR itself has brought research, science, technology and innovation projects to solve water hyacinth problems and help create jobs for people in Nakhon Phanom, covering an area of 855 rai, with the intention to become “Nakhon Phanom Model”. These projects are ready to extend the results to every provincial administrative organisation to become a centre for sustainable water hyacinth and weed control in order to create jobs and generate income for the nation in a stable, prosperous and sustainable way.

TISTR GAVE DONATIONS TO CONTRIBUTE TO THE DEVELOPMENT OF MATERNITY AND OPERATING ROOMS AT KHLONG LUANG HOSPITAL ON TISTR'S 59TH ANNIVERSARY

On June 1, 2022, Prof. (Research) Dr. Chutima Eamchochawalit, TISTR's Governor, together with the executives donated 229,599 Baht for the development of maternity and operating rooms in the 10-Storey building of Khlong Luang Hospital on the 59th anniversary of TISTR. In this event, Chonnisa Rungrueang, M.D., a Director of Klongluang Hospital was honoured to be the representative to receive the donation at the Admin Building, TISTR Technopolis, Khlong Ha, Khlong Luang, Pathum Thani.

TISTR JOINED HANDS WITH NIA AND 15 ALLIANCES TO DRIVE THE "TIGER WARRIOR" PROJECT

On Friday, May 27, 2022, at NIA, Prof. (Research) Dr. Chutima Eamchochawalit, TISTR's Governor and Dr. Pun-Arj Chairatana, Executive Director of the National Innovation Agency (Public Organisation), together with 15 alliances, government and private sectors, signed cooperation agreements for "non-financial support mechanism in innovation" or "Tiger Warrior" to enhance the competence of Thai entrepreneurs to be ready to compete and stimulate the development of innovative business effectively.

TISTR JOINED HANDS WITH NRCT AND 38 RAJABHAT UNIVERSITIES TO PRESENT/ DISSEMINATE RESEARCH PLANS TO ENHANCE CREATIVE COMMUNITY-BASED TOURISM CAPACITIES FOR AREA DEVELOPMENT BASED ON LOCAL IDENTITIES

On July 12, 2022 at Centra by Centara Government Complex Hotel & Convention Center Chaeng Watthana, Bangkok, Dr. Danuch Tanterdtid, a Vice Minister of the Ministry of Higher Education, Science, Research and Innovation presided over the opening ceremony "Presentations, dissemination of research results and plans to enhance the potential of creative community-based tourism to develop areas based on local identity". The event was organised by the National Research Council of Thailand (NRCT) in collaboration with a network of 38 Rajabhat universities and the Thailand Institute of Scientific and Technological Research (TISTR) to present research funded results in promoting tourism by using local communities as tools to raise product and tourism standards, as well as to added economic value by developing the identity of each area. At the opening ceremony, Dr. Wiparat De-ong, a Executive Director of NRCT, delivered a report on the objectives of the event, and Dr. Apakorn Supanya, a Deputy Governor Strategies and Innovation of TISTR honoured the opening ceremony and participated in the seminar on "Guidelines for Utilising Research Results".

TISTR EXHIBITED COMPREHENSIVE BIO-PRODUCT SERVICES AT THAILAND RESEARCH EXPO 2022

TISTR has brought research results on “TISTR biochemicals enhance agricultural productivity and area-based development with STI” to participate in the Thailand Research Expo 2022, which the National Research Council of Thailand (NRCT) together with alliances held between 1-5 August 2022 at the Centara Grand Hotel and Bangkok Convention Center, Central World, Bangkok. In this event, TISTR has participated in both on-site and online exhibitions.

TISTR PARTICIPATED IN THE EXHIBITION “MIRACULOUS WORLD OF MICROORGANISMS” AT THE SCIENCE FAIR 2022

TISTR participated in the exhibition of the Science Fair 2022 to promote knowledge and understanding of science and technology among Thai youth. In this event, TISTR has exhibited research results/services from the use of microorganisms which help create business opportunities for domestic entrepreneurs of all levels. It can also help drive the grassroots economy in agriculture, food, health food, medicine, energy, and the environment. The event was held between 13-21 August 2022 at Building 9-10, IMPACT Exhibition and Convention Center, Muang Thong Thani, Nonthaburi.

TISTR ATTENDED THE PRESS CONFERENCE OF FI ASIA 2022 /VITAFOODS ASIA 2022

On August 17, 2022 at The Landmark Hotel, Bangkok, Prof. (Research) Dr. Chutima Eamchochawalit, TISTR's Governor attended the press conference of Food Ingredients Asia 2022 (Fi Asia 2022) and Vitafoods Asia 2022. In this event, Dr. Apakorn Supanya, a Deputy Governor of Strategies and Innovation of TISTR participated in a discussion on industrial development in food ingredients, beverages, and nutrients in Thailand.

Achievement Awards

On 31 January 2022, TISTR received Outstanding State Enterprise 2021 Award on strategic cooperations for outstanding development, at Santi Maitri Building, the Government House. It was a success of the integrated cooperation among TISTR, Bank for Agriculture and Agricultural Cooperatives (BAAC) and Export-Import Bank of Thailand (EXIM Bank), under the project to support small and medium enterprises (SMEs) and enhance entrepreneurs capabilities.

On 14 June 2022, TISTR received a plaque of honor "MHESI Helps the Nation through COVID-19 Crisis", at Bangkok Marriott Marquis Queen's Park Hotel, Bangkok.

On 5 August 2022, TISTR received Thailand Research Expo Award 2022 for the presentation of TISTR Biocontrol agents for agricultural yield improvement and area-based development by STI at Centara Grand and Bangkok Convention Centre at Central World, Bangkok.

On 12 September 2022, TISTR by Material Properties Analysis and Development Centre (MPAD) received Public Sector Excellence Award 2022 (PSEA 2022) in category of Good service level from government sector – service development, for Biodegradation Testing Laboratory (BioD)'s performance according to international standards, granted by the Office of the Public Sector Development Commission (OPDC), via virtual conference.

On 19 September 2022, TISTR received the Human Rights Award 2022 : Outstanding Organisational Model, at Miracle Grand Convention Hotel, Bangkok.

On 30 September 2022, TISTR received the Best Business Service Provider Award : the Best Practice of Networking both Domestic and International Network, under the project to promote the entrepreneurs, via BDS system 2022.

TISTR received a system certificate as the one and only tourism certification body in Thailand, granted by Thai Industrial Standards Institute (TISI), at TISI, Bangkok.

TISTR received Aviation Space and Defence Certification (AS9100), at TISTR Technopolis, Pathum Thani.

TISTR by Innovative Centre for Production of Industrially used microorganisms (ICPIM), and Biodiversity Research Centre (BRC), was certified for Good Hygiene Practices (GHPs) in workplaces, and Hazard Analysis Critical Control Point (HACCP) in food productions, granted by Management System Certification Institute (Thailand), Foundation for Industrial Development, which was effective from 26 August 2022 to 25 August 2025.

Important projects

Provincial grassroots economy upgrading projects with science, technology and innovation

TISTR has implemented a project to upgrade the grassroots economy at the provincial level with science, technology, and innovation to restore the economy and society affected by the outbreak of COVID-19. Based on the principle of “do less, get more”, this project brings science, technology, and ready-to-use innovations to develop the value chain and elevate the country to a high-income country. The project was implemented by developing and promoting start-up and community enterprises to be able to create community innovation products, as well as provide knowledge so that these groups can add value and raise product quality according to standards. It also builds customer confidence in buying the products which resulted in generating more income for farmers and entrepreneurs at the regional and local levels. The goal of this project was to add value to agricultural products such as rice, bananas, vegetables, fruits, and herbs along the value chain. This is done by producing off-season crops and enhancing product quality (increasing size, keeping fresh longer), product nutritional value and processing agricultural products from the developed science, technology, and innovation infrastructure in the region. In addition, technology transfer of essential substances extraction and production standards for cosmetics and medicines were conducted for farmers, community enterprises and local entrepreneurs in order to create high quality and unique products from local raw materials by the wisdom of Thai scientists. This resulted in stimulating domestic consumption of innovative products from local raw materials and bulding a strong and sustainable circular economy. In addition, it can stimulate investment of farmers who have received technology transfer and when such technology is utilised, it will increase the supply of production factors, both land, labour and related business such as fertiliser and pest control, irrigation, post-harvest, packaging and transportation. As for the processing enterprises, there will be investments in agricultural raw materials, chemicals, equipment, storage, labour employment, the cost of preliminary preparation of raw materials, packaging, as well as branding, marketing and advertising. This project has operating areas in eight provinces, namely Chanthaburi, Chumphon, Pathum Thani, Phang Nga, Phetchabun, Sakon Nakhon, Samut Songkhram and Udon Thani, where more than 2,522 cases have been transferred knowledge of science and technology to increase productivity, reduce costs and create added value for local agricultural products. More than 9 innovative processed products from local raw materials have been created, such as herbal eye mask powder, Chiang Da tea, galingale herbal tea mixed with vitamin C, nourishing cream to reduce dark spots from tamarind extract, scrub from avocado oil and pink salt, and hair serum mixed with avocado oil, etc. All in all, the provision of appropriate technology and knowledge transfer for the community will enable the community to be self-reliant by generating income on their own, resulting in strong and sustainable development of the community.

Municipal Solid Waste Management according to BCG Principles towards Sustainable Development Goals

TISTR by Expert Centre of Innovative Clean Energy and Environment, [INNOEN] has implemented a project to increase the capacity of the APEC economic zone to create a network of science, technology, and innovation for municipal solid waste management by sharing lessons learned and case studies of successful municipal solid waste management. The project started with a webinar to gather experts from APEC economies such as Japan, Sweden, Singapore, Vietnam, Taiwan, and Russia to exchange information and find best practices available in each economic zone. The use of technology for community waste management, especially technology that is in line with the principles of the Bio-Circular-Green economic policy (BCG) to turn waste into value-added raw materials and energy for the sustainable development goals (SDG). TISTR has expertise in community waste management technology and has a learning centre for community waste management technology which is a waste separation building in Tan Diao subdistrict, Kaeng Khoi district, Saraburi province or Tan Diao Model. TISTR therefore has expanded the results of the Tan Diao Model in three other provinces. The municipal solid waste management that TISTR has conveyed was the production and processing process, which was a technology suitable for the community to be able to operate on their own. In addition, TISTR developed an application that connected and enhanced waste management between communities and entrepreneurs. TISTR also developed unique community products that helped increase income for the community, as well as providing opportunities for women to learn. Therefore, it is confident that this project will bring concrete benefits to Thailand and the APEC economic zone, which will lead to sustainable conservation of the global environment.

Development of Ornamental Plant and Flower Clusters for Sustainable Careers and Competitiveness of SMEs in APEC

TISTR by Expert Centre of Innovative Agriculture, [INNOAG] established a collaborative network of research and development of ornamental plants in APEC countries by initiating the project through a webinar and applying lessons learned during an exchange of knowledge between experts from the APEC economic zone. Information from the knowledge exchange has been used in practice to increase the value of ornamental plants in APEC economies, which will be an important mechanism to increase understanding and strengthen the concept of BCG in agricultural operations, including

developing the potential of ornamental plants entrepreneurs in APEC economies from upstream to downstream to achieve sustainability in the business sector. The APEC economic zone has a suitable environment for growing flowers and ornamental plants. There are experts in the development of ornamental plants and there are many entrepreneurs engaged in exporting ornamental plants. TISTR has alliance agencies that can provide consultation and coordination, such as Japan, Malaysia, Indonesia, and can seek additional agencies in other economic areas that may be interested, such as Vietnam, the Philippines, China, and Mexico, etc. However, quantity, quality and variety of ornamental plants are still problems that need to be solved. Thailand therefore has been implementing projects to solve such problems since 2020. The solution has been implemented by bringing together experts from various fields such as smart farming, agricultural products, added value creation, packaging design and innovation, as well as agro-tourism to enhance the capabilities of farmers and local operators. Over the past two years, this project has successfully produced new generations of entrepreneurs in six provinces of Thailand by empowering and building the potential of farmers and entrepreneurs. It also promoted networking and exchanged knowledge among the participating countries, especially project participants who come from fields or businesses related to floriculture. This can be regarded as a preliminary result and beneficial to the further development of ornamental plants and flower clusters in the economy. In addition, TISTR has presented a case of success of the Thai ornamental plant entrepreneur development project in International Workshop on Development of Ornamental Plant and Flower Clusters for Sustainable Careers and Competitiveness of SMEs in APEC, where TISTR has demonstrated the use of knowledge, technology, and innovation to strengthen entrepreneurs of ornamental plants both upstream, midstream and downstream. The project was in line with the concept of Bio-Circular-Green (BCG) for the country's economic sustainability. TISTR representatives also exchanged knowledge on innovation trends, species development, cultivation, trading of ornamental plants and creating value-added products at the workshops.

Capacity building Workshop on Testing Methods for Internet of Things (IoT) Products

TISTR by the Electrical and Electronic Standards Laboratory, Industrial Metrology and Testing Service Centre (MTC), submitted a project proposal through the working group on APEC sub-committee on Standards and Conformance (SCSC) and received approval from the APEC Project Fund (Asia -Pacific Economic Cooperation) to carry out a project to develop the potential of analytical methods for testing IoT products. This project was a capacity building by learning from the expertise of IoT leaders from the economic area to develop collaborative testing lab capabilities through workshops and Round Robin Test activities under the supervision and guidance of experts. Currently, there is a huge increase in demand and usage of IoT products, especially during the COVID-19 pandemic. Internet technology is therefore important and helps drive the country towards the New Normal era. However, there are differences in the internet product testing analysis process, including the variety of standards and limitations of testing capabilities, testing processes and local contexts. Therefore, this project aims to provide testing analysis services and create testing services that are consistent and acceptable according to international standards. All of these will benefit the development of science and technology services in Thailand. It also meets the needs of entrepreneurs and enables collaboration and creation of new analytical services based on international standards to move towards a sustainable future together in the Asia-Pacific region.

SMARTinFOOD: Insect-based Food Sources to Supplement Nutrient Deficiencies in Vulnerable Areas won WAITRO Innovation Award 2021

TISTR, in collaboration with international research agencies partners LEITAT, Spain, FIIRO, Nigeria and CSIR, South Africa, received the WAITRO Innovation Award 2021 from the SMARTinFOOD: Insect-based Food Sources to Supplement Nutrient Deficiencies in Vulnerable Areas Project. This project was a research and development of alternative food innovations in response to the Sustainable Development Goals in Article 2 on Zero Hunger and Greenhouse Gas Emissions, which the Food and Agriculture Organization of the United Nations. (FAO) considers it extremely important. TISTR by Tropical Insect Conservation Centre at Lam Ta Khong Research Station, Nakhon Ratchasima has served in research on the use of insects as food additives in animal feed. This research was done based on the Zero Waste principle by using crickets to remove cassava waste from bioethanol plants. In addition, it was an extension of the knowledge gained from TISTR's original research and development in using crickets as a feed supplement that inhibits pathogenic microorganisms in the gastrointestinal tract. It was to promote the reduction of the use of antibiotics in animals. Spain served to encourage greater consumption of insects in Europe. Nigeria and South Africa were the main beneficiaries due to their poverty and food shortages.

Completed Research and Development Projects

Thailand Institute of Scientific and Technological Research (TISTR) conducts research and development in line with the new economic model "BCG" and the sufficiency economy philosophy, without leaving anyone behind, to step towards sustainable national development. TISTR's activities consist of Bio economy which focuses on the efficient use of resources, Circular economy which focuses on maximising the use of materials, and Green economy which focuses on solving pollution problems. In the fiscal year 2022, there were 68 research and development projects completed under the efforts of all expert centres, Biodiversity Research Centre, Industrial Metrology and Testing Service Centre (MTC), Material Properties Analysis and Development Centre (MPAD), Thai Packaging Centre (TPC), Office of Certification Body (OCB) and Technology and Innovation Management Office (TIO). The details are as follows:

1) Expert Centre of Innovative Agriculture (InnoAg)

InnoAg strives for excellence in community agricultural technology and integration of research and development of technology and innovation according to the country's needs for both social and commercial benefits. It also carries out the transfer of technology and develops the necessary infrastructure to serve the full range of economic and social sectors. In addition, InnoAg specialises in organic agriculture and research to promote the cultivation of medicinal crops, native and new cash crops, mushroom strain improvement, crop inputs, fertiliser technology, biocontrol, microorganisms and bio-products for agriculture, post-harvest technology, plant breeding and tissue culture, plant genetic preservation and plant protection.

In the fiscal year 2022, there were five projects that have been completed as follows:

1.1) Research and development on stingless bee culture in high agroforest areas for functional yield

1.2) Development of planting system to increase the amount of bioactive compounds and selection of suitable centella asiatica varieties by region

1.3) Increase of bioactive compounds in centella asiatica by elicitors

1.4) Innovative use of cold plasma and micro/nano bubbles to maintain the freshness of fruits and vegetables

1.5) Evolutionary learning centre project for plant species utilisation

2) Expert Centre of Innovative Health Food (InnoFood)

InnoFood focuses on research and development to add value to domestic raw materials in the field of functional foods and dietary supplements, as well as to create a comprehensive range of health food innovations and health food products. It also develops infrastructure to help entrepreneurs enhance their products into commercialisation to compete in the global market. InnoFood specialises in functional food and beverage products, dietary supplement, natural food ingredients, and machine design for food production.

In the fiscal year 2022, there were 12 completed projects as follows:

2.1) Partnership program in production of graduates in master's degree and doctoral degree between TISTR and educational institutions (Phase 4)

2.2) Technological development and innovative food products for entrepreneurs

2.3) Research and development of naturally active food ingredient from grains for controlling hyperlipidemia to apply in functional food product for pre-aging and aging society

2.4) Research and development of naturally active food ingredient from vegetable and fruit for controlling hypertension and hyperlipidemia to apply in functional food product for pre-aging and aging population

2.5) Research and development of peptide hydrolysate production technology from rice bran to use in immune boosting functional food product

2.6) Research and development of functional food product from sugar industry byproduct with cholesterol-lowering property

2.7) Research and development of innovative functional product from probiotics to support brain system function for aging population

2.8) Research and development of beta-glucan from microorganisms to use as aquaculture immune booster

2.9) Innovative development of bioactive polysaccharide and glycoside extracts from plants to promote bone mass

2.10) Innovative development of vegetable and fruit extracts for gout patients

2.11) Development of extraction technology of protein isolate from Thailand's bio-based plants

2.12) Research and development of bioactive functional polysaccharides from commercial mushrooms in semi-industrial scale

3) Expert Centre of Innovative Herbal Products (InnoHerb)

InnoHerb focuses on expertise in cosmeceutical and herbal medicine products. It is an integrated centre for research, development, service and creation of innovative, comprehensive herbal health products that are internationally recognised which makes it possible to further research and value adding of products for commercialisation. InnoHerb also has expertise in herbal extraction technology and pharmacological and toxicological studies.

In the fiscal year 2022, there were 14 completed projects as follows:

3.1) Research and development of herbal extract innovation standards with economic potential to upgrade and propel the herbal product industry

3.2) Research and development of nutraceutical products to balance brain function with products from stingless bee

3.3) Research and development of cosmeceutical products to reduce puffiness under the eyes with products from stingless bees

3.4) Research and development of wound healing gel products from stingless bees

3.5) Research and development of innovative pharmaceutical products to nourish eyesight and slow down macular degeneration for the elderly from pigments in medicinal plants

3.6) Research and development of innovative pharmaceutical products from medicinal plant pigments to reduce the risk of osteoporosis for the elderly

3.7) Research and development of efficacy testing and safety of bioactive compounds to enhance immune system in animals

3.8) Research and development of dietary supplements to reduce the risk of cardiovascular disease from hypertension with peptide hydrolysate extract from rice

3.9) Research and development of innovative pharmaceutical products to slow down the deterioration of skin cells for the elderly from pigments in medicinal plants

3.10) Development of molecular biology technology at the cellular level to create a test system for evaluating eye health effects using 3D corneal cell regeneration techniques

3.11) Development of biotechnology to create testing system for evaluating effects to liver by 3-dimensional construction technique of round liver cells

3.12) Development of molecular biology technology at the cell level to create a test system for evaluating the effects on lungs and white blood cells by co-culture techniques

3.13) Development of molecular and cell biotechnology to create testing system for evaluating effects to skin by construction technique of model inflammatory skin tissue with specific cytokines

3.14) Development of biomolecular technology with technique of specific gene transfer to create immunomodulatory activity testing system of probiotics and probiotic products

4) Expert Centre of Innovative Clean Energy and Environment

InnoEn focuses on excellence in renewable energy and environmental management for a sustainable green economy and society of the country. It also focuses on developing infrastructure for the transfer of knowledge, technology and innovation. InnoEn specialises in clean energy from biomass, environmental management, and projects related to energy-related resources, and projects on climate change and biodiversity, and regulations/mechanisms in carbon footprint and water footprint.

In the fiscal year 2022, there were 19 completed projects as follows:

4.1) Production of solid fuel from empty palm bunch by hydrothermal carbonisation process

4.2) Technology demonstration in cost reduction of ethanol production from cassava 5,000 liter per day

4.3) Cellulosic fermentation technology combined with ethanol fermentation from cassava

4.4) Development of high-efficiency algae farming system as a model for commercial algae production

4.5) Development of bio-lubricant production from palm oil

4.6) Development of production process of liquid insulator from palm oil

4.7) Development of methyl ester sulfonate production from palm oil for surfactant use

4.8) Development of bio paraffin production process for use as a phase changer from palm oil

4.9) Development of bio-methanol product quality equivalent to commercial methanol used in biodiesel production industry

4.10) Preliminary economic feasibility assessment of bio-methanol replacement commercial methanol

4.11) Value addition of bio-methanol by metha-forming process to use as bio-gasoline fuel

4.12) Value addition of bio-methanol to bio-LPG for household and industrial heat sectors

4.13) Evaluation of preliminary economic feasibility of bio-methanol usage as bio-gasoline and bio-LPG

4.14) Development of algae factory cultivation system to support carbon dioxide as production factor

4.15) Development of appropriate energy technology for production process of products from fruit and seeds of cashew nut

4.16) Treatment of waste dump site leachate by coagulation combined with Fenton process and sludge utilisation

4.17) Composite materials from plastic waste in waste dump site

4.18) Water clarifier products from palm ash to treat and improve water quality

4.19) Risk evaluation in environment, health and economic appropriateness of anaerobic membrane bioreactor

5) Expert Centre of Innovative Materials (InnoMat)

InnoMat focuses on material innovation research and development, as well as technology and innovation transfer to enhance industrial development and help create sustainable jobs and income for communities. InnoMat specialises in research, development, technology and innovation in healthcare materials, energy and environmental materials, and natural materials which enhances the value and standard of the products.

In the fiscal year 2022, there were two completed projects as follows:

5.1) Development of processing technology for products from rubber trees to increase the potential of farmers and rubber entrepreneurs in the upper northeastern region 1

5.2) Development of riverbank erosion prevention product from oil palm fiber

6) Biodiversity Research Centre (BRC)

BRC is a collection, conservation and research centre for sustainable utilisation of the country's biological resources with the objective of enhancing the country's competitiveness in bioindustry and bioeconomy at the regional and global levels. BRC specialises in the collection, preservation and management of biological resource-based systems, i.e. microorganisms, plants and animals, and research and development of science, technology and innovation of biological substances and biological products.

In the fiscal year 2022, there were 10 projects completed as follows:

6.1) Development of innovative product for oral health of pre-aging and aging population

6.2) Research and development of innovative nutraceutical product from flavonoids in herb to reduce radiation toxic in elderly treated with radiation therapy and diagnostic radiation

6.3) Algae technology for innovative research and development in the bioindustry

6.4) Research and development of naturally active food ingredient for controlling hypertension and hyperlipidemia for pre-aging and aging society

6.5) Research and development of effective probiotic microorganisms for aquaculture

6.6) Research and development of effective mixed microorganisms for piglet breeding

6.7) Research and development of animal feed additives from fermented pig placenta to promote the health of mother sows and newborn piglets

6.8) Research and development of vitamin B complex production from actinobacteria to promote postpartum piglets' health

6.9) Development of Next Generation Sequencing technology to support the registration of probiotics and probiotic products

6.10) Development of ISO 17025 accredited laboratories: Methods for the determination of probiotic microorganisms in functional products

7) Industrial Metrology and Testing Service Centre (MTC)

MTC focuses on enhancing the capabilities of the industry, supporting and strengthening government agencies and the academic sector to obtain internationally accepted analytical, testing and calibration results and be able to compete in the global market according to the policy of the government.

In the fiscal year 2022, there were two completed projects as follows:

7.1) Industrial potential development and food safety innovation

7.2) Upgrading standards for testing and calibration of medical equipment

8) Material Properties Analysis and Development Centre (MPAD)

MPAD provides services and consulting on testing, analysis and inspection of raw materials, parts and products according to international standards and requirements. In addition, it also offers technical consulting for improvement and development of comprehensive materials from upstream to downstream and provides biodegradation testing services both domestically and internationally.

In the fiscal year 2022, there was only one completed projects:

8.1) Mobile biological treatment system to remedy water resource nearby waste dump site

9) Thai Packaging Center (TPC)

TPC is a comprehensive national packaging technology centre that are comparable to international standards. TPC aims to help maintain product quality, reduce product loss from the use of substandard packaging, and develop packaging that enhances product value and increases export efficiency. TPC has expertise in packaging development and packaging testing.

In the fiscal year 2022, there was only one completed projects:

9.1) Intelligent packaging testing and development unit for agricultural products and food industry

10) Office of Certification Body (OCB)

OCB is an agency established under the Institute of Scientific and Technological Research of Thailand (TISTR) as a certifying body for working standards in accordance with international standards, which have been accepted both domestically and internationally. OCB has been certified for ISO/IEC 17021-1 : 2015 from the National Accreditations Council (NAC),Thai Industrial Standards Institute (TISI) and has been certified with ISO / IEC 17021-1: 2015 and ISO / TS 22003: 2013 from the National Bureau of Agricultural Commodity and Food Standards (ACFS). In addition, OCB has been listed as a certification body/inspection body with government agencies from the Food and Drug Administration (FDA), Department of Agriculture and Department of Livestock Development. OCB provides domestic audit and certification services and operates with impartiality, non-discrimination, transparency and fairness.

In the fiscal year 2022, there was only one completed projects:

10.1) Capacity building on product certification and complete range services

11) The Technology and Innovation Management Office (TIO)

TIO is a unit that drives the transfer of technology for both commercial and social utilisation in order to develop innovative businesses, analyse the feasibility and market opportunities of commercial research.

In the fiscal year 2022, there was only one completed projects:

11.1) Identity innovative development to leverage innovative community

Patents and Petty Patents

Note: *Patents and petty patents of TISTR are registered in Thailand. The names in foreign languages are not included when applying for registration. The names of such patents and petty patents therefore contain only specific terms or technical terms that the applicants use in foreign languages.*

1. PATENTS – 10 ITEMS

NO.	TITLE
1.	A prototype of stack cube tank system for carbon dioxide scrubber by algae
2.	The process of separating methane and pure carbon dioxide from biogas production sources with a pressure-alternating adsorption system
3.	Mobile bioremediation kits for heavy metal-contaminated water
4.	Bottle cap design
5.	The process of producing sodium calcium aluminosilicate compound from oyster shells
6.	The production process of anti-epoxidized bacterial bio-plasticizer from rubber seeds
7.	Terracotta tile design
8.	Formula and manufacturing process of natural rubber assembly cushioning
9.	Biomethanol Purity Boost Kit
10.	The process of synthesizing LPG from methanol and biomethanol with thermal chemical processes

2. PETTY PATENTS – 68 ITEMS

NO.	TITLE
1.	Formula and process of producing pellets cover the soil from the ashes that have been burned
2.	Recipe and manufacturing process of gel from burnt ash
3.	Mushroom neck insertion device

NO.	TITLE
4.	Formula and process of producing probiotic-reinforced crispy grains, *Lactobacillus reuteri* TISTR 2736
5.	Leachate treatment process with Fenton process in combination with 2-step coagulation
6.	The process of producing clear water additives from plant ash
7.	The process of manufacturing composite materials from plastic waste in combination with plant fibers
8.	Recipe and manufacturing process of bran protein supplement drinks for ready-to-brew exercisers
9.	Formula and process of producing serum products with extracts, peels and golden banana pulp with anti-inflammatory properties
10.	Formula and manufacturing process of acid reflux relief products from aloe vera
11.	Odor-absorbing cubes from recycled pulp and production process
12.	Functional food ingredients are powdered from a mixture of red okra extract and passion fruit powder
13.	Medical Mask Testing Machine
14.	Recipe and production process of ready-made lemon-flavoured drinks in UHT boxes
15.	The process of producing ready-to-cook lemon juice with water spray retort sterilization
16.	Formula and production process of serum products from red lotus extract
17.	Formulation and production method of planting materials from fired clay filled with earthworm droppings
18.	Formula and manufacturing process of perlite thermal insulation material sheets
19.	Formula and process of producing acne gel from jasmine rice extract
20.	A prototype of carbon dioxide fixation system using vertical coherent algae

NO.	TITLE
21.	Formula and production process of powdered mixed probiotics related to the human intestines
22.	Horizontal dry biogas production reaction tanks
23.	The algae culture prototype in positive pressure condition provides top-lit LED or vertical LED light
24.	Solar-powered food and herbal products drying cabinet in vertical cylinder shape
25.	Formula and production process of probiotic blend powders associated with the human liver
26.	Recipes and procedures for producing beta glucan pellets from *Nostoc muscorum* algae to feed aquatic animals
27.	The extraction process of polysaccharide biologically active substances from aloe vera by enzyme technology
28.	A prototype of pagoda cube tank system for carbon dioxide scrubber by algae
29.	A safety valve reduces gas pressure with folded bracing arms
30.	A prototype of algae culture in a closed system providing LED submersible lighting
31.	Formula and production process of probiotic powders associated with LDL fats
32.	Biocellulose Production Process from *Komagataeibacter nataicola TISTR 975* from old coconut water
33.	Recipe and process of producing healthy cookies containing molasses and dietary fiber
34.	Recipe and process of producing healthy brownies containing molasses and dietary fiber
35.	The process of preparing yeast germs for the production of ethanol from cassava with the Cellulosic Ethanol process
36.	Formula and production process of creams containing algae polysaccharide extract and probiotic microbial by-products

NO.	TITLE
37.	The process of preservation of microbial cells with prebiotic substance isomaltooligosaccharides from cassava
38.	The process of producing isomaltooligosaccharides from tapioca starch
39.	The retention process of riceberry extract with nanotrans ethosome technology
40.	Directional low pressure steam pipe fittings for using in the steaming process of Hang rice
41.	Production process of temperature and time indicators for food packaging
42.	Semi-finished rice porridge recipes with probiotic supplements and production process
43.	Formula and production process of Chan Rong honey jelly products
44.	Propeller fin continuous belt fryer
45.	Functional food containing red okra extract and passion fruit powder and production processes
46.	Culture and extraction of violacein violet from *Chromobacterium amazonense bacteria TISTR 2766*
47.	Recipe and process of producing instant cocoa-flavoured red bean drinking powder containing probiotics
48.	Production method of a freshness indicator for fresh seafood
49.	The process of preparing extract, *Nostoc commune TISTR 8160*, as product ingredients
50.	Formula and production process of wound healing gel products from Chan Rong honey
51.	The production process of functional food components with the property of reducing fat content from potato peel
52.	Utilization of DNA primers to identify the identity of *Bacillus subtilis bacteria*
53.	The process of producing coarse extract from rice fermentation with yeast germs of the genus *Galactomyces*

NO.	TITLE
54.	Production process of protein hydrolysate from yeast residue with protease enzymes from *Rhizopus arrhizus3188*
55.	Asparagus cutting machine with washing system
56.	Formula and process of preparing coarse extract of Thai watermelon peel in solid dispersion form by solvent evaporation technique with nano-sized powder spray dryer
57.	The production process of functional food components with the property of reducing fat content from molasses
58.	The process of producing protein hydrolysate from bioactive shiitake mushrooms with degradation by protease enzymes
59.	The liquor product is distilled three times from squeezed juice and cashew pulp
60.	Formula and production process of pharmaceutical mixed formula increase the absorption of natural lutein as a self-induced emulsion
61.	Coffee bean cleaning and culling machine
62.	High efficiency herbal toothpaste mixer
63.	Formulated cell structure between fiboin from collagen-infused silk for corneal mucosal cells and preparation process
64.	The liver cell culture process under three-dimensional spherical conditions for using in toxicological tests
65.	Recipe and process of producing avocado ice cream supplementing probiotic microorganisms
66.	Finished powder immunostimulating product recipes from polysaccharide extract of 3 mixed mushrooms and production processes
67.	The retention process of flavonoids from tamarind seed shells with nanotechnology
68.	Recipe and process of producing instant soup from mung beans containing lotus seed extract as a component

National and International Publications

1. NATIONAL PUBLICATIONS – 38 ARTICLES

NO.	ARTICLE TITLE	JOURNAL
1.	Development of Grey Oyster Mushroom Production Technology with Selenium Supplemented Rice Straw Cultivation Substrates	Journal of Science and Technology, Ubon Ratchathani University, Vol. 23 No. 3, September - December 2021, p. 1-11
2.	Quantity and Quality Yields of Oyster Mushrooms: *Pleurotus Pulmonarius* TISTR_Ppul-01 and *Pleurotus Ostreatus* TISTR_Post-01 with Waste Coffee Grounds	Khon Kaen Agriculture Journal, Vol. 49 No. 1, November - December 2021, p. 1551-1562
3.	Effect of Selenium Biofortification in Cultivation Material on Selenium Content of White and Grey Oyster Mushroom (*Pleurotus ostreatus* (Jacquin Fries) P. Kummer)	King Mongkut's Agricultural Journal, Vol. 39 No. 4, October - December 2021, p. 282-291
4.	Effects of Gamma Irradiation on the Growth and the Yield of Asiatic Pennywort (*Centella asiatica* L. Urb.) Grown in Ubon Ratchathani Province	Wichcha Journal Nakhon Si Thammarat Rajabhat University, Vol. 40 No. 2, July - December 2021, p. 106-117
5.	Effect of Osmotically Process on Bastard Oleaster (*Elaeagnus latifolia* L.) Fruit Bar	Progress in Applied Science and Technology, Vol. 11 No. 3, September - December 2021, p. 21-26
6.	Effects of BA and NAA on Seed Germination and in vitro Shoot Growth of Phuang Chawa (*Codonopsis javanica* (Blume) Hook.f. & Thomson)	Thai Journal of Science and Technology, Vol. 30 No. 1, January - February 2022, p. 51-62
7.	Effects of BA and NAA on Seed Germination and In vitro Shoot Growth of Phai Bong Yai [*Dendrocalamus brandisii* (Munro) Kurz.]	Thai Science and Technology Journal, Vol. 29 No. 6, November - December 2021, p. 941-949
8.	Effect of Fertilizer Formulas on Growth and Yield of Asiatic Pennywort (*Centella asiatica* (L.) Urb.)	Khon Kaen Agriculture Journal, Vol. 50 No. 1 (Suppl.), 2022, p. 576-581
9.	Anticancer Activity of the Bark Extract of *Phyllanthus emblica* on Cholangiocarcinoma in vitro	Journal of Basic and Applied Pharmacology 1(1) (July – December 2021), pp. 60-71.
10.	Influence of *Trichoderma harzianum* and Germination Test Methods on Germination and Seedling Growth of Indica and Japonica Rice)	Agricultural Science Journal, Vol. 52 No. 3, September - December 2021, p. 325-340
11.	Effects of Seed Priming with Plant Nutrients and Hormones on Germination and Growth of Morning Glory (*Ipomoea aquatica* Forsk.)	Agricultural Science Journal, Vol. 52 No. 3, September - December 2021, p. 250-262
12.	Examination of Host Plants and Quantity of Ectomycorrhiza *(Astraeus odoratus*) Suitable for Promoting Ectomycorrhiza Rooting of Dipterocarpaceae Seedlings under Greenhouse Conditions	King Mongkut's Agricultural Journal, Vol. 40 No. 1, January - April 2022, p. 28-37
13.	Effect of Oxide on Solid Particles Erosion Behavior of Aisi 410 Martensitic Stainless Steel	Suranaree Journal of Science and Technology 29(1) (January - February 2022), pp. 010088(1-6)
14.	Suitability study of indigenous rice varieties for promoting cultivation in Pathum Thani Province	RMUTSB Academic Journal, Vol. 10 No. 1, January - June 2022, p. 89-97

NO.	ARTICLE TITLE	JOURNAL
15.	Effect of Selenium Supplemented Hom Thong Banana Tree Compost on Growth, Yield, and Selenium Content of Lettuce	Wichcha Journal Nakhon Si Thammarat Rajabhat University, Vol. 41 No. 1, January - June 2022, p. 15-24
16.	Effect of BA and NAA on Callus Induction of Star Grass (*Hypoxis aurea* Lour.)	Agriculture and Technology Journal, Vol. 3 No. 1, January - April 2022, p. 1-11
17.	The Physical and Mechanical Properties of Agar and Carrageenan Film Incorporated with Hydrolysate-Konjac Glucomannan	Srinakharinwirot Science Journal, Vol. 38 No. 1, June 2022, p. 70-82
18.	Efficiency of Different Composting Patterns on Organic Fertilizer Quality	Agricultural Science Journal, Vol. 53 No. 1, January – April 2022, p. 19-34
19.	Simple Method to Synthesize g-C3N4 Doped Sn to Reduce Bandgap Energy (Eg)	Suan Sunandha Science and Technology Journal 9(2) (July 2022), pp. 63-70.
20.	Ultrasonic Assisted Extraction Enhanced Total Phenolic and Antioxidant Activities from *Aegle marmelos* (L.) Corr. Extract	Journal of Health Science and Alternative Medicine Special Volume for 2nd International Conference on Integrative Medicine 20-21 July 2022, Chiang Rai, Thailand, pp. 275-278.
21.	Preparation of Slow-Release Fertilizers Containing Nitrogen and Potassium Minerals using Zeolite Adsorbent	Udon Thani Rajabhat University Journal of Sciences and Technology, Vol. 10 No. 2, May - August 2022, p. 163-181
22.	A Novel Exopolysaccharides from Nitrogen Fixing Acetic Acid Bacterium, Nguyenibacter vanlangensis AR-R3	Journal of Applied Research on Science and Technology (JARST), Vol. 21 No. 2, July - December 2022, p. 1-13
23.	Influence of Air and Nitrogen Atmosphere on g-C3N4 Synthesized from Urea	Thai Journal of Nanoscience and Nanotechnology, Vol. 7 No. 1, 2022, p. 1-11
24.	Hydrolysis of Cassava Stillage Residue by Commercial Enzymatic	The 18th KU KPS National Conference, 8-9 December 2021 at the school building, including any faculties of Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom Province, p. 3251-3256

NO.	ARTICLE TITLE	JOURNAL
25.	Result of Cassava Stillage Residue Pretreatment with Steam Explosion	The 18th KU KPS National Conference, 8-9 December 2021 at the school building, including any faculties of Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom Province, p. 3257-3262
26.	Effects of Mulberry Fruit Extract on Cytotoxicity in Bone Cells and Acute Oral Toxicity in Mice	The 11th National Conference in Toxicology (NCT11) “Toxicology and Safety Concern towards Pandemic Era”, 27-28 October 2021, Virtual Conference, Bangkok, Thailand
27.	Development of Beta-glucan From Microorganism as Active Ingredient in Nano-cosmeceutical Products for Skin Radiance and Youthfulness	14th National Research Academic Conference for Support Personnel in Higher Education Institutions “Thongkwaw Academics’ 2022: Promote research, job development, and organizational development” 30-31 March and 1 April 2022 at the Office of Academic Services, Chiang Mai University, Chiang Mai Province, p. 1021-1032
28.	Antioxidant Activities of Extracts from *Cladophora* spp.	14th National Research Academic Conference for Support Personnel in Higher Education Institutions “Thongkwaw Academics’ 2022: Promote research, job development, and organizational development” 30-31 March and 1 April 2022 at the Office of Academic Services, Chiang Mai University, Chiang Mai Province, p. 1088-1097

NO.	ARTICLE TITLE	JOURNAL
29.	Study on Quantity of Vitamin B from Actinobacteria "*Modestobacte caceresii* DMS 101691T"	14th National Research Academic Conference for Support Personnel in Higher Education Institutions "Thongkwaw Academics' 2022: Promote research, job development, and organizational development" 30-31 March and 1 April 2022 at the Office of Academic Services, Chiang Mai University, Chiang Mai Province, p. 1035-1046
30.	Screening and Identification of *Galactomyces* spp. from Fruits Collected in the Northern Part of Thailand	14th National Research Academic Conference for Support Personnel in Higher Education Institutions "Thongkwaw Academics' 2022: Promote research, job development, and organizational development" 30-31 March and 1 April 2022 at the Office of Academic Services, Chiang Mai University, Chiang Mai Province, p. 1047-1058
31.	Anti-adipogenesis Effect of Passion Fruit Extract on 3T3-L1 Adipocytes	Proceedings of the 2nd Oriental Medicine and Sciences Conference 2022, 26 March 2022, Online Conference, p. 75-82
32.	Microencapsulation of Lotus Seed (*Nelumbo nucifera* Gaertn.) Extract Substance: Process Conditions and Antioxidant Activity	Proceedings of MJU Annual Conference 2021, 24-25 December 2021 at the 80-year school building, Mae Jo University, Chiang Mai Province, p. 1207-1216
33.	Car lift for moving motorcycles	13th Engineering, Science, Technology, and Architecture Conference 2022 (ESTACON 13 (2022)) 19 August 2022 at Prabhakorn Convention Hall, North Eastern University, Muang District, Khon Kaen Province

NO.	ARTICLE TITLE	JOURNAL
34.	Improve Efficiency of a Monopole Antenna in Technology Zigbee for Farm Application	13th Engineering, Science, Technology, and Architecture Conference 2022 (ESTACON 13 (2022)) 19 August 2022 at Prabhakorn Convention Hall, North Eastern University, Muang District, Khon Kaen Province
35.	Gain Enhancement of a Planar Dipole Antenna Using Curve EBG Two Parts for DTV System	13th Engineering, Science, Technology, and Architecture Conference 2022 (ESTACON 13 (2022)) 19 August 2022 at Prabhakorn Convention Hall, North Eastern University, Muang District, Khon Kaen Province
36.	Gain Enhancement of a Monopole Antenna in LoRaWAN system for Farm Application	13th Engineering, Science, Technology, and Architecture Conference 2022 (ESTACON 13 (2022)) 19 August 2022 at Prabhakorn Convention Hall, North Eastern University, Muang District, Khon Kaen Province
37.	Bandwidth and Gain Improvement of a Bow-Tie Antenna Using Electromagnetic Band Gap and Increase with the Circular Notch for Radar Application	13th Engineering, Science, Technology, and Architecture Conference 2022 (ESTACON 13 (2022)) 19 August 2022 at Prabhakorn Convention Hall, North Eastern University, Muang District, Khon Kaen Province
38.	Chaotic Signal Application for Automatic Movement	13th Engineering, Science, Technology, and Architecture Conference 2022 (ESTACON 13 (2022)) 19 August 2022 at Prabhakorn Convention Hall, North Eastern University, Muang District, Khon Kaen Province

2. INTERNATIONAL PUBLICATIONS – 67 ARTICLES

NO.	ARTICLE TITLE	JOURNAL
1.	Antioxidant Activities and Prebiotic Properties of the Tropical Mushroom *Macrocybe crassa*	Bioactive Carbohydrates and Dietary Fiber, Vol. 27, May 2022, 100298, p. 1-8 (In progress (May 2022))
2.	The effects of ethanolic extract of Okra fruit, *Abelmoschus Esculentus* (L.) Moench on cellular senescence in aging neuron	Songklanakarin Journal of Science and Technology (SJST), Vol. 43 No. 5, September - October 2021, p. 1367-1373
3.	Lactic Acid Bacteria Bacteriocin, an Antimicrobial Peptide Effective Against Multidrug Resistance: a Comprehensive Review	International Journal of Peptide Research and Therapeutics, Vol. 28 No. 1, January 2022, p. 1-14
4.	The *Fungus Metarhizium* sp. BCC 4849 is an Effective and Safe Mycoinsecticide for the Management of Spider Mites and Other Insect Pests	Insects, Vol. 13 No. 1, January 2022, p. 1-18
5.	Investigations of the Antipyretic Effect and Safety of Prasachandaeng, a Traditional Remedy from Thailand National List of Essential Medicines	Biomedicine & Pharmacotherapy, Vol. 147, March 2022, 112673, p. 1-11
6.	Ecotoxicity Testing of Paraquat Metabolites Degraded by Filamentous Fungi in Model Organism	Science of the Total Environment, Vol. 822, 20 May 2022, 153631, p. 1-7
7.	Upgrading of Palm Empty Fruit Bunch for Solid Biofuel Production Through Hydrothermal Carbonization	Journal of Physics: Conference Series, Vol. 2175, 2022, 012031, p. 1-8
8.	Influence of torrefaction on yields and characteristics of densified solid biofuel	Journal of Physics: Conference Series, Vol. 2175, 2022, 012027, p. 1-8
9.	Variability of Morphological and Agronomical Characteristics of *Centella asiatica* in Thailand	Trends in Sciences, Vol. 18 No. 23, 1 December 2021, p. 1-10
10.	How do King Cobras Move Across a Major Highway? Unintentional Wildlife Crossing Structures May Facilitate Movement	Ecology and Evolution, Vol. 12 No. 3, March 2022, e8691, p. 1-15
11.	Mechanisms of Trichomes and Terpene Compounds in Indigenous and Commercial Thai Rice Varieties against Brown Planthopper	Insects, Vol. 13 No. 5, May 2022, p. 1-16
12.	Plant Host Selection for Spore Production of *Glomas mosseae*	Acta Horticulturae, Vol. 1339, ISHS 2022, DOI: 10.17660/ ActaHortic.2022.1339.61, p. 477-482
13.	Development of Transient Expression System for Gene Functional Analysis in *Setaria viridis*	Acta Horticulturae, Vol. 1339, ISHS 2022, DOI: 10.17660/ ActaHortic.2022.1339.54, p. 429-434
14.	Pollen Germination, Early Pollen Tube Growth and Ovary Development of Endrobium Orchid: Dependence on Auxin and Ethylene	Agriculture and Natural Resources, Vol. 56 No. 2, March - April 2022, p. 399-408
15.	Influence of Varieties and Elicitors on Biomass and Bioactive Compound Yield of Centella Asiatica Growing in Pathum Thani	International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, Vol. 13 No. 4, 2022, p. 1-10
16.	Mycelial Growth-promoting Potential of Extracellular Metabolites of *Paraburkholderia* spp. Isolated from *Rhizopogon roseolus* Sporocarp	Journal of Pure and Applied Microbiology, Vol. 16 No. 2, p. 1154-1166 Article Number: 7386, p. 1154-1166

NO.	ARTICLE TITLE	JOURNAL
17.	A New Species of the ant genus *Lepisiota* Santschi, 1926 (Hymenoptera: Formicidae) from Thailand	Far Eastern Entomologist, Vol. 456, p. 1-8
18.	Hydrogen Production by Steam Reforming of Fuel Oil over Ni-Based Fiber Catalyst	Materials Today: Proceedings, Vol. 57 No. 3, 2022, pp. 1147-1153
19.	Photo-Protective and Anti-Inflammatory Effects of *Antidesma thwaitesianum* Müll. Arg. Fruit Extract against UVB-Induced Keratinocyte Cell Damage	Molecules, Vol. 27 No. 15, 2022, 5034, p. 1-15
20.	Hibiscus Sabdariffa Extract Improves Hepatic Steatosis, Partially Through IRS-1/Akt and Nrf2 Signaling Pathways in Rats Fed a High Fat Diet	Scientific Reports, Vol. 12, 2022, Article number: 7022
21.	Physico-chemical Properties and Digestibility of Native and Citrate Starches Change in Different Ways by Synchrotron Radiation	International Journal of Biological Macromolecules, Vol. 207, 15 May 2022, p. 475-483
22.	Investigation of the Molecular Characterization and Antioxidant Activity of Bio-oil Produced from High Moisture Oil Palm Residues Employing Hydrothermal Liquefaction	Biomass and Bioenergy, Vol. 163, August 2022, 106538, p. 1-11
23.	Progress Towards Wafer-scale Fabrication based on Gel Casting Technique for 1–3 Randomised Piezocomposite μUS Linear Array	Journal of the European Ceramic Society, Vol. 42 No. 13, October 2022, p. 5565-5574

NO.	ARTICLE TITLE	JOURNAL
24.	Fibroblast Growth Factor-23 and Parathyroid Hormone Suppress Small Intestinal Magnesium Absorption	Physiological Reports, Vol. 10 No. 7, April 2022, p. 1-15
25.	Effect of Controlled Atmospheric Conditions Combined with Salt Acid Immersion on Trimmed Young Coconut Qualities during Cold Storage	Food Packaging and Shelf Life, Vol. 32, June 2022, 100857, p. 1-32
26.	Oral Administration of Ethanolic Extract of Shrimp Shells-Loaded Liposome Protects against Aβ-Induced Memory Impairment in Rats	Foods, Vol. 11 No. 17, 1 September 2022, 2670, p. 1-17
27.	Characterization, Genome Analysis and Probiotic Properties of L-Lactic Acid Producing *Enterococcus lactis* FM11-1	Current Applied Science and Technology, Vol. 22 No. 5, September - October 2022, p. 1-15
28.	UV-activated Coating Polymer Particle Containing Quaternary Ammonium for Antimicrobial Fabrics	Colloid and Polymer Science, Vol. 300 No. 4, April 2022, Special Issue in Memory of Prof. Okubo, p. 351-364
29.	Relation of Chemical Treatment Process to The Properties and Morphology of Water Hyacinth Fibers	Proceedings of 21st International Union of Materials Research Societies- International Conference in Asia (IUMRS-ICA 2020), 23-26 February 2021 at Faculty of Science, Chiang Mai University, Chiang Mai, Thailand, p. 162-168 (available on the website on 27 October 2021)

NO.	ARTICLE TITLE	JOURNAL
30.	Restored CO_2 from Flue gas and Utilization by Converting to Methanol by 3 Step Processes: Steam Reforming, Reverse Water Gas Shift, and Hydrogenation	Proceedings of ICCDUR 2022: 16. International Conference on Carbon Dioxide Utilization and Reduction, 3-4 March 2022 in Bangkok, Thailand
31.	Cytotoxic, Nitric Oxide and Phagocytic Activity of Synbiotics using Lactic Acid Bacteria and Isomalto-oligosaccharides	Proceeding of Thai Society for Biotechnology International Conference Online, 29 April 2022 Online Conference, Bangkok, Thailand, p. 273-277
32.	Cytotoxic, Nitric Oxide and Phagocytic Activity of Lactic Acid Bacteria from Swine	Proceeding of the 33rd Annual Meeting of the Thai Society for Biotechnology and International Conference (TSB 2021), 25 November 2021 Virtual Conference, Bangkok, Thailand, p. 354-358
33.	Evaluation of Prebiotic Activity of Isomalto-oligosaccharides Produced from Rice Starch	Proceeding of Thai Society for Biotechnology International Conference Online, 29 April 2022 Online Conference, Bangkok, Thailand, p. 283-287
34.	High-quality Refuse Derived Fuel (HQRDF) from Municipal Solid Waste and Agricultural Waste	Proceeding of the 3rd International Conference on Environment, Livelihood and Services (ICELS 2022), 14-16 March 2022, Bangkok, Thailand (Virtual Conference), p. 263-270
35.	The Isolation and Quantitative Determination of Protocatechuic Acid from *Sechium Edule* (Jacq) Swartz	Proceeding of the 6th TICC International Conference 2022, 5 March 2022, Online Conference, p. 356-363
36.	Evaluation of Rice Bran Protein Extracts on Antioxidants Activity and Streptozotocin-Induced Cytotoxicity	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p.13-16

NO.	ARTICLE TITLE	JOURNAL
37.	Characterizations, Bioactivities, and Safety Studies of Bio Compound Preparation from Goat Hoof	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 17-20
38.	Development and Validation of a HPLC Method for Rosmarinic Acid in Gout Treatment Capsules Containing Mentha Cordifolia Leaf Extract	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March, 2022 via Zoom Webinar, p. 29-31
39.	Effects of Natural Compounds on Psoriasis-Associated Cytokines Induced Keratinocyte (HaCaT) Cells	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 76-78
40.	HPLC Analysis and Antioxidant Activity of Lutein and Zeaxanthin in Various Plants	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 1-4
41.	Anti-genotoxicity Assessment of the Mushroom *Ganoderma lucidum* and *Pleurotus eryngii* Extracts in V79 Cells	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 25-28
42.	Antibacterial Potency of (unripe, half ripe fruit and leave from) *Carissa carandas* Linn. Ethanolic Extracts against Seven Upper Respiratory Pathogens	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 32-34
43.	Construction of Three-Dimensional (3D) Co-culture System for *in vitro* Genotoxicity Tests	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 53-56
44.	Preliminary Study on Anti-zoonotic Dermatophytes Activity of Seven Essential Oils	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 57-59

NO.	ARTICLE TITLE	JOURNAL
45.	The Preparation and Characterization of Ferulic Acid Solid Dispersions Prepared by Spray-drying	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 72-75
46.	Beneficial Effects of Stingless Bee Honey on Stress Management in Mice	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 5-8
47.	Effect of Stingless Bee Honey Wound Gel in Excisional Wound Healing Model in Rats	Proceeding of 37th International Annual Meeting in Pharmaceutical Sciences (IAMPS 37), 24-25 March 2022 via Zoom Webinar, p. 9-12
48.	Preliminary Study on Release Property of Active Ingredient Free Radical Scavenging Activity in Rice berry Rice Extract-Loaded Nanoparticles	Proceedings of International Conference and Exhibition on Pharmaceutical Sciences and Technology 2022 (PST 2022), 23-24 June 2022, Online Conference, p.70-73
NO.	ARTICLE TITLE	JOURNAL
49.	Preparation of Flat Sheet Polysulfone Membrane Coated with PDMS for Carbon Dioxide/Methane Gas Separation at Low Pressure	Proceedings of the 11th RajaMangala University of Technology International Conference, 18-20 May 2022, Royal Cliff Grand Hotel, Pattaya, Thailand
50.	Modified Potassium Carbonate as Catalyst for Palm-based Lubricant Synthesis	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), June 30 - July 1, 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 175-179
51.	Economic study of alternative using biogas for biomethanol substituting commercial methanol in biodiesel production	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), June 30 - July 1, 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 123-127

NO.	ARTICLE TITLE	JOURNAL
52.	Effect of CH_4/CO_2 Ratio to Quantity and Quality of Biomethanol Produced from Biogas	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 138-143
53.	Cassava-based Ethanol Production Using High Gravity (HG) Fermentation Process with in situ Ethanol Recovery (ISER)	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 165-169
54.	Naphtha Upgrading to Gasoline Using Bio-methanol via Methaforming Process over H-Zsm5 Catalyst	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July, 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 149-153
55.	Synthesis of Green-LPG via Green-methanol from Carbon Dioxide Recycling - Closing the Loop of the Anthropogenic Carbon Cycle	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 128-131
56.	Performance of CO_2 Removal from Bioethylene Production Using Alkali Solution: A Pilot Scale Study	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 397-402
57.	Effect of PDMS Coating of Polysulfone Membrane on CO_2/CH_4 Selectivity for Gas Separation	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 530-534

NO.	ARTICLE TITLE	JOURNAL
58.	Chemical Components and Fiber Properties from Different Parts of Oil Palm Fiber	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 678-682
59.	Studies on Carbon Dioxide/Methane Gas Separation Performance at Low Pressure of PDMS-Coated Polysulfone Hollow Fiber Membrane	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 651-620
60.	Fabrication of Fiber Cement Pipe Reinforced with Banana and Water Hyacinth Fiber	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 635-639
61.	The Effectiveness of a Vertical Flow Constructed Wetland with Water Hyacinth Plant as a Household Wastewater Treatment	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 349-353
62.	The Alternative Application of Chemically Modified Palm Oil Methyl Ester as a Natural Insulating Fluid	Proceedings of The Pure and Applied Chemistry International Conference 2022 (PACCON 2022), 30 June - 1 July 2022 at KMITL Convention Hall, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, p. 180-185
63.	Gallic acid, the Isolation and Method Development for the Quantitative Determination from *Phyllanthus emblica* L. Extract	Proceedings of the 2nd International Conference on Science Technology & Innovation-Maejo University (2nd ICSTI-MJU) 2022, 18 March 2022, Chiang Mai, Thailand, p. 1-7

NO.	ARTICLE TITLE	JOURNAL
64.	Value Added Mango Peel Powder as Dietary Fiber in Crispy Mixed-vegetable Sheet	Proceedings of the 47th International Congress on Science, Technology, Technology-Based Innovation (STT 47th), 5-7 October 2021, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand, Virtual Conference, p. 567-573
65.	Enhancing Bioactive Polysaccharides Extraction from Aloe Vera (Aloe barbadensis Miller) by Enzymatic Treatments	Proceeding of the 33rd Annual Meeting of the Thai Society for Biotechnology and International Conference (TSB 2021), 25 November 2021, Virtual Conference, Bangkok, Thailand, p. 100-104
66.	Evaluation of Total Phenolic Content and in vitro Antioxidant Activity of Medicinal Plants	Proceeding of International Conference on Food and Applied Bioscience (FAB 2022), 14-15 February 2022, Information Technology Service Center, Chiang Mai University, Chiang Mai, Thailand, p. 108-116
67.	Effect of Rice Flour and Cassava Flour Blended with Soy Protein Isolate on Low Moisture Extrusion for Development to Textured Vegetable Protein	Proceeding of 15th International & National Conference, 21 March 2022, Graduate School, Suan Sunandha Rajabhat University, p. 293-305

Technology transfer for Commercialisation

TISTR is an innovative organisation that operates to meet the needs of the country under the TISTR 4.0 policy by focusing on R&D in science, technology and innovation (STI) of multidisciplinary subjects. For the fiscal year 2022, TISTR has implemented a total of 115 research and consulting services projects. Examples of projects from four groups can be summarised as follows:

Strategies and Innovation Management Group (SIM)

A project to develop the capabilities of local entrepreneurs based on basic resources to create grassroots and circular economy in Nan province according to the policy of Office of National Higher Education Science Research and Innovation Policy Council (NXPO) and Program Management Unit for Area-based Development (PMU-A)

Thailand Institute of Scientific and Technological Research (TISTR) as the country's research and development agency has an important mission in research and development of science, technology and innovation (STI). Currently, it has entered its 60th year in response to government policies and driving the country's economy by adopting the BCG economic policy as a framework for elevating the entire economy, increasing gross national product, distributing income to communities, creating strong communities, and considering the environment. TISTR develops and drives Thailand with the BCG economic model, consisting of 4 strategic areas: 1) Agriculture and Food, 2) Health and Medicine, 3) Energy, Materials and Biochemicals, and 4) Tourism and Creative Economy. TISTR's performance under the cooperation of Technology and Innovation Management Office (TIO), Innovative Business Services Division (IBS), and Expert Centre of Innovative Herbal Products (InnoHerb) succeeded in the production of the local herbal identity development project and the quality and efficiency of the products have been tested. TISTR has encouraged community enterprises in Nan province to produce herbal extracts for Lion Corporation (Thailand) Limited to be developed into products from Triphala herbs with a market value of 50 million Baht per year. It has also promoted other unique herbs such as *Litsea Glutinosa* leaf and Wampee to develop health products from local resources.

Research and Development Group for Bio-industries (RDB)

A project to study and develop probiotic food supplements that have beneficial properties to reduce fatty liver disease with probiotics and transfer the technology to Innobic (Asia) Co., Ltd., an affiliate of PTT Public Company Limited, to produce probiotic food supplements for the gastrointestinal tract

TISTR aimed to develop technology infrastructure (shared service) through the operation of the Production of Industrial used microorganisms (ICPIM) and the Food Innovation Service Plant (FISP) that have been certified by GMP. By implementing this project, TISTR intended to raise standards, create added value, create opportunities for entrepreneurs to access production and processing technologies, as well as aimed to create new businesses in food and health products from probiotics and prebiotics that are suitable for Thai people. This project was in line with the vision of Innobic (Asia) Co., Ltd., aiming to be a leader in the life science business by using science and technology to enhance the quality of life for Thai people through partnership in an open innovation and speed to market manner. This project focused on four target product groups: 1) medicines for non-communicable diseases such as cancer because there are many patients who need to continue treatment with technology that requires more money; 2) future food and nutrition or food as medicine, which is accessible to everyone, such as food for the elderly with longevity; 3) medical equipment and materials, focusing on disposable types; and 4) diagnosis system, which is the development of technology behind the diagnosis of various diseases. The project was undertaken by the Biodiversity Research Centre (BRC) in conjunction with the Expert Centre of Innovative Health Food (InnoFood), which focused on biodiversity utilisation in accordance with BCG policies.

Research and Development Group for Sustainable Development (RDS)

Development and technology transfer project of gel production from coal ash extract to BLCP Power Limited, a pilot scale: Phase 2, utilisation of the ash sludge extracted from power plant ash

Direction of research, technology and innovation development, including business operations of the 21st century have moved towards sustainable development and sustainable living by focusing on solving the problem of resource shortage, reducing the impact of climate change by reusing resources from used products in production processes or recycling resources to complete product life cycle while minimising waste throughout the process (circular economy). Based on the concept of sustainable development and the circular economy, BLCP Power Plant, therefore, aimed to extract important substances from coal ash obtained from power plants to be processed into value-added products. It was to maximise the use of waste resources, reduce environmental pollution, promote the full life cycle of waste materials, and generate income or business from power plant waste resources. TISTR by Expert Centre of Innovative Materials (InnoMat) has cooperated with the power plant in researching the extraction of important substances from coal ash obtained from the power plant and processing it into various products such as gel. The operation started from analysing and testing at the laboratory level before studying the extraction under various conditions until the optimal extraction conditions

were obtained. After that, gel production was expanded on a pilot scale. The reactor tanks, production batches, and production trials were designed for the production process. The analysis of the properties and consistency of the gel production were also conducted. In addition, the economic feasibility of the extraction and product development process has been studied in order to promote the recycling of waste materials throughout the life cycle and to generate income or generate business practices based on production from sustainable waste resources of the power plant. All of these operations were for the purpose of generating income and creating business practices based on sustainable production from waste resources of the power plant.

Industrial Services Group (IDS)

Engineering consulting project for the prototype development of train weighing equipment for Armtech Engineering Co., Ltd.

Railways play an important role in bearing the train's weight and supporting it along the rails. The load capacity of the rails must meet the standards for the design of the rails and the train. Therefore, allowing trains to run on rails, the load must not exceed the standard limit because it may cause damage to the railway and cause derailment of a train. Keeping track of each train's load can help reduce railways damage and train accidents. TISTR by Railway Transportation System Testing Centre (RTTC) has designed and developed train weighing equipment which can be installed at the foot of the tracks without modifying the existing railway tracks. Armtech Engineering CoLtd.,therefore, has prepared and installed train weighing equipment to collect data and monitor the train at weighbridge. TISTR is equipped with modern analytical testing equipment along with the skills and experience in providing design, testing and analysis services to verify the quality and service life of engineering parts and railway systems for domestic and foreign enterprises for many years.

In addition, TISTR has a network and integrated cooperation with government agencies, state enterprises, as well as the private sectors to support the use of research and development results that meet international standards to enhance entrepreneurs potential and SMEs of Thailand. Entrepreneurs can actually use the research results of TISTR. TISTR has also accelerated the preparation of operational plans and pushed for systematic technology transfer. For this year, there are 11 research projects that have been commercialised as follows:

NO.	PROJECT	TECHNOLOGY TRANSFER RECIPIENT
1.	Technology transfer of rubber coating on fabric gloves	Harvest Hut Company Limited
2.	Technology transfer for producing cosmetic products from Hom Thong banana blossoms	Mind Health Care Company Limited
3.	Technology transfer of the production process of commercial functional beverage products "G-HERB (G-HERB)" for controlling sugar and fat levels	Research X Company Limited
4.	Development and transfer of mixed strains probiotic products for immune stimulation	Kovic Kate International (Thailand) Company Limited
5.	Technology transfer of mushroom substrate filling device	FN Advance Limited Partnership
6.	OEM authorisation of Emerald Cut Smell Lock Box	Safer Pac (Thailand) Company Limited
7.	Technology transfer for ready-to-cook lime juice production	Central Food Intertrade Company Limited
8.	Technology transfer for ready-to-drink lime juice production	
9.	Licensing for the patent on a horizontal dry biogas production reactor	Ubon Bio Power Company Limited
10.	Licensing for the petty patent on odor absorbing solid from recycle pulp and production process under the innovative identity project, project of development of odor absorbing product from aroma galangal residues, innovative plant of Tha Bua, Pichit	Pichit Community College
11	Licensing for bacteria strains to produce a product for decomposing organic matter in aquaculture ponds	Grobest Corporation Limited

Technology Transfer for Social Benefit

In 2022, TISTR conducted technology transfer for social benefit using science, technology and innovation to improve people's quality of life. TISTR has operated through three main projects as follows:

Project of development of identity innovative community under collaborative operations with government agencies and important private sector in the area for the fiscal year 2022

TISTR focused on area-based development to meet the needs of communities and people in various areas, resulting in the creation of the "identity innovative community project". TISTR has brought knowledge in science, technology, and innovation to create a product identity or community innovation to add value to the prototype products. This has been done in collaboration with local government and private sectors in 2022.

TISTR has brought research results from each centre of expertise to develop and drive the potential of community enterprise, entrepreneurs, and farmers in order to elevate the community into an innovative community that can relate to the bio-industry and tourism industry. The results of such operations were efficient utilisation of the unique resources in the area, fair redistribution of income to upstream producers, employment, job creation, and ultimately, it could lead to sustainable conservation of those resources. TISTR has implemented 29 innovative community development projects (29 communities) in 15 provinces as follows:

LIST	IMPLEMENTED PROJECT	INNOVATIVE COMMUNITY	BENEFIT AREA
1	Nan Bamboo juice development project for use as an ingredient in health products	Porpiang Ruamjai Santisuk organic-agro community enterprise, Nan province	Nan province
2	Triphala medicinal product development project in Nan	Ban Kew Muang farmer group, Nan province	Nan province

LIST	IMPLEMENTED PROJECT	INNOVATIVE COMMUNITY	BENEFIT AREA
3	Ginger extract development project for cosmetics	Chewavethee community enterprise,Tambon Namkian, Nan province	Nan province
4	Herbal shampoo development project from community herbs as a cosmetic product	Ban Mae Krabung community enterprise, Kanchanaburi province	Kanchanaburi province
5	Development project of cosmetic products from Lingzhi mushroom (*Ganoderma Casuarinicolaspecies*)	Chaipattana Foundation Farmer Group Network, Chiang Mai province	Chiang Mai province
6	Kura Lanna research and development project for cosmetics production	North Hongya Wiang community enterprise, Nan province	Nan province
7	Development project of Processing Wampee for health food	Nan Rice and Fruit Processing Community Enterprise	Nan province
8	Prototype development project of processed products from cashew nuts	Lanna Cashew Processing Community Enterprise, Phu Phiang District, Nan Province	Nan province
9	Processing project of veggie crisps from *Centella asiatica* leaves	Ban Mom Chaemcommunity enterprise, Nonthaburi province	Nonthaburi province
10	Potential development project on goat milk production of Sripong Farm Farmers Group, Krabi province	Sripong Farm Farmers Group, Krabi province	Krabi province
11	Development project of dehumidifier for agricultural products	Kew Muang farmer group, Santisuk district, Nan province	Nan province
12	Development project of area for collecting and pruning organic fruits and vegetables in Nan Province	Porpiang Ruamjai Santisuk organic-agro community enterprise, Nan province	Nan province

LIST	IMPLEMENTED PROJECT	INNOVATIVE COMMUNITY	BENEFIT AREA
13	Development project of Nam Wa butterfly pea flowers in Nan Province for the production of health products	Tambon Tha Li Shiva-Som community enterprise, Nan province	Nan province
14	Project of safety chrysanthemum, Ubon Ratchathani province	Plaeng Yai flowering plant group, Moo 3, Warin Chamrap district, Ubon Ratchathani province	Ubon Ratchathani province
15	Project for development and promotion of fresh pineapple sorting for distribution	Tambon Huai Sai, Tambon Bo Nok, Tambon Ban Buang community enterprises, Prachuap Kiri Khan province	Prachuap Kiri Khan province
16	Meat drying technology transfer project using hot air and solar energy	Tambon Kud Numsai community	Khon Kaen province
17	Project on upgrading food safety products from bamboo mushroom to green food standards of the Chang Lek subdistrict community, Phra Nakhon Si Ayutthaya province	Wat Changlek school and Wat Changlek	Phra Nakhon Si Ayutthaya province
18	Technology transfer and product development project for lip balm from dragon fruit	Ban Rong Chik community	Loei province
19	Biomass furnace technology transfer project for mushroom farmers	Ban Dong Nam Cha enterprise group, Wang Muang district, Saraburi province	Saraburi province
20	Biochar technology transfer project	Farmer group in the area Tambon Nong Yang Suea, Muak Lek district, Saraburi province	Saraburi province

LIST	IMPLEMENTED PROJECT	INNOVATIVE COMMUNITY	BENEFIT AREA
21	Technology transfer project of steam production from biomass to sterilise mushroom cubes	Ban Wang Thong mushroom cultivation farmer group, Chiang Klang district, Nan province	Nan province
22	Project for extension development of mascot sculpture made from Mon brick clay, Pa Mok identity, to generate income for the community	Pa Mok community/ Ban Bang Sadet miniature doll centre	Ang Thong province
23	Project of natural yarn dyed with identity colorant from local plants, Maha Sarakham province	Ban Nong Sinmai silk group, Maha Sarakham province	Maha Sarakham province
24	Local fabric dyeing project with laterite soil developed to reflect heat	Ban Santipap Pattana weaving and sewing group	Loei province
25	Phi Ta Khon pot development project, Dan Sai Identity, Loei province	Plaeng Yai flowering and ornamental plant group, Dan Sai district, Loei province	Loei province
26	Project of natural containers made from bananas in Banana Land Community, Phu Luang district, Loei province	Phu Luang organic-agro tourism community, Loei province	Loei province
27	Herbal toothpaste production process development project for SMEs	Mrs. Sornvanee Kamlungkua, Ban Lum Toei health herb enterprise	Nakhon Si Thammarat province
28	Development project of coffee bean size sorting process	Mr. Yongyut Chantakhet, Ban Nai Krang integrated gardening farmer group, Ranong province	Ranong province
29	Development project of odor-absorbing products from aroma galangal, Tha Bua Subdistrict identity plants, Phichit Province	Ban Klong Ta Ngao community, Pho Thale district, Phichit province	Phichit province

Industrial Entrepreneurs Potential Development Project to Compete in the New Normal Economy

TISTR has brought knowledge in science, technology and innovation, health food expertise, and other supporting services to be conveyed in Nakhon Ratchasima, Chaiyaphum and Surin provinces to create added value in agricultural product processing and to create new products. It also helped reduce waste from agricultural raw materials that were not up to standard.

Project to raise the standards of tourist attractions and product standards from Thai wisdom in the region linked and integrated with Rajabhat universities

TISTR has been funded by the National Research Council of Thailand (NRCT) and has cooperated with 38 Rajabhat universities in implementing the quality standard system to help raise the standard of community products that use local ingredients and local wisdom in order to be certified for quality standards. The main problem of community products was standardisation and quality assurance because products without quality assurance cannot be widely distributed. Therefore, raising OTOPs community products will help community entrepreneurs to sell more products in tourist attractions and help build tourists' confidence in buying products. For identity products to promote tourism in 7 target areas in 16 provinces, as a result, there were 28 community products that have been tested for product standards (FDA). Furthermore, the readiness of production sites and tourist attractions has been prepared according to the quality certification assessment criteria of 25 items, of which more than 30% have been certified for quality systems.

Science and Technology Services

TISTR by Industrial Services Group (IDS) focuses on providing science and technology services to raise the quality of industrial products in the country to international standards. IDS provides services with modern equipment according to international standards and has developed and designed testing equipment and test methods suitable for the use of various materials and products according to customer requirements. TISTR also supports the National Quality Infrastructure (NQI) to strengthen the competitiveness of Thai entrepreneurs to the international level. As of 2022, there were 2,910 service recipients, 261,303 service items, and 483 quality system audits and certifications.

In addition, 1,262 people from industry and government sectors have been trained to improve their science and technology skills through 53 training courses.

TISTR provides services to support the manufacturing and service industries of the country in term of science and technology services that have been certified according to international standards such as ISO 9001, ISO/IEC. 17020, ISO/IEC 17021-1, ISO/IEC 17025, ISO/IEC 17043, ISO/IEC 17065 and ISO/TS 22003 cover the following industrial requirements:

Analysis and testing services for raw materials, packaging products and calibration

TISTR provides industrial testing services for raw materials, products, packaging and calibration. Details are as follows:

- Analysis and testing of food, beverage and cosmetic products covering items for FDA registration by providing analysis services for main ingredients, contamination and nutritional value as well as safety testing. In addition, it also provides herbal testing services such as hemp, marijuana, *Andrographis paniculata*, Kratom, etc.
- Analysis and testing services for industrial products such as PVC pipes, electric tubes, and standard building paints TISI.272-2549 and TISI.2321-2549. In addition, it has also conducted an audit of the manufacture of industrial products according to Section 5 of the Thai Industrial Standards Institute in various TISI such as TISI. 17-2561, TISI. 982-2556 TISI. 2321-2564 etc.
- Acts as an inspection body to inspect according to ISO /IEC 17020 in the field of electrical equipment, testing and evaluating the life of the boiler and evaluating damage at the work site of vessel and boiler in power plants.
- Testing services for rail, road and water transportation systems, as well as providing testing services for electric vehicles.

■ Analysis and testing services for materials and packaging (paper, plastic, etc.), retail packaging, packaging for transportation and packaging for dangerous goods. It also provides research and developing services and consulting services on packaging as well as studying the shelf life of food products and packaging design services.

■ Research services and biodegradation analysis of raw materials or products that are environmentally friendly and research services for the removal of hazardous substances in the environment by biological processes.

■ Calibration services for industrial massage equipment covering all fields of measurement, including electricity, frequency, sound, light, temperature, humidity, volume, force, torque, mass, pressure, dimensions, flow and wind speed. In addition, it also provides testing and calibration services for medical equipment such as masks, medical supplies cabinets, plasma cabinets, blood cabinets, as well as air quality measurement services for negative and positive pressure rooms in the hospitals.

In 2022, there were 16 new scopes that were certified with international standards to meet the needs of customers, namely:

■ Single-use mask flammability test

■ Single-cycle bending test for metallic bone plates according to ASTM F382: ANNEX A

■ Insulated rail joint test according to AREMA Vol. 1 (Ch.4-part 3) which consists of 4 items: Straightness Measurement, Electrical Resistance Test, Longitudinal Compression Test, and Rolling Load Test, and according to the TOR SRT Technical Specification of State consists of 5 items: Alignment Check, Electrical Resistance Test, Tensile Load Test or Pull – Apart Force Test, Joint Compression test, and Stroke Rolling Load Test

■ Analysis of N-propil paraben content in beverages in sealed containers and analysis of methyl paraben and N-butyl paraben content in seasoning products obtained by digesting the proteins of soy and some sauces.

■ Drop test and stacking test of paper boxes for hazardous goods

Quality system certification services for products and services according to international standards

TISTR is a Certification Body that has working standards according to international standards, which are accepted both domestically and internationally. TISTR provides quality auditing and certification services, certifying products and services for government operators, private sectors, community enterprises and the public sector with transparency and impartiality. TISTR is also accredited according to international standards ISO/IEC 17021-1, ISO/IEC 17065 and ISO/TS 22003. TISTR provides auditing and certification to international standards covering the following areas:

■ Auditing and accreditation to various international standards such as ISO 9001, ISO 14001, ISO 45001, ISO 22000, GHPs and HACCP etc.

■ Providing audit services for food production premises as an inspection body that has been registered with the Food and Drug Administration. (FDA) in issuing a production system standard certificate according to the criteria of the Food Law and issuing inspection records to be used as evidence for the renewal of a food production license, including auditing of production processes and machinery list to apply for permission from the FDA according to the announcement of the Ministry of Public Health No. 420. In addition, it also provides audit services and certification services for GMP and HACCP systems.

■ Auditing and certification services for agricultural standard systems according to general standards such as TAS 9023, TAS 9024, TAS 9047, etc. and mandatory standards such as TAS 1004, TAS 9035, and TAS 6401, TA 9046, etc. In addition, it also provides audit services for factories that have been registered with the Department of Agriculture, resulting in enhancing the potential of Thai entrepreneurs in exporting agricultural products such as durian and longan.

■ Greenhouse gas reduction audit service by verifying the carbon footprint of the organisation.

■ Quality audit and certification services cover products and services including good agricultural practices (GAP) for food crops according to TAS 9001, organic agriculture according to TAS 9000 Volume 1, biodegradable plastic products according to ISO 17088 and TIS 17088. In addition, it also provides audit services of tax benefits for companies or juristic partnerships that use biodegradable plastics, as well as auditing and certifying tourist attractions and activities. TISTR is currently the only certification body accredited by the TISI.

Training services and others

TISTR also contributes to the empowerment of the public and private sectors by providing training to transfer knowledge and technology in various fields, including specialized courses to SMEs and start-up industries to develop personnel in all groups by providing them related knowledges on quality systems, packaging, food, metallurgy and testing, analysis and metrology, and energy and environment, etc. TISTR also offers non-degree and Train-the-Trainer programs to enhance professional skills covering teachers, undergraduates and masters as well as university staff to enhance their research skills, and operational skills in both online and on-site to develop human resources with science, technology and innovation in line with the strategic plan of MHESI that focuses on developing the quality of human resources to increase competitiveness and drive the country’s industry.

Additionally, TISTR is registered as the host organisation of the Council of Engineers for engineering training and can provide PDU grades.

TISTR has also been registered by the Department of Industrial Works as an organisation that provides a course for the controller of boilers or boilers that use liquid as a heat conductor according to the announcement of the Ministry of Industry. Those who pass the exam will receive a boiler controller certificate according to the criteria of the Department of Industrial Works. Moreover, TISTR is also a proficiency testing provider accredited according to ISO/IEC 17043 in the field of electrical temperature and chemical.

In 2022, TISTR was licensed as a juristic person under Section 11 that can provide inspection and certification services for machinery, cranes, and boilers in accordance with the Ministry of Labor regulations that have established management standards and operations on occupational safety, health and conditions, working environment with machinery, cranes and radiators B.E. 2021.

International Collaboration

TISTR conducted international collaboration projects to share its knowledge and research through international networks to achieve sustainable development goals (SDGs) as follows:

APEC Events as Thailand hosted APEC in 2022

As Thailand hosted APEC meetings in 2022, under the theme “Open. Connect. Balance”, by focusing three areas: 1) to promote inclusive and sustainable growth, 2) to facilitate trade and investment, and 3) to reconnect the region, especially cross-border travel and tourism to recover the regional economy in post COVID-19, and promoting Bio-Circular-Green Economy model, or BCG Model, TISTR (InnoAg and InnoEn) implemented projects under the APEC framework. The projects were endorsed by APEC Policy Partnership on Science, Technology and Innovation (PPSTI), having the Office of the Permanent Secretary of the Ministry of Higher Education, Science, Research and Innovation (MHESI) as Thailand Focal Point of PPSTI, to share its knowledge and research to drive APEC priorities and support the Asia-Pacific region development, through the event “International Workshop on Development of Ornamental Plant and Flower Clusters for Sustainable Career and Competitiveness of SMEs in APEC” on 19 – 20 July 2022, and “APEC Webinar Municipal Solid Waste Management by Circular Economy Concept” on 7 September 2022. These projects aim to create cooperation networks and promote STI applications to increase value of products in ornamental plant and flower businesses and capacity of community solid waste management in APEC economic region sustainably. Besides, TISTR (by EEL - MTC) has a project on “Capacity Building Workshop on Testing Methods of Internet of Thing (IoT) Products”, endorsed by APEC Sub-Committee on Standards and Conformance (SCSC), in cooperation with the Thai Industrial Standard Institute (TISI) as Thailand Focal Point of SCSC, and start the project in 2023. The project aims to develop the capacity of a research laboratory of IoT product testing and analysis in the APEC economy region, to meet international standards *(Figures 1 - 2).*

Multilateral cooperation projects

TISTR recognises benefits resulted from multilateral cooperation network, to extend its knowledge and utilise its research in the global context, by implementing projects with foreign research agencies, as following;

- TISTR (RTTC) received financial support from MHESI to implement a project “the Promotion of Modern Railway Technology Transfer to Enhance Safety and Efficiency of Operation and Maintenance of Railway Connecting Thailand-Lao PDR-China”, in cooperation with foreign research agencies – China Railway Rolling Stock Corporation (CRRC), China Railway Construction Corporation

(CRCC), Southwest Jiaotong University (SWJTU), China, the National University of Laos, Lao PDR, and University Teknologi MARA, Malaysia. It included a seminar to exchange and transfer technology of railway systems in the ASEAN region, produce high-skilled workers in railway operation and maintenance, and develop platforms to support safety and efficiency of railway operation and maintenance connecting Thailand-Lao PDR-China, on 27 July 2022 *(Figures 3)*.

- TISTR (InnoRobot) received financial support from MHESI to implement a project "Production System of Quality, Low-cost, and Sustainable Community Water Supply Using IoT in a Shortage Area", in cooperation with Thai Universities and foreign research agencies – CSIR Central Electronics Engineering Research Institute, (CSIR-CEERI) India, CSIR National Environmental Engineering Research Institute (CSIR-NEERI) India, and University of Southampton, United Kingdom. It included "International Workshop on the Research Network Creation of IoT for Community Water Supply Production (Hybrid Workshop)" on 30 August 2022, to exchange knowledge of production system of quality, low-cost and sustainable water using IoT in shortage areas, and to create research network of foreign research agencies and community water sources using IoT, and a study visit to Bang Sue Environmental Education and Conservation Center, Bangkok *(Figures 4-5)*.

- TISTR (InnoEn) received financial support from Thailand International Cooperation Agency (TICA) to implement a project "Third Country Training Program for Renewable Energy Technologies and Knowledge Transfer for Strengthening and Achieving ASEAN's Sustainable Development Goals", in cooperation with the National Science and Technology Development Agency (NSTDA), Thailand International Cooperation Agency (TICA), and Japan International Cooperation Agency (JICA), to transfer modern renewable energy production technology to ASEAN region by promoting appropriate technology and its applications to each ASEAN member states, and aims to establish a low-carbon society and an energy security in the region to achieve the Sustainable Development Goals (SDGs). The project will start in 2023.

- TISTR (RTTC) received financial support from United Nations (UN) under Perez- Guerrero Trust Fund for South-South Cooperation (PGTF) and Thailand International Cooperation Agency (TICA), to implement a project "Technical Cooperation for Research and Development and Implementation of Railway Inspection and Monitoring Technology" to upgrade safety level of ASEAN railway system operation by modern railway inspection and monitoring, to establish railway system safety platform based on operation areas and practical usages in ASEAN region, and to reduce technology costs imported from the developed countries, according to ASEAN Connectivity Master Plan.

Roles as a Regional Focal Point

TISTR, as a regional focal point, conducts knowledge linkage and cooperative integration through international networks for opportunities to expand knowledge and success in research applications internationally and concretely, and to access funding sources to achieve SDGs together in the future.

In this year, TISTR, as a Regional Focal Point (RFP) for Asia and the Pacific, World Association of Industrial and Technological Research Organization (WAITRO) has outstanding roles with important results, such as two wining of WAITRO Innovation Award 2021: a project to develop alternative protein from insect with WAITRO members in Spain, South Africa and Nigeria, and a project of extraction technology to develop flour products from Konjac plants with WAITRO member in Indonesia. Besides, TISTR Governor, together with TISTR and WAITRO members representatives in the Asia-Pacific, attended "WAITRO Horizon Europe Workshop Capacity Building & Network Event" in Spain, to present interested topics of the region *(Figure 6-7)*.

Moreover, TISTR, as Thailand Focal Point of ASEAN Sub-Committee on Food Science and Technology (SCFST), in cooperation with Informa Market, organised "(ASEAN Symposium) Panel Discussion on Plant-based Revolution Recent Insight into Products and Development Technologies and Their Future Applications", in FiAsia/Vitafood Asia 2022, which aimed to promote knowledge exchange among ASEAN researchers in plant-based food processing technologies, methods and techniques in research and development of nutritious, affordable and sustainable alternative proteins, quality improvement, production development and safety testing for the products, and examples of successful cases of innovative food products in commercialisation *(Figures 8)*.

Resulting from the above implemented projects, TISTR gained opportunities to show its potential in research and development through STI international activities and events, as well as, multilateral cooperative networks, in order to gain more recognition and acknowledgement in the global community. It also helped to broaden vision and strengthen capacity of TISTR researchers to conduct research and development in STI, responding to global challenges and international standards through the integration of knowledge and expertise of TISTR and foreign researchers in various scientific fields, and through the participation with the global community to achieve sustainable social and economic development, and environment conservation.

(1) International Workshop on Development of Ornamental Plant and Flower Clusters for Sustainable Careers and Competitiveness of SMEs in APEC

(2) APEC Webinar Municipal Solid Waste Management by Circular Economy Concept

(3) The Promotion of Modern Railway Technology Transfer to Enhance Safety and Efficiency of Operation and Maintenance of Railway Connecting Thailand-Lao PDR-China

(4) International Workshop on the Research Network Creation of IoT for Community Water Supply Production (Hybrid Workshop)

(5) A study visit to Bang Sue Environmental Education and Conservation Center, Bangkok

(6) TISTR won 2 places of WAITRO Innovation Award 2021

(7) TISTR Governor and WAITRO member representatives in the Asia-Pacific attended “WAITRO Horizon Europe Capacity Building & Networking Event”, in Spain.

(8) (ASEAN Symposium) Panel Discussion on The Panel Discussion on the Plant-based Revolution Recent Insight into Products and Development Technologies and Their Future Application