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Global food security is increasingly in the spotlight today due to the combined impacts of climate change, over-exploitation of finite natural resources, population growth, urbanization and environmental destruction. These factors directly impact agricultural productivity around the world. At the same time, food safety is also emerging as an important factor in both domestic and export markets. Safeguard our food supply even as production practices become ever-more intensive has moved to the top of the policy agenda as well as among supply chain actors. Aside from the very real risk to consumer health, a major food safety incident involving a global supply chain can lead to serious financial and reputational harm, from which the companies involved may never recover.

As a major food producer and exporter, it is therefore imperative for Thailand to upgrade its approaches, systems, technologies and regulatory framework to mitigate food safety risks at every step in the food supply chain. Combined with cost-effective traceability systems to contain any incident identified by enabling rapid withdrawal of suspect batches from retail shelves, such reform will serve to build international confidence in Thailand's food exports and safeguard its reputation as the *"Kitchen of the World"*. Research is urgently needed in areas such as climate-smart farming to ensure reliable production, the use of ICT tools and satellite imagery to provide accurate and cost-effective forecasting tools, as well as to make technical and market recommendations available to farmers via mobile phones. More is needed to establish a cost-effective integrated system for monitoring and surveillance, including rapid alert systems in the event of a food safety incident. Moreover, analysis and enforcement capacity needs a major upgrade to increase the risks of non-compliance for offenders. Finally, it will be vital for Thailand to re-examine the established conventional production systems based on intensive agrochemical use, and undertake major efforts to incentivize uptake of more ecologically balanced, resource-efficient, climate-smart and sustainable modes of production. As a major player in the global food industry, Thailand must take steps now to ensure full compliance with the latest international food safety standards if it is to retain and extend its export trade competitiveness and contribute to national economic development in a new and challenging era.

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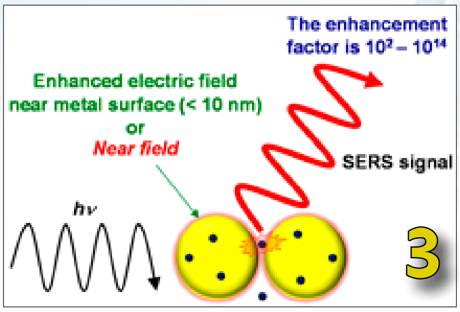
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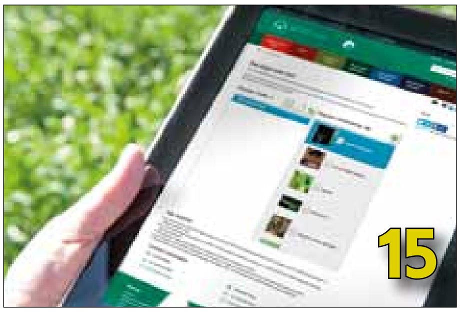
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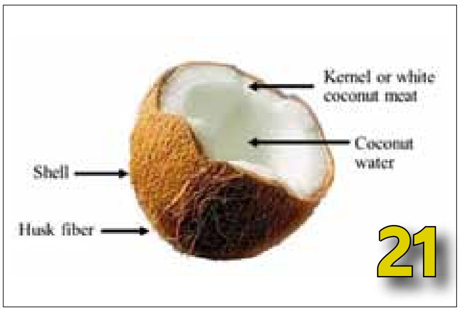
Kernel or white coconut meat
Coconut water
Shell
Husk fiber
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Article

Surface-Enhanced Raman Scattering (SERS) Technique for the Detection of Carbofuran in Agricultural Products

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Introduction

Contamination in agricultural products is an important problem since it greatly affects Thai population's health. The residues such as chemicals, insecticides, pesticides found in vegetable, fruit, meat, food or other agricultural products lead to health problems, several diseases and cancers and thus a lot of money is spent excessively each year to treat these patients. In addition, agricultural products such as rice, vegetable, and many kinds of fruit containing contaminants are unable to sell at high price and cannot be exported to any developed countries, e.g. the United States of America, Japan, European Union countries. Moreover, a detection of disease, chemicals, insecticide or pesticide residues in some agricultural products can cause cancellation or deny for further purchase orders of other products, resulting in a severe problem for Thai agricultural products export. Therefore, agricultural products should be preliminary examined by manufacturer or factory to enhance the quality of life of Thai population and to prevent the cancellation of overseas orders for agricultural products.

Nowadays, there are various acceptable analytical chemistry methods for detection of trace contaminants in agricultural products (Li et al., 2010; Sun et al., 2011; Funari et al., 2013; Zhu et al., 2014), for example, gas chromatography with mass spectrometry (GC-MS), ion chromatography (IC), high-performance liquid chromatography (HPLC), combined solid-phase extraction/diffuse reflectance spectroscopy, gel electrophoresis coupled to inductively coupled plasma-mass spectrometry (GE coupled to ICP-MS), atomic emission spectrometry (AES), inductively coupled plasma atomic emission spectrometry (ICP-AES), capillary electrophoresis (CE), ion-selective electrode polarography, cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), quartz crystal microbalance (QCM). However, these methods have some limitations, such as a sample preparation procedure with several steps, a long analysis time, a requirement of complicated and expensive instruments, a high-priced analysis, and an incapability to perform analysis at a fieldwork or outside a laboratory. In order to overcome the limitations of these techniques, new method/technique for trace detection of contaminant in agricultural products should be developed in such a way that it is efficient, convenient, and easy to use so that it can be passed on to relevant person. Thus, surface-enhanced Raman scattering is introduced as a suitable candidate technique for the detection of trace contaminant in agricultural products.

Background and principle of surface-enhance Raman scattering

In Raman spectroscopy, a laser light is irradiated to a sample, then this incident light interacts with various vibrations of chemical bonds in the molecule causing the shift in frequencies of scattered light. Measuring the intensity of these scattered light at each wavelength provides a fingerprint of the molecule which can be used to identify the compound. However, if a sample has a trace amount, intensity of the scattered light will be very weak, and thus it is undetectable. To solve this problem, surface-enhanced Raman scattering (SERS) is introduced. In this technique, a sample molecule is absorbed on rough metal surface or on metal nanoparticle (a particle with at least one dimension less than 100 nm). When a light is shined on metal surface, incident light that has the same frequency as that of the electron cloud (plasmon) induces a resonance of plasmon on the surface of particle. This resonance is thus well-known as surface plasmon resonance (SPR). Resonance frequencies of electron cloud on surface depend on surface roughness as well as shape and size of particle. Since this resonance produces exceptional large electromagnetic field all over metal surface, it can be assumed that molecule absorbed on metal surface was exposed to a large amount of incident light. Thus, the scattering is greatly increased and so the Raman spectra signal is greatly amplified. According to this concept, the technique is called surface-enhanced Raman scattering (SERS). The enhancement factor is in a range of 10^2–10^{14} so it can be used to analyze and study trace sample (Figure 1)

As stated above, SERS can be performed on either rough metal surface or metal nanoparticle. In quantitative trace analysis, the use of metal nanoparticle is more practical because an increase in signal due to surface plasmon resonance can be easily adjusted by controlling shape and size of synthesized particle. A sample molecule must be attached on the surface of metal nanoparticles. To increase sensitivity and selectivity of sample analysis using SERS, sample molecule and surface of metal nanoparticles are typically designed or modified so that the sample molecule can be selectively and rapidly trapped on the surface of metal nanoparticles. Several research works have been reported for the application of SERS to determine various insecticides and contaminants in food and agricultural products (Kang et al., 2002; Han et al., 2011; Tang et al., 2011; Liu et al., 2013; Fan et al., 2014; Yang et al., 2014).

Carbofuran is one of the most toxic insecticides and is widely used in agriculture. Its chemical structure is shown in Figure 2. Carbofuran has long been used in large amount each year in Thailand. In 2008, its import volume is over 10,000 tons. They are imported mainly from China, Indonesia, and Vietnam.

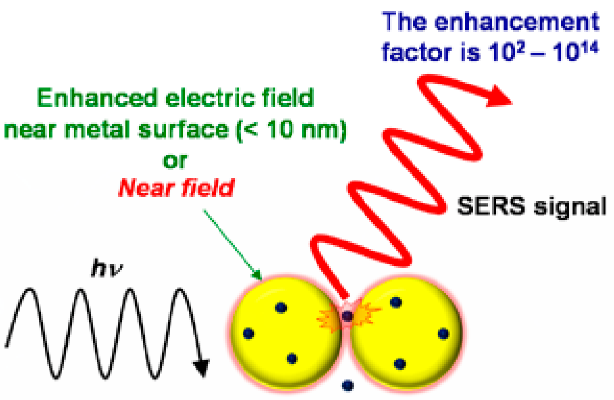

Figure 1 Schematic representation of SERS on the surface of metal nanoparticle.
Source: Pienpinijtham (2015)

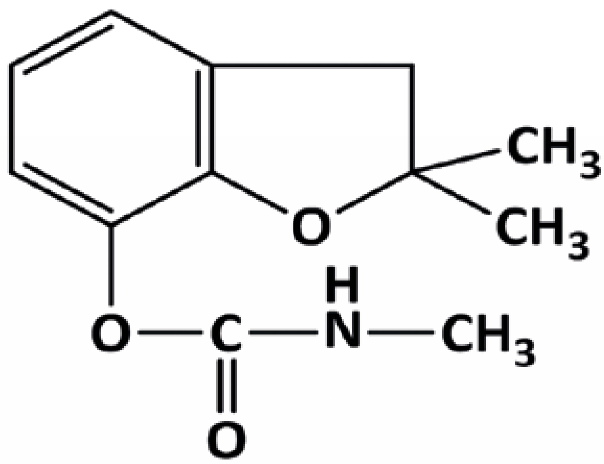

Figure 2 Chemical structure of carbofuran.
Source: Pienpinijtham (2015)

Currently, it is not allowed to use and sell carbofuran in many countries including the United State of American, Canada, European Union countries, Myanmar, Malaysia, Vietnam, Singapore. In Thailand, carbofuran was put in the dangerous chemicals watch list by the Department of Agriculture for a long time. Surprisingly, it is not yet banned for its use, although there are many reports about large amount of carbofuran residues in environment and agricultural products which directly affect human health, ecosystem, and national export industry. In this research, selective and sensitive substrate for the determination of carbofuran insecticide residue in agricultural product using SERS was designed with the purpose to bring on a simple and easy method for carbofuran detection.

Procedure for carbofuran measurement using surface-enhanced Raman scattering

In this research, silver nanoparticles (AgNPs) were used as substrate for SERS. As chemical structure of carbofuran is not conducive to direct absorption on silver surface, carbofuran must be converted to another compound that can be attached on silver surface. First, carbofuran was hydrolyzed to carbofuran phenol by dissolving carbofuran in 0.2 M potassium hydroxide (KOH) in ethanol and storing at 50°C for 3 hours (Figure 3). Second, diazonium ion was prepared by mixing 1 mM *p*-aminothiophenol and 5% sodium nitrite ($NaNO_2$) in 0.1 M HCl with a ratio of 1:1 by volume at 0°C for 1 minute. Third, diazo-coupling reaction was carried out by mixing carbofuran phenol and diazonium ion with a ratio of 1:1 by volume at 0°C for 1 minute. The azo compound, which is a derivative of carbofuran with a thiol group (–SH) and can easily be attached to silver surface, was obtained. Finally, the synthesized azo compound was combined with AgNPs colloid with a ratio of 1:1 by volume for 5 minutes. The azo compound was then attached on AgNPs surface. SERS spectra were collected using an excitation laser at 780 nm with a power of 14 mW.

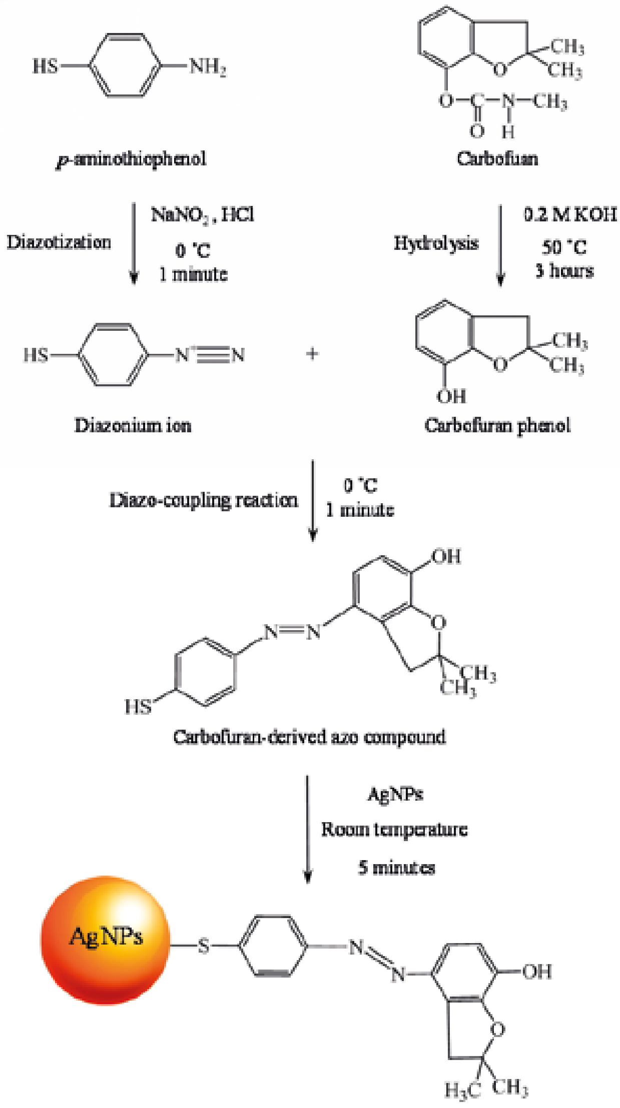

Figure 3 Chemical reactions to attach carbofuran on surface of silver nanoparticles

Source: Sukmanee et al. (2017)

Measurement results of carbofuran in a prepared solution

The Raman spectra of 1000 ppm carbofuran in ethanol are similar to those of pure ethanol, which is a solvent (Figure 4). This indicates that carbofuran could not be detected solely by Raman spectroscopy even though it has a very high concentration of 1000 ppm. Therefore, carbofuran was converted to carbofuran phenol and subsequently it was reacted with diazonium ion to produce azo compound that is a derivative of carbofuran phenol. SERS spectra were then measured using AgNPs as substrate and are given in Figure 5. The spectra have different peaks

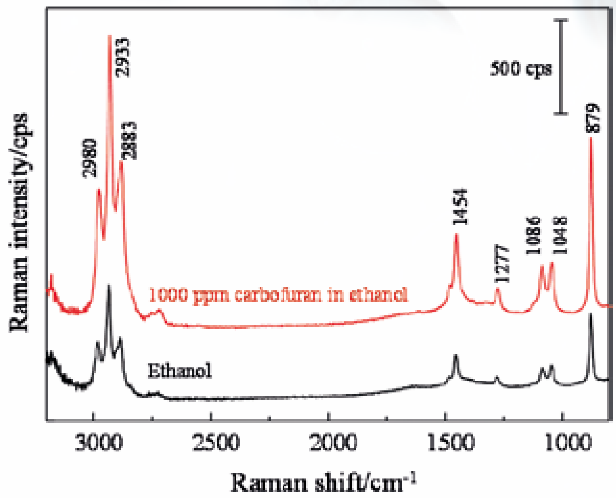

Figure 4 SERS spectra of pure ethanol and 1000 ppm carbofuran in ethanol.

Source: Sukmanee et al. (2017)

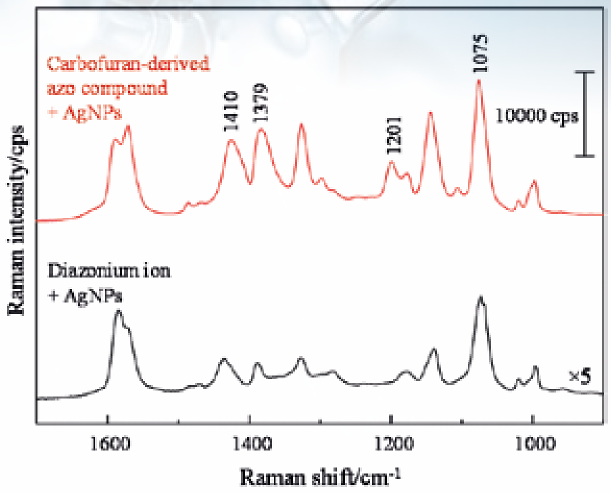

Figure 5 SERS spectra of AgNPs with the diazonium ion and with the carbofuran-derived azo compound.

Source: Sukmanee et al. (2017)

from those of pure ethanol. Comparing with spectra of diazonium ion, significant differences were observed as evidenced by peaks of carbofuran-derived azo compound at 1410 (related to –N=N– stretching), 1379 (related to C–C stretching, and C–H and O–H bending in phenol group), and 1201 cm^{-1} (related to C–N stretching, CCN (phenyl–N) in-plane bending, C–H and O–H bending, and C–C stretching in phenol group). Thus, this method can be used to measure carbofuran.

In this study, efficiency of the method was evaluated by measuring SERS spectra of carbofuran sample at various concentrations. The results are given in Figure 6.

Correlation between carbofuran concentration and the ratio of peak area at 1201 cm^{-1} (attributed to C–N stretching, CCN (phenyl–N) in-plane bending, C–H and O–H bending, and C–C stretching in phenol group of carbofuran-derived azo compound) and 1075 cm^{-1} (attributed to C–S stretching of diazonium ion) is shown in Figure 7. It is clearly seen that the ratio is proportional to carbofuran concentration. Therefore, this ratio can be used to determine carbofuran concentration. The detection limit of this method, which is the lowest concentration of carbofuran that can be reliably detected with this method, is 0.452 ppm.

Since real sample contains many compounds that may interfere the measurement of carbofuran, selective measurement method is essentially needed. In this research work, our method was evaluated by measuring various solutions, in which each contains carbofuran at 5 ppm and one added compound at 1 mM. These added compounds include acetic acid, ascorbic acid (vitamin c), formic acid, fructose, glucose, lactose, maltose, sodium chloride (table salt), and cane sugar, which are common compounds and may be found in agricultural products. Results show that

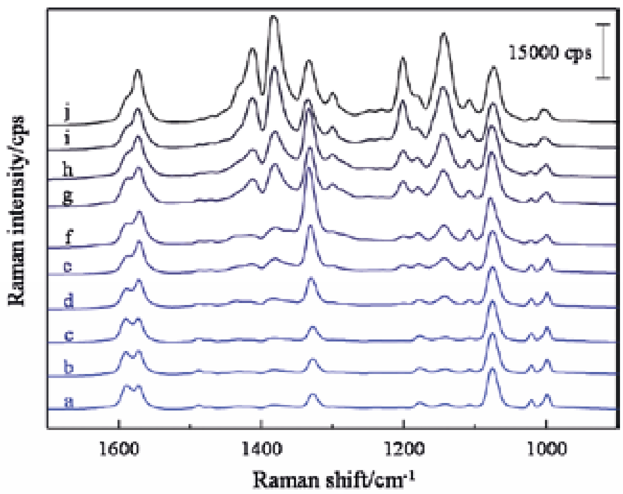

Figure 6 SERS spectra of azo compounds derived from carbofuran of (a) 0 (b) 0.1 (c) 0.5 (d) 1 (e) 5 (f) 10 (g) 50 (h) 100 (i) 500 and (j) 1000 ppm.

Source: Sukmanee et al. (2017)

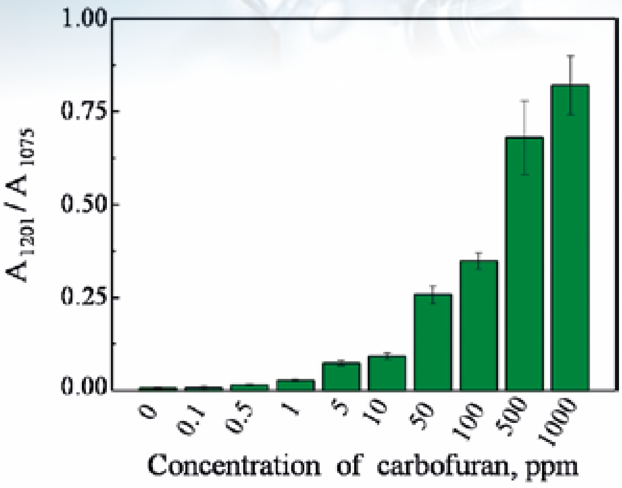

Figure 7 Plot between carbofuran concentration and ratio of peak area at 1201 and 1075 cm^{-1}.
Source: Sukmanee et al. (2017)

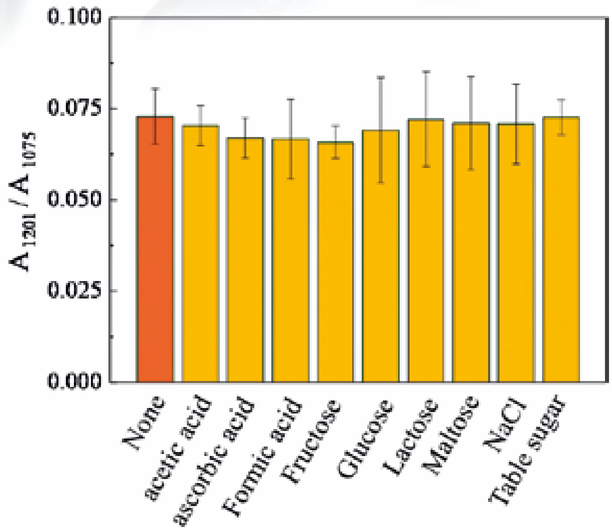

Figure 8 Ratio of peak area at 1201 and 1075 cm^{-1} of carbofuran sample added with various compounds.
Source: Sukmanee et al. (2017)

ratios of peak intensity at 1201 and 1075 cm^{-1} of sample containing other compounds are not significantly different from that of sample with only carbofuran (Figure 8). This indicates that our proposed method is applicable to measure carbofuran without interference from other compounds.

Measurement results of carbofuran in agricultural product sample

Our developed SERS technique was applied to measure carbofuran in two agricultural products, rice and soybean, of which carbofuran is often used at planting. Rice and soybean samples were washed and cleaned with ethanol to ensure that there is no carbofuran residue. Then, carbofuran solutions with calculated amount were sprayed on 5 grams of each samples. After drying, the samples with carbofuran contamination were obtained. They were soaked in 5 mL of ethanol to extract carbofuran from the samples. The extracted carbofuran solutions were analyzed with our developed SERS technique.

Measurement results of carbofuran in rice and soybean are displayed as plots between carbofuran concentration in rice and soybean samples and the ratio of peak area at 1201 and 1075 cm^{-1} (Figure 9). The plots show an excellent linear correlation and thus the method can be used to measure carbofuran residue in rice and soybean. The detection limit of this method for rice and soybean is 0.446 and 0.520 ppm, respectively.

Conclusions

The surface-enhanced Raman scattering technique can be applied for the detection of carbofuran, which is an insecticide contaminated in agricultural product. Carbofuran in a solution with low concentration down to 0.452 ppm can be measured by using our developed method. The method has quite high selectivity to carbofuran, i.e. it is not interfered by other compounds including acetic acid, ascorbic acid (vitamin c), formic acid, fructose, glucose, lactose, maltose, sodium chloride (table salt), and cane sugar, which are common compounds and may be found in agricultural products. Using our developed method, carbofuran concentration in rice and soybean, which are real samples of agricultural products, were successfully determined with detection limits of 0.446 and 0.520 ppm, respectively. If this technique is used in conjunction with portable Raman spectrometer, it enables the convenient and quick on-site measurement of carbofuran contaminated in agricultural products. It is not necessarily to send samples for laboratory analysis and hence saving cost and time. This is another way to help improving the quality of agricultural products.

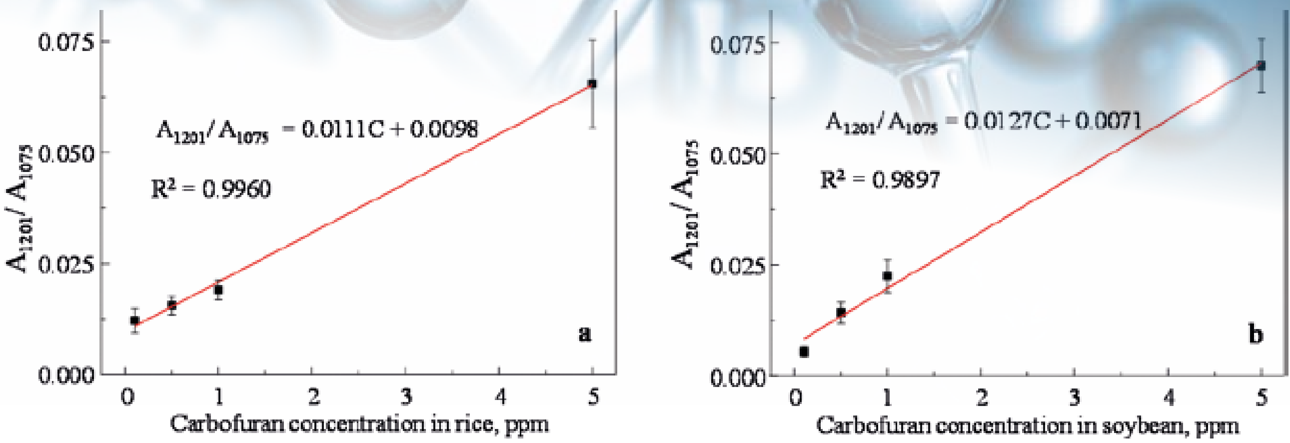

Figure 9 Plots between carbofuran concentration in (a) rice and (b) soybean and ratio of peak area at 1201 and 1075 cm^{-1}.
Source: Sukmanee et al. (2017)

Acknowledgment

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The Use of Biochar for Food Security in Maize Production

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Introduction

Agricultural production is highly vulnerable to climate change, which leads to multiple direct and indirect impacts on agricultural production, including temperature extremes, droughts, flooding, and changes in frequency and volume of precipitation. These impacts affect are considered as major threats to food security and food production, especially in developing countries whose cultivation depend on the natural environment.

Biochar has been recognized as an effective soil amendment (Sriburi and Wijitkosum, 2016; Wijitkosum and Kallayasiri, 2015; Yooyen et al., 2015; Masulili et al., 2010; Lehmann, 2009; Lehmann and Rondon, 2006; Yamato et al., 2006), supporting plant production (Wijitkosum and Kallayasiri, 2015; Thies and Rillig, 2009; Chan et al., 2007), and contributing to plant growth and improved yields, both in terms of quality and quantity (Sriburi and Wijitkosum, 2016; Wijitkosum and Kallayasiri, 2015; Zhang et al., 2012; Lehmann et al., 2011). Biochar can be produced from agricultural crop wastes such as corncobs, paddy husks, cassava roots, palm bunches, rice straw (Sriburi and Wijitkosum, 2016; Zhan et al., 2015; Liu et al. 2014), and tree pruning scraps from both hard and softwoods (Sriburi and Wijitkosum, 2016; Sun et al., 2014).

Maize is the most widely grown field crop in Phetchabun, Nakhon Ratchasima and Loei provinces in northern Thailand (Office of Agricultural Economics, 2012). Cultivation has continuously expanded in recent years; production today averages 5 million tons a year, of which 95% is for domestic use. This growth is a response to increasing demand from the animal feed industry which has been expanding due to strong growth in livestock exports, especially to Asian markets.

Despite the expansion of the maize area, farmers suffer from high production costs, especially for investment in inputs such as seeds, agrochemical fertilisers and insecticides. Moreover, falling productivity and yield quality are apparent due to soil degradation. Together, higher production costs and falling productivity are impacting on farmers and their families, who face increasing indebtedness and lower quality of life.

Incorporating biochar into soils used for maize production can help reverse the deterioration on soil quality and fertility and contribute to soil amelioration and higher yields. Biochar is healthy and environmentally safe, with low production cost through a simple production process.

Biochar: Soil Amelioration Substance to Sustainable Agriculture

The biochar used in this study was produced from cassava crop waste (Figure 1). The cassava wastes undergone pyrolysis process using a controlled temperature biochar retort for slow pyrolysis (patent number 50528). The retort was especially designed for agriculturalists to produce biochar for their own use. The biochar process is simple and low-cost (Sriburi and Wijitkosum, 2015), but the quality of the resulting biochar was similar to that produced under fully controlled laboratory conditions in a high temperature retort (Wijitkosum and Kallayasiri, 2015).

The biochar obtained from the retort was analysed to identify its characteristics and functional properties, following the Standardized Product Definition and Product Testing Guidelines for Biochar that is Used in Soil (International Biochar Initiative, 2014). Biochar samples were selected using a random sampling process. The biochar was ground into no more than 3 mm in size before being incorporated into soil in farmers' fields (Wijitkosum, 2015).

Analyses of physical characteristics and properties of biochar from cassava waste obtained from the controlled temperature biochar retort for slow pyrolysis at 500 – 600 degrees Celsius are shown in Table 1.

Biochar from cassava waste contained physical characteristics suitable for use as a soil ameliorant. It is characterized by a high surface area (200.46 m^2/g), high pore volume (0.1219 cm^3/g), and high carbon content of 62.95% (H:C ratio = 0.43). As the biochar was high in fixed carbon, its stability allowed the biochar to remain in the soil for a long period (Lehmann, 2007; Glaser et al., 2002). It also possessed high alkalinity (pH 9.6), an electrical conductivity (EC) of 1.35 dS/m and cation exchange capacity (CEC) of 11.00 cmol/kg. These key characteristics enhanced availability and exchange of plant nutrients (Sohi et al., 2010; Brewer et al., 2009; Chan et al., 2007; Glaser et al., 2002). Moreover, biochar also contained 25.89% organic matter, total nitrogen of 0.98%), available phosphorus (0.82%), and exchangeable potassium (1.68%).

Figure 1 Crop waste from cassava (left) and cassava biochar (right)

Photographed by: Yooyen, July 2014

Table 1 Properties and composition of cassava biochar obtained by slow pyrolysis in a controlled temperature biochar retort

Parameters	Unit	Cassava Biochar
Physical properties		
Surface area	m^2/g	200.46 ± 10.52
Pore volume	cm^3/g	0.1219 ± 0.0038
Average pore diameter	Å	24.36 ± 1.59
Composition of biochar		
Total organic C	%wt	62.95 ± 0.34
Total H	%wt	2.24 ± 0.08
Total N	%wt	1.36 ± 0.02
Total O	%wt	33.45
H/C Ratio	wt/wt	0.43
Chemical properties		
pH		9.6
Electrical Conductivity (EC)	dS/m	1.35
Cation exchange capacity (CEC)	cmol/kg	11.00
Organic matter	%	25.89
Total nitrogen	%	0.98
Available phosphorus	%	0.82
Exchangeable potassium	%	1.68

Source: Wijitkosum (2015)

The Adaptive Use of Biochar for Increasing Maize Production

The study was conducted on an experimental site at Pa-Deng Biochar Research Centre, Pa Deng, Kaeng Krachan, Petchaburi, Western Thailand. Soils in the area were predominantly sandy clay loam (SCL) with low fertility (1.32% organic matter) and weakly acid (pH 6.95). Single-crossed maize seeds were used for the study. The study was conducted in a complete randomized design (CRD) in four treatments, each with four replicates. The four treatments were: control treatment (soil with only organic fertilizer added at 0.56 kg/m^2: T1); soil incorporated with organic fertilizer at 0.56 kg/m^2 plus biochar at 0.5 kg/m^2 (T6); soil incorporated with organic fertilizer at 0.56 kg/m^2 plus biochar at 2.5 kg/m^2 (T7); and soil incorporated with organic fertilizer at 0.56 kg/m^2 plus biochar at 3 kg/m^2 (T8).

The organic fertiliser used in this study was agricultural crop wastes from post-harvest soybeans grown by local farmers. The organic fertiliser obtained complied with the standard set by Thailand's Department of Agriculture (Department of Agriculture, 2005).

Analysis of the results from weight of seeds and numbers of pods per plant indicated that the most productive treatment in terms of grain yield (0.740 kg/m^2) was obtained in treatment T7 (Figure 2) (incorporating organic fertiliser plus biochar at 2.5 kg/m^2), followed by at 0.726 kg/m2 for T8 (organic matter at 0.56 kg/m2 plus biochar 3.0 kg/m^2), at 0.723 kg/m^2 for T1 (the control treatment without biochar) and at 0.710 kg/m^2 for T6 (organic matter at 0.56kg/m^2 plus biochar at 0.5 kg/m^2). However, treatment differences were not statistically significant at $p>0.05$.

In terms of average number of cobs per plant from 8 sample plants per treatment, the results revealed that T7 yielded the highest cob number (13 cobs) followed by T8 (12 cobs). T1 and T6 both yielded an average 6 cops per plant, although cobs from T6 were larger in size than those from T1 (Figure 3).

The results indicated that incorporating an appropriate amount of biochar and organic fertiliser in the soil boosted yields. The biochar treatments all resulted in higher yields than the untreated control, which was equivalent to normal farm practice in the locality. The positive results may be attributed to the highly porous structure of biochar, its high CEC (11 cmol/kg), a large number of cations on the surface, appropriate pH (6.96) which help retain beneficial nutrients and trace elements and boost their availability to the crop. Biochar has a high affinity for nutrients, and is effective at adsorbing them; the nutrients are then slowly and continuously released season-long for plant use (Wijitkosum and Jiwnok, 2015; Yooyen et al., 2015; Knowles et al., 2011; Lehmann, 2007; Chan et al., 2007; Sriburi and Wijitkosum, 2015). These results for maize are consistent with higher yields obtained with biochar treatments in other crops such as rice (Wijitkosum and Kallayasiri, 2015), soybeans (Yooyen et al., 2015; Yooyen, 2013) and radish (Sriburi and Wijitkosum, 2015). Using biochar may take time to produce results that are statistically significant. The results may be obvious in the first crop cycle, but it may take a longer time in some cases for the effects of biochar to be apparent in terms of increased long-term soil fertility and

Maize at 24 days after emergence (DAE)

Maize at 40 DAE

Maize at 74 DAE

Maize at 110 DAE

Figure 2 Maize plots at different growth stages, for T7 (soil incorporated with biochar at 2.5 kg/m^2)

Photographed by: Jiwnok, 2014

Figure 3 Maize cobs from 8 sample plants per treatment

Photographed by: Jiwnok, October 2014

structure. Studies conducted by Butnan et al. (2015) and Major et al. (2010) showed that the results of their field experiments were statistically significant only from the second crop cycle onwards.

Biochar is also known to reduce loss of soil nutrients, especially in tropical areas where soils are already very low in nutrients and subject to a high rate of weathering. Using non-organic synthetic commercial soil ameliorants was less effective. Due to the low soil CEC, chemical fertilisers frequently used by farmers are easily leached from the soil before the soil can absorb them. This leads to over-use of chemical fertilisers, higher production costs, and long-term damage to soil structure and fertility (Sparkes and Stoutjesdijk, 2011; Bruun, 2011; Brady and Weil, 2002; Bruno et al., 2002). The use of biochar in agricultural areas also contributes to plant growth in multiple ways including improving soil structure, reducing soil density (Jones et al., 2010; Bhogal et al., 2009; Novak et al., 2009), and improved soil drainage (Laird et al., 2010; Novak et al., 2009). Moreover, biochar is able to retain plant nutrients within the soils for a long period of time which helps reduce the need for both chemical and organic fertilisers. This helps conserve natural resources and the surrounding environment by reducing soil and water contamination and accumulation of chemicals in the environment.

Therefore, using biochar in agricultural areas helps increase food security and promote sustainable agriculture.

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Article

Reflections on the Role of Southeast Asian Universities in Agricultural Extension Services (AES) and Food Security

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Introduction

Southeast Asia is a tropical biodiverse region where agriculture and food production play major roles in the lives of the region's population. For at least eight ASEAN member countries (Cambodia, Laos, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Vietnam), agriculture represents a significant part of the national economy and is a major source of employment for millions of mostly rural people.

For example, data from the World Bank indicated that in 2015, Thailand's agricultural sector accounted for 9.1% (World Bank, 2017) of the nation's GDP. But agriculture's economic contribution does not fully reflect agriculture's broader importance to the country, its people and national culture. With a total population of approximately 67 million, around 25 million or 38% of Thailand's population are engaged in agriculture (Thailand's Agricultural Economic Indicators, Office of Agricultural Economic, 2015).

Yet many Thai farmers face a life of continuing poverty and food insecurity, which constrains the country's long term sustainable development. At the same time, Thailand's agricultur al sector, as in the rest of Southeast Asia, is based on *"conventional"* industrialized practices such as mono-cropping and agrochemical-dependent farming- systems that have long threatened the environment as well as traditional cultures and ways of life for smallholder farmers.

These *"conventional"* food production systems represent one of the greatest contributors to a range of environmental problems such as drought, land degradation, deforestation, water pollution, and climate change. In many cases, conventional agriculture also encourages overuse or abuse of agrochemicals by small farmers. At the same time, conventional agriculture has also lived up to its promise to deliver adequate food and nutritional security for many.

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Though modest improvements in regional food security have been reported over the past decade, available data from Southeast Asia (which nevertheless need better disaggregation and further study by country, sub-region and particular rural areas) suggest that nutritional and food insecurity are still significant across the region. Moreover, these issues are often associated with a dependency on conventional production systems, which we argue are unsustainable.

For example, FAO data for the 2010–2012 period suggest that some 72 million people were undernourished or food insecure, representing around 12.1% of the population of Southeast Asia, with significant variation within and among ASEAN member States. From 2014–2016 (using some projected data with provisional estimates) there seemed reason for optimism; nevertheless, still some 60.6 million people were undernourished and facing food insecurity, out of a global total of around 795 million people. This figure still represents around 9.6% of Southeast Asia's overall population (FAO, IFAD and WFP, 2015). Essentially, then, despite modest improvements in recent years, the existing and dominant conventional agri-food system still does not adequately serve basic needs for food security, subsistence, socioeconomic or health for almost 10% of Southeast Asia's peoples. There are potentially many reasons for this persistent and troubling reality, most of which lie outside the scope of this article.

However, one major contributing factor to Thai farmers' poverty (and associated food insecurity) is arguably the lack of appropriate knowledge, proper training and low educational achievement (Saranchi, 2015). The right kinds of knowledge and applied learning then, we would assume, if used correctly, could help farmers better manage their farms more efficiently to improve productivity, ensure income consistency, and enhance their standard of living. However, there is limited research on how this gap in rural education, training and extension of various kinds may have contributed to environmental or food insecurity problems (or solutions).

Some research has begun to explore related issues. As we have demonstrated elsewhere, the public extension system in Thailand has not (so far) effectively addressed such concerns, especially the dependence of both farmers and governments on agro-chemicals (Nelles and Visetnoi, 2016).

Through some follow-up work we also wanted to know more about the role of Higher Education Institutions (HEIs) in providing more ecologically oriented Agricultural Extension Services (AES) for farmers that might provide alternatives to conventional agriculture. So in 2016 we undertook a small project supported by Chulalongkorn University to study agricultural extension services among selected Higher Education Institutions (HEIs) of Southeast Asia and their roles in environmental sustainability, food security and rural development. Our one year study: *"Mapping and Assessing University-based Farmer Extension Services in ASEAN through an Agro-ecological/Organic Lens"* was led by Chulalongkorn University School of Agricultural Resources (CUSAR). With limited resources our initial Chulalongkorn University supported research focus was on five countries: Indonesia, Lao PDR, Philippines, Thailand, and Vietnam. However, with the granting of complementary funding from other sources we added three additional countries to our study – Cambodia, Malaysia and Myanmar.

SWOT analysis for Agricultural Extension Services in each country

In Table 1 below we summarize problems and key challenges concerning the Agricultural Extension Services System (AESS) in the region as well as university-based support to farmers. We do this through a classic Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis in the five selected Southeast Asian countries covered by our Chulalongkorn University project. These SWOT results derive

Table 1 SWOT analysis for AESS for selected countries in SE Asia

STRENGTHS	WEAKNESSES
Indonesia: • Number of qualified experts • Demonstration plot and field station • Strong curriculum for agricultural extension	**Indonesia:** • Limited financial support and infrastructure • Limited market accessing power
Lao PDR: • Government has vision and clear strategy in supporting green agriculture • Availability of teaching and learning program to support agricultural extension and organic agriculture in both Bachelor and Master degree.	**Lao PDR:** • Higher price for organic products • Lack of impact assessment of organic farming and agroecology extension at grass root level
Philippines: • Local Government Unit started to promote organic agriculture more	**Philippines:** • The majority of agricultural curricula are based on use of conventional or chemical-based production practices • Lack of integrated and coherent support mechanisms for agroecology and organic agriculture
Thailand: • Many HEIs experts and qualified scholars in agriculture • Locations of HEIs and distribution across country • Good network between institutions • Availability of budget and funding • Good National Policy	**Thailand:** • Insufficient focus on sustainable agriculture (SA) such as organic agriculture (OA), agroecological (AE) farming education and extension, both, in farmers and scholars • Insufficient availability of training courses and tools for OA and AE • Lack of systemic linkage between organization to work together in improving AESS • Insufficient courses/ subjects for AE students especially in OA, AE e.g. integrated farming etc.
Vietnam: • Government has emphasized and seen the importance of agricultural extension system	**Vietnam:** • Lack of human resource such as experts and skilled workers in extension field • Lack of market brands of products
THREATS	**OPPORTUNITIES**
Indonesia: • A dominant roles of agrochemical industries • Climate change • Cost for organic product certification • Higher price for organic products	**Indonesia:** • Increase market for healthy and safe product • Collaboration between universities and related stakeholders
Lao PDR: • Low association between its Ministry of Agriculture and Forestry • No specific research fund to support research in organic farming and agroecology • Unbalanced workload for teaching staff i.e. only 20% of working time spent on research	**Lao PDR:** • To expand extension services in agroecology to local farmers and students as well as consumers
Philippines: • Lack of land tenure for small farmers i.e. lack of land ownership • Inadequate support (or minimal) from government when compared to the previous promotion of the Green Revolution in the past i.e. conventional farming	**Philippines:** • Increasing demand for organic agriculture products
Thailand: • Lack of effective way to implement policy (proper/ consistent implementation) • Bureaucracy and lack of integration and cooperation among and within government organizations • Inconsistency of support and funding and policy for OA and SA • Reduction of students and research in field of AE	**Thailand:** • Create network between HEIs in the region and local government • Provide more tools and academic services to enhance and encourage more SA (OA, AE), both, for universities and rural communities
Vietnam: • Overuse of agrochemicals • High incidence of poverty • Environmental degradation	**Vietnam:** • Discipline of smallholder farmers in taking care of their own farms

Source: Nelles (2017)

Note: A more detailed overview of these five-country case studies and the SWOT analyses can be found in published proceedings of a research symposium held in February 2017 to discuss and compare findings among our partners (Nelles, 2017).

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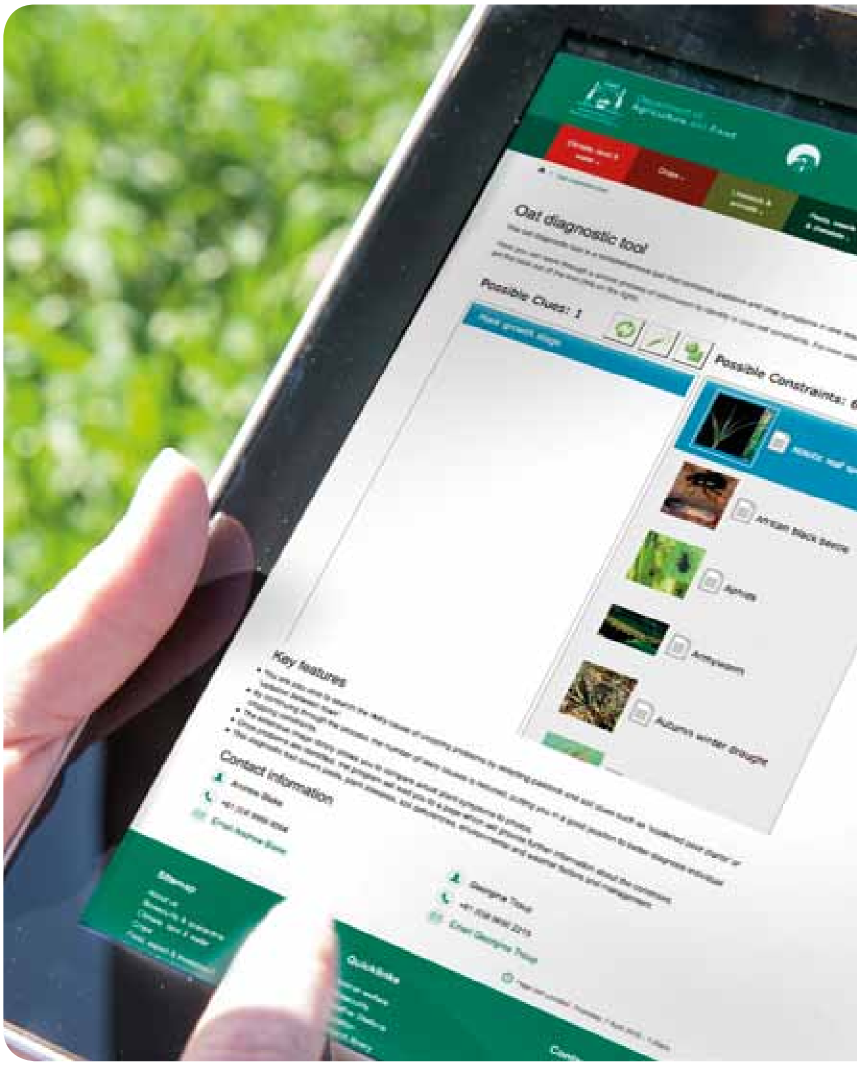

directly from our research partners in the respective countries.

To illustrate some key themes, there is an increase in the role of universities in Indonesia undertaking research into organic farming methods and supporting related infrastructure due partly to increasing establishment of demonstration plots and farms. The Philippines, on the other hand faces a problem of limited numbers of skilled workers and academic experts. Vietnam, although it has had a formal agricultural extension system for more than two decades, still faces numerous challenges, especially in terms of a lack of specialized human resources. In Thailand, the government focuses more on industrialized agriculture while it lacks a clear policy and effective implementation to support organic agriculture. Similarly, Lao PDR faces rapid expansion of commercial agriculture, associated with intensive use of agrochemical inputs. In none of these five countries does any AESS help to guarantee food security for all citizens.

Conclusion

Our research suggests that a lack of, or poorly implemented, systemic program and institutionalized linkages have constrained the ability of university researchers to apply their research outputs to farmers, or to design, develop and deliver meaningful extension services to farmers. We therefore suggest that universities must find better ways to work with farmers and communities, especially through cooperation between university projects and local government agencies. There are some constraints to implementing such an approach, since most

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academic resources are bound to a specific domain, and are often dependent on project funding and the interests of individual researchers.

Nonetheless our comparative SWOT analysis has identified many common issues and problems among the countries studied, especially in terms of lack of expertise, budget and support for teaching and research as well as the lack of linkages and cooperation among key stakeholders.

Another concern (with respect to the Thai case, for example) is that the pedagogical content of agricultural education and extension services have been influenced by modern agriculture and technology methods, i.e. conventional agrochemical-intensive farming. At the same time, there is some evidence of progressive trends toward more curricula and programs that have emphasized SA or OA. However, this may be insufficient, especially if universities should provide training courses about OA or SA to farmers. In sum, more systemic study is required in order to better understand the underlying causes of environmental problems in agriculture, how they relate to food security or insecurity, and innovative ways to mitigate these. We need to rethink and redesign AESS for universities accordingly.

Future recommendations and suggestions to improve AESS for HEIs in Southeast Asia:

- Provide better support or incentives to scholars for sustainable agriculture and organic agriculture research from governments.
- Increase number of experts and skilled officials to provide a cadre of graduates and workers

that have sufficient knowledge and be able to train and advise farmers in the field in approaches such as agroecology and organic farming.

- Create real-world channels and approaches that incentivize cooperation between researchers and governmental agencies at all levels, to meet the real-world needs of farmers.
- Set up a system to facilitate research and funding that could allow more interaction between HEIs and government agencies.
- Promote establishment of more training programmes in universities to enhance access by small farmers to adequate, science-based education and training.
- Provide more funding and budget for teaching and research on organic agriculture and/or agroecology.
- Require more systemic research and adequate documentation or programmes, courses, teaching, faculty as well as the problem of student recruitment and lower enrollment levels.

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Article

Development and Modification of Local Plant Protein Used as a Safe Food Additive: Coconut Protein

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Introduction

Concern over food safety has increased in recent years, with the growing incidence of food contamination by pathogens, pesticide residues or other chemicals. These incidents result from increased industrialization and poor regulation, leading to behavioural change by supply chain actors, including food manufacturers and distributors, inspecting organizations and consumers. Food manufacturers attempt to increase product safety by selecting high-safety ingredients, using natural substances instead of synthetic chemicals, and improved manufacturing processes to minimize or eliminate risk of contamination. Such changes are essential to build and sustain consumer trust, for example through products that are *"chemical-free"* or *"eco-friendly"*.

Food additives, seasoning additives and functional substances, are used to improve the food's colour, taste, or other qualities, are a potential source of risk if used inappropriately in food manufacture. Emulsifiers are an important category of food additives used to ensure homogeneity in the product, for example in products such as mayonnaise which contain non-miscible liquids (water and oil). Emulsifiers are traditionally synthetic in nature.

To replace the use of synthetic chemical emulsifiers, modified coconut protein was studied as a potential natural and safe alternative to synthetic emulsifiers and surfactants such as polysorbate and sorbitan ester (under trademarks such as Tween and Span, respectively) and other substances. Use of coconut protein also increases the overall protein content in the food product, and may offer other nutritional benefits such as prophylaxis, antioxidation and activity against free radicals. Synthetic food additives do not exhibit such properties. Also, improving and modifying coconut protein will increase the available options that will add to the range of uses for coconut and its products, increase coconut's value, and make use of by-products from processing coconut oil.

https://www.bioriginal.com

http://smallmoleculetechnologies.com

Theory and concept of developing and modifying coconut protein

Coconut (*Cocos nucifera* L.) is important to the economy of Thailand and other tropical South East Asian countries, especially Indonesia and The Philippines. Overall production is 50-60 million tonnes per year (FAO and APCC, 2013; Thaiphanit and Anprung, 2016a).

Fresh coconut comprises approximately 35.2% fat, 3.8% protein, and 40.0% water. It also contains dietary fibres, carbohydrate, potassium, copper, and iron (Kwon, Park, and Rhee, 1996). The meat (kernel) of young coconut fruits is thin and soft. It becomes thicker and harder as the fruit ripens, with each used for different culinary purposes. Coconut meat is processed for use in many food products such as coconut oil, thick coconut milk, dried grated coconut meat, and coconut sugar. Today, virgin coconut oil produced using cold press method is increasingly popular among health-conscious consumers, and generates considerable value-added. Demand for virgin coconut oil for food and cosmetics is growing continuously in international and domestic markets, such as in the Philippines, Indonesia, and Malaysia (Thaiphanit and Anprung, 2016b).

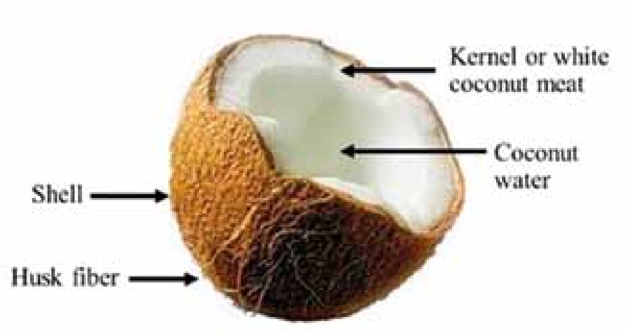


Figure 1 Parts of ripe coconut
Source: Thaiphanit (2015)

As by-products of production of virgin coconut oil, skim milk and insoluble protein have hitherto not found wide usage in the food industry, though they contain up to 33% protein when dry (Smith et al., 2009). Moreover, coconut protein contains all nine essential amino acids sufficient for the need of an adult, as recommended by FAO/WHO. The main acids are leucine, lysine, and valine. Coconut oil is also high in glutamic acid, arginine, and aspartic acid (Thaiphanit and Anprung, 2014), which can fight free radicals (Thaiphanit and Anprung, 2013). In the medical field, it is found that arginine from coconut protein can control blood sugar, serum cholesterol, and triglyceride level, as well as protect the heart (DebMandal and Mandal, 2011; Salil, Nevina, and Rajamohan, 2011). Studies of chemical structure reveal that coconut protein consists of globulin size 11S and 7S, which weigh 326 and 156 kDa, respectively (Thaiphanit and Anprung, 2016b). These qualities are similar to the qualities of soy protein (Palazolo, Mitidieri, and Wagner, 2003). Accordingly, this by-product offers an inexpensive protein source compared with that from milk or meat. Moreover, more studies about functional properties such as dissolution property, emulsification property, foaming ability, and other phytochemical properties of coconut protein are important in making use of coconut protein as a safe functional substance. It can replace the use of soy protein, which needs to be imported from other countries nowadays.

Therefore, the development and modification of local plant protein to be used as a safe food additive aim at producing a natural functional substance from coconut protein. The natural functional substance is to be used as an emulsifying agent, using an enzymatic technique, and is ready to be used in manufacturing, both in food and cosmetics products.

Development and modification of local plant protein used as a safe food additive

The research methodology used in the investigation is described below.

1. The aim was to prepare concentrated coconut protein in order to obtain coconut protein powder containing at least 80% protein concentration by weight, with a minimal amount of denaturing. The cooperation of 100 Phan Maprao Thai group, Prachuab Khiri Khan Province was sought to obtain coconut skim milk and precipitated protein (the by-product of virgin coconut oil production). Isoelectric precipitation was used to the separate protein (Thaiphanit and Anprung, 2013, 2014, 2016b), followed by freeze drying.
2. The physicochemical and functional properties of coconut protein were investigated, including the types and amount of amino acid, as well as antioxidation, solubility and emulsification.
3. In modifying coconut protein, it is essential to select a modification technique that is safe for both researchers and the resulting food product. Consequently, food grade enzyme was used to modify the coconut protein for this study. Enzymatic techniques are more preferable than chemicals for protein modification, due to its specificity, ease of control over the reaction, low risk of unwanted by-products or contaminants, and the ability to ensure a mild reaction (Anprung, 2004).

Results of development and modification of local plant protein used as a safe food additive

After studying the preparation of thick coconut protein using the by-products of production of cold pressed virgin coconut oil from fresh coconut meat as raw material, the result shows that the by-product has potential as a useful raw material in producing coconut protein powder. The resulting protein powder is pure, fine and soft white in colour, with a mild aroma of coconut milk (Figure 2). It contains all nine essential amino acids (Table 1), and the process has a yield of 4.56%.

The resulting coconut protein has clear antioxidant and emulsification properties, especially on soybean oil and virgin coconut oil in water emulsion. However, it was found to be unsuitable for palm olein oil in water emulsion. In conclusion, natural coconut protein can act as an emulsifier, but with moderate emulsification properties.

Figure 2 Coconut protein powder from by-products of production of cold pressed virgin coconut oil
Source: Thaiphanit (2015)

Table 1 Types and amount of amino acids found in coconut protein

Essential amino acid	Amount (g/100g)	Non-essential amino acid	Amount (g/100g)
Histidine	2.2925	Alanine	3.6468
Isoleucine	2.0545	Arginine	12.2219
Leucine	4.7699	Aspartic acid	8.6481
Lysine	3.3476	Cysteine	1.6299
Methionine	1.5512	Glutamic acid	21.6721
Phenylalanine	4.3078	Glycine	3.9061
Threonine	2.7611	Proline	3.3710
Tryptophan	1.3807	Serine	4.1111
Valine	3.3253	Tyrosine	2.1073

Source: Adapted from Thaiphanit and Anprung (2016b)

Its Emulsifying Activity Index (EAI) was measured at approximately 42 m^2/g. Its low solubility represents a second drawback. It can dissolve only as much as 50%, and with lowest solubility at pH 4.5 (Figure 3 and 4).

Hence, to improve the functional properties of coconut protein so, it is essential to modify the protein using two types of food-grade commercial proteinases (Alcalase and Flavourzyme), at between 8-14% degree of hydrolysis (DH). The results show that each type of enzyme caused changes in terms of polypeptide size (Figure 5) and surface morphology (Figure 6). This leads to significant improvements in antioxidant and surface activity at the interfaces (air-water, and water-oil), solubility, and emulsification.

However, coconut protein modified using Alcalase had higher antioxidant and surface activity than was obtained using Flavourzyme, but had a lower percentage of protein solubility. Coconut protein modified using Alcalase at DH 8% resulted in the highest antioxidant and surface activity. This shows that modifying coconut protein using low DH

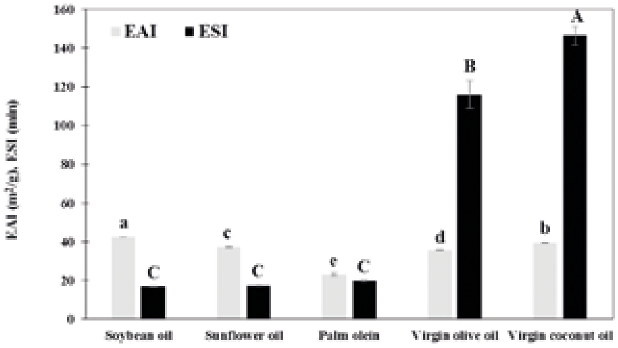


Figure 3 Emulsifying properties of coconut protein

Source: Thaiphanit (2015)

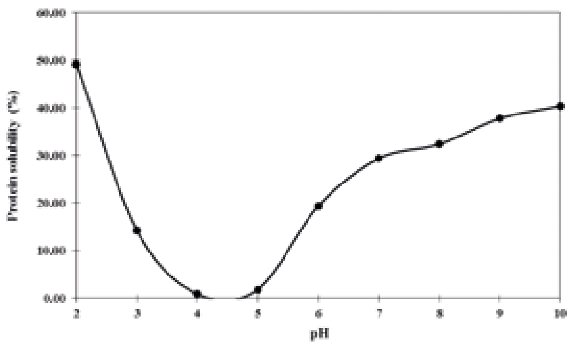


Figure 4 Soluble properties of coconut protein

Source: Thaiphanit (2015)

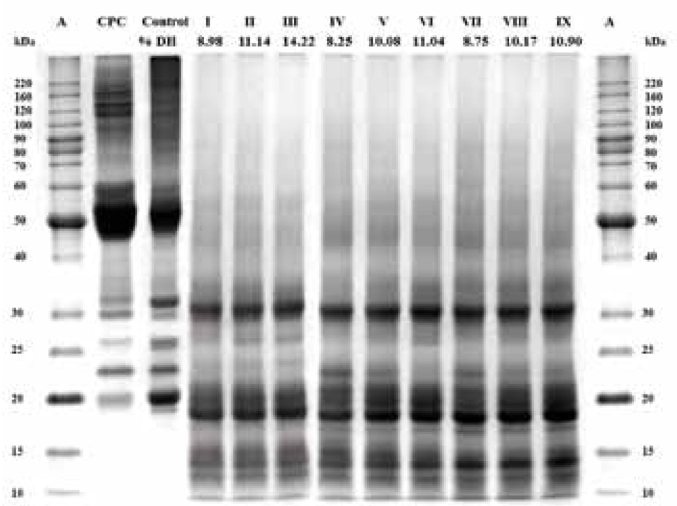
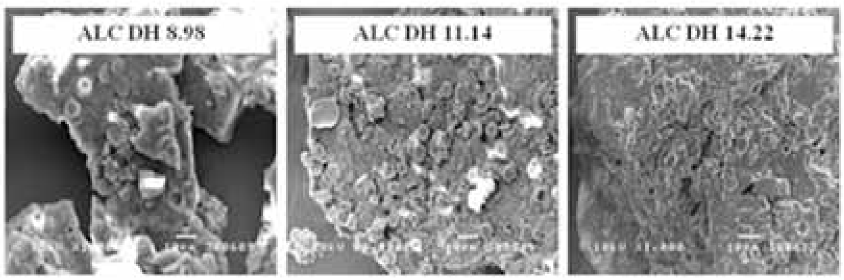


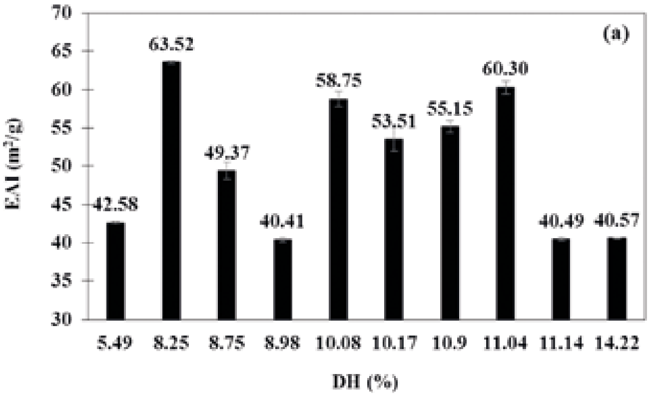
Figure 5 Example picture from SDS-PAGE, showing polypeptide size in coconut protein, modified using Alcalase
Source: Thaiphanit (2015)



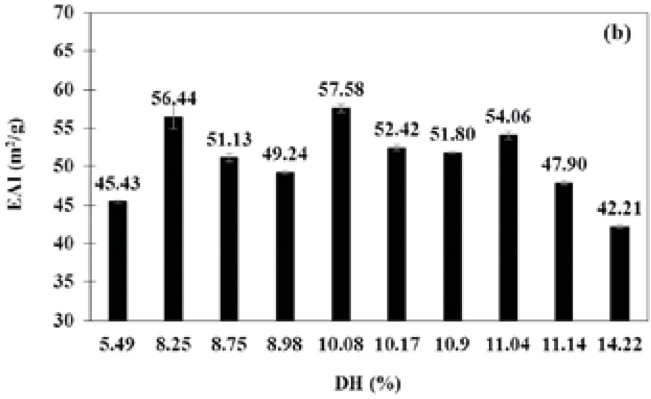
(A) Degree of hydrolysis of coconut protein using Alcalase
between 8.98%, 11.14%, and 14.22%

(B) Degree of hydrolysis of coconut protein using Flavourzyme
between 10.25%, 12.60%, and 14.37%

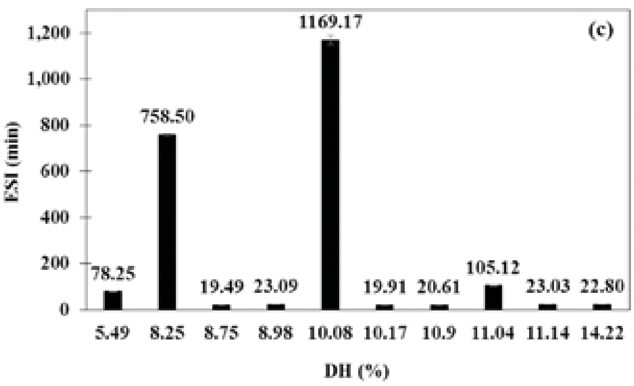
Figure 6 Example pictures from SEM, showing surface morphology of modified coconut protein
Source: Thaiphanit (2015)



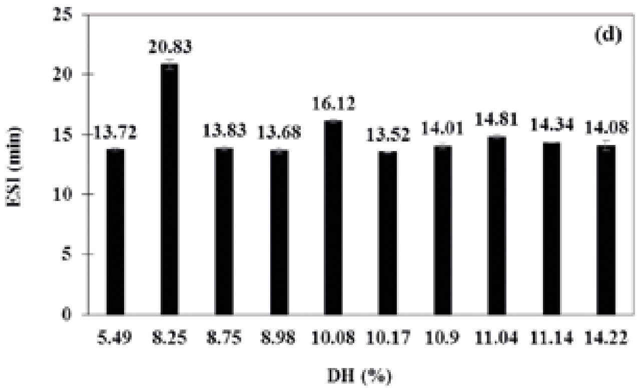
Emulsifying Activity Index (EAI) of modified coconut protein in virgin olive oil in water emulsion



Emulsifying Activity Index (EAI) of modified coconut protein in sunflower seed oil in water emulsion



Emulsion Stability Index (ESI) of modified coconut protein in virgin olive oil in water emulsion



Emulsion Stability Index (ESI) of modified coconut protein in sunflower seed oil in water emulsion

Figure 7 Example pictures showing emulsifying properties of coconut protein, modified using Alcalase at degree of hydrolysis between 5.49-14.22%
Source: Thaiphanit, Schleining, and Anprung (2016)

Alcalase can be used as a mixture to promote health, because of its antioxidant and emulsification in food. In addition, it can dissolve best at 66% and has the highest EAI at 79 m^2/g. Nevertheless, due to heat reaction inhibition in enzymatic modification, the resulting coconut protein was slightly brownish in colour.

Conclusion

The study examined the utility of modified coconut protein as a safe alternative to synthetic emulsifiers in food. In this project, the by-product from production of cold-pressed virgin coconut oil was used as raw material. The enzymatically modified coconut protein powder was found to have good potential for this purpose at DH 8-10%, using two types of food-grade commercial proteinases (Alcalase and Flavourzyme). The resulting coconut protein powder was superior to non-modified coconut protein powder in terms of its emulsification, antioxidant and other properties.

Acknowledgements

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Rice Production Cost Reduction Program and Credit for Delayed Sale of Wet Season Unpolished Rice Project

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Introduction

Rice is one of Thailand's most crucial food and agricultural commodities, and an important source of export earnings. Moreover, rice is the country's main staple and is at the heart of the culture for Thai people. For over 30 years, Thailand has been the main player in global rice exports. However, rice farmers are among the poorest people in the country. That is mainly attributed to cheap and fluctuating prices due to inconsistency between demand and supply in the rice market. Price fluctuations make it difficult for farmers to plan their production and sale. Such situation has led to extremely high levels of indebtedness among rice farmers, both to government-owned banks and loan sharks.

Many governments have attempted to help farmers, including providing aids on production, price regulation, and marketing. However, those policies failed to help farmers in the long run because most governments focused mainly on short-term solutions such as price regulation (Laiprakobsup, 2014) rather than helping farmers plan their cultivation. Another problem is the policy itself, which hampers farmers' access to government support. To demonstrate, farmers received only 37% of the benefit from the entire budget from the rice pledging scheme, while downstream businesses and government agencies shared an equal proportion (Siamwalla and Poapongsakorn, 2007). Furthermore, farmers who are poorer, have less budget and small production volumes are likely to receive a lower level of support than business sectors or farmers who are better positioned financially. This problem leads to the issue of policy inequality where poorer farmers have less access to government support measures than richer ones (Laiprakobsup, 2017; Benchakhan et al, 2014). Worse than that, these policies cannot be successful due to the notorious opportunity for corruption during many processes along the way (Siamwalla et al, 2016).

Based on the history of agricultural problem-solving policies and action comes the research entitled "*Policy Control, Agricultural Produce Oligopoly, Policy Inequality, and Underdevelopment in Agriculture: A Case Study of Thai Rice*", the purpose of this research is to analyse and elucidate the underdevelopment of Thai agriculture by surveying how policies are formulated and implemented to help farmers in the field. The research identifies causes of problems in Thailand's agricultural development and policy implementation that affect farmers and the entire farming sector, including rice.

Research methodology

The researchers divided the scope of the research into two parts. The first part discusses policy implementation by the Thai government and the policymaking process from 2001 until the present time. The second part involves policy implemented to help rice farmers in the field. Data were collected using focus group discussion with farmers from the Central Region, North-eastern Region, and the Southern Region of Thailand. Issues discussed as potential causes of underdevelopment included policy monopoly, policy dependency, and policy inequality.

Data were collected from 600 farmers from 8 provinces of the three regions mentioned above, from September 2016 to February 2017 (Table 1). The average age of the focus group discussion participants was 50 – 60, with average education at only primary level. The selected sample group was based on varied geographical characteristics of the land

Table 1 Focus group discussion with farmers from 8 provinces

Province	District	Date
Surin	Mueang Surin and Prasat	9-11 September 2016
Suphan Buri	Sam Chuk, Doem Bang Nang Buat, and Mueang Suphan Buri	23-25 September 2016
Phra Nakhon Si Ayutthaya	Uthai and Sena	14-16 October 2016
Si Sa Ket	Uthumphon Phisai, Khukhan, Phahu, and Kanthararom	18-20 November 2016
Roi Et	Selaphum, Suwannaphum, and Thawat Buri	10-12 December 2016
Phichit	Pho Thap Chang	31 January-1 February 2017
Phatthalung	Mueang Phatthalung and Pa Phayom	11-12 February 2017
Nakhon Si Thammarat	Hua Sai, Chian Yai and Pak Phanang	13-14 February 2017

Source: Phakhin Dumphupha (2016)

Figure 1 Field survey of rice production, Suphan Buri Province
Source: Kan Sangtong, taken in September 2016

Figure 2 Farmer sun-drying rice, Si Sa Ket Province
Source: Kan Sangtong, taken in November 2016

Figure 3 Community rice miller in Phatthalung Province
Source: Kan Sangtong, taken in February 2017

i.e. lowland and upland, the number of growing seasons (1 – 3 seasons per year), distance of their farms from water sources (within or outside of irrigation area), type of plantation (growing rice as a single crop or mixed farming system). In addition, in selecting the sample group, the researcher also considered political preference of the farmers which is a crucial factor that influences their opinions toward certain government policies.

Two topics were discussed. The first topic concerned agricultural production systems, socio-economic factors, and property ownership of farmers. The second topic involved farmers' access to government support. On the second topic, the researchers applied thematic analysis (Braun and Clarke, 2006) as the question guideline for the discussion. Questions were mainly directed towards the manner of access to support purportedly provided to farmers, administration of government agencies relevant to the policy implementation, production costs, and obstacles to farmer access to government support schemes.

Regarding the rice pledging scheme, the researchers applied process tracing technique (Bennet and George, 1997) by asking respondents about accessibility to the scheme and the impact of the implementation of the scheme. The questions were mainly *"why"* and *"how"* in order to systematically identify how the scheme impacts farmers. The researcher asked the focus group discussion participants on issues relating to the production systems when the scheme was active, and the cost of producing, cultivating, and pledging their rice.

By using a semi-structured focus group method, the researchers asked participants to share their experience with the rice pledging scheme in order to evaluate its implementation by the respective government agencies. In addition, in some focus group discussions with some villages, some participants were representatives from Ministry of

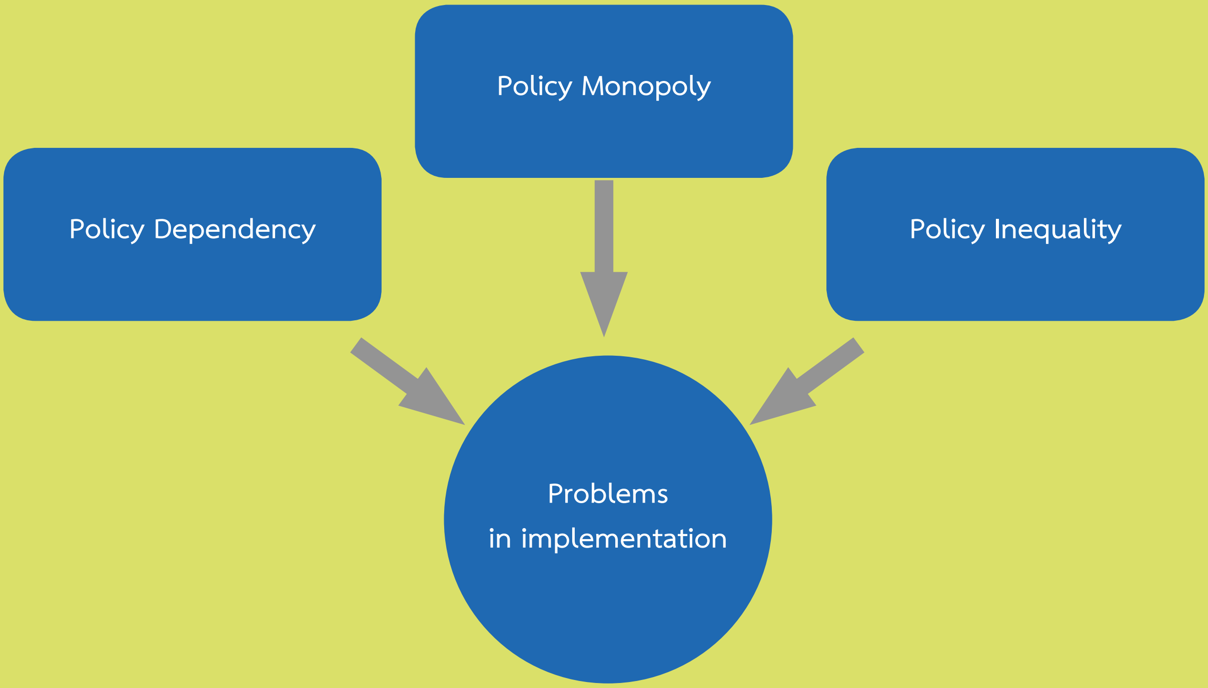

Figure 4 Problems in implementing farmer support policies
Source: Thanapan Laiprakobsup, designed on 20 June 2017

Agriculture and Cooperatives, Bank for Agriculture and Agricultural Co-operatives, and executives of local administrative organizations. The participation of government agencies allowed them to answer farmers' questions directly. Apart from discussion with farmers in the study area, the researchers also took pictures of the actual fields to use as reference of production system and general context of the farmers in each respective area (Figures 1–3).

Problems in implementing farmer support policies

The failure to successfully implement the policies to help farmers was found to be caused by the following factors (Figure 4).

1) Policy monopolies involve vertical policy implementation. In a policy monopoly, the government defines how, when, and from whom the farmers will receive assistance. Policy monopolies also include policies implemented by certain government agencies, agricultural business, and certain groups of farmers (e.g. agricultural cooperatives), which offer preferential support and do not allow farmers any say in implementation. Examples include farmer registration and rice quality inspection. These policy monopolies are evident in the rice pledging scheme and the rice production cost reduction programme.

2) Policy dependency refers to a situation in which policies are implemented so that farmers must depend on the government's help in growing, harvesting, and marketing (Benchakhan et al, 2014). In this case, if the government has no effective support policy in place, farmers are likely to encounter problems with both production and marketing. In other cases, policy dependency also refers to the fact that farmers depend on the government with respect to income. To clarify, their income tends to be lower if the government does not have a policy to help. A clear example of such policy dependency is the rice pledging scheme.

3) Policy inequality involves discrepancy of access by poorer farmers to support under government policies to help farmers (Laiprakobsup, 2017). Wealthy farmers are more likely to have greater access to support than resource-poor farmers with weaker financial status. Other causes could include dedication of agencies assessing the project, community-level relationships, and level of production to sell to the market. Inequality of access to government support in the central region (Phra Nakhon Si Ayutthaya and Suphan Buri) is reported to be more severe than in other regions. This is because rice farmers in the central region tend to grow rice to supply the market. As they grow only rice since their lands are more suitable for growing rice than other crops, farmers in the central region need to rent additional land to grow more rice to increase production volumes and increase their bargaining power with the authorities.

Results

According to the focus group discussion with farmers who were samples in this research, the implementation of short-term farmer support projects e.g. the rice pledging scheme and production cost reduction program, affected the farmers as explained below.

1) Rice Pledging Scheme

The discussions with farmers in the central and north-eastern regions (refer to Research Methodology) led to the following conclusions:

1.1) Farmers tend grow shorter-duration rice varieties so that they can supply to the rice pledging scheme as quickly as possible. This has reduced production of native varieties that are mostly long-duration. In the long run, this will eventually lead to extinction of native rice and loss of biodiversity.

1.2) Farmers need to spend more money at every step of production and harvesting. In particular, farmers must shoulder higher costs of labour and machinery for land preparation, cost of large amounts of high quality seed, and cost of input such as pesticides. These costs are spent to maximize yield, in order to break even for entering the rice pledging scheme. Cost of harvesting and transportation to the rice pledging site can also be high. During periods of oversupply or when the pledging site is closed, farmers must cover costs of queuing in the line to supply rice.

1.3) When costs are high, poor farmers usually sell their produce to merchants who could be middlemen, employer of industrial rice miller strolling in the area, or middlemen from different localities who patrol the area to offer their harvesting service. The costs that farmers have to spend for these middlemen or service providers are more affordable. However, the rice prices offered by these middlemen are lower than the standard price since they need to cover their own costs of transportation and profit margins.

1.4) Farmers frequently cannot sell rice at the standard pledging price due to excessive moisture content in the grain. Since the pledging duration is limited, farmers do not have enough time to dry rice to the specified moisture content. In addition, most farmers do not own equipment to measure the moisture content of their grain, leaving them reliant on the buyer's measurement.

1.5) Farmers have no say in the implementation of key processes such as moisture testing, rice drying process in a heating machine, stock maintenance and storage. This makes it impossible for farmers to know the quality of their product.

2) Production Cost Reduction Program or 1,000 Baht per Rai Program

The discussions with farmers in the central and north-eastern regions led to the following conclusions:

2.1) There is confusion over the process of farmer registration, especially those who rent the land outside their locality. Conflict arises between farmers and state agencies because it is hard to prove whether the registrant is really engaged in farming. In some cases, local administrative organizations and staff such as village headman and officials of sub-district administration organization offices can help in the negotiation to persuade farmers to join the programme. With problems being reviewed on a case by case basis, it is impossible for farmers to get the money at the same time. Some farmers receive immediate financial support, while others must suffer long delays. According to the discussion with farmers from the southern region in February 2017, which was well after the harvesting season, some farmers had yet to receive the promised financial support of 1,000 baht per rai.

2.2) The financial support barely covers the increased production cost. In the 2016-2017 growing season, the government plans to give farmers 1,000 baht per rai, up to a maximum holding of 10 rai. Therefore, the maximum level of support that farmers can potentially receive is 10,000 baht (Laiprakobsup, 2017), which is considered very low compared to the current production cost.

2.3) Farmers who rent land are likely to get lower support than land owners. Farmers renting land will typically be required or forced to share a percentage of the financial support with his landlord. This was found to be prevalent in the central region due to the high production volume and commercial mode of production. Farmers with limited land have no option but to rent additional land. This increases the bargaining power of landlords over farmers to demand increasing shares of the support provided under the scheme. According to the discussion, the division of financial support (1,000 baht per rai) is part of the agreement terms and conditions that many farmers in the central region need to accept.

Conclusion

Policy implementation with farmers should enable them to improve their way of production and marketing so that they can be self-reliant in the long run, rather than permanently dependent on government support. The recommendations from this research project are as follows:

1) The government should establish a policy to enhance and develop farmers on rice growing technique and technology rather than simply provide short-term price support. This will lower the level of dependency on government support. Also, a part of the budget can be devoted to developing efficient farming methods.

2) Farmers or their representatives should be allowed to join the policy implementation as the inspectors of these programs and schemes in order for higher participation in public policy and transparency of policy implementation by government agencies.

3) The policy implementation should be evaluated with a view to narrowing the severe inequalities in access to the support program and pledging scheme. For example, it should be evaluated on how much farmers have access to the information about the programs and to what extent the support measures reach the farmers.

Acknowledgement

This article is part of the research project entitled ***"Policy Control, agricultural produce oligopoly, policy inequality and underdevelopment of agriculture sector: a case study of rice policy implementation (CU-59-071-HS)"*** funded by Ratchadaphiseksomphot Endowment Fund to support in-depth research in high potential fields (cluster) in social development and human security, Chulalongkorn University.

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Food Safety toward Economic Structure in the New Era

Prof. Sirirat Kokpol, Ph.D. is the chairperson of Food Research and Testing Program, aiming to improve food quality and safety in a new economic era. Her efforts have led to certification in 2010 of the Food Research and Testing Laboratory of Chulalongkorn University under the ISO 17025: 2005 Standard.

Prof. Sirirat Kokpol, Ph.D.

Thailand is one of the world's leading food producers and exporters, generating a major contribution to the national economy. In 2016, Thailand became the world's 13th largest food exporter, up from 15th in 2015. Food exports in 2017 are expected to reach approximately US$ 27.4 billion, compared with US$ 26.3 billion in 2016. Fierce competition in global markets has been accompanied by imposition of increasingly stringent food quality and safety measures by Thailand's major trade partners (EU, USA, and Japan), aimed both at protecting their consumers and also as a non-tariff barrier for use in diplomatic and international trade negotiations. To ensure continuing market access, Thailand has to redouble its efforts to ensure global confidence in the safety and quality of Thai food exports in the global market.

Food safety and food security

"...Food security involves food nutrition, safety, and balance..."

Global food security has been increasingly threatened by political volatility and increasing natural calamities such as drought, flood and other extreme weather conditions. Food security is guaranteed when four distinct components are satisfied: 1) availability, 2) access, 3) utilization, and 4) stability. Food availability means that people have sufficient food of decent quality to meet their daily calorific and protein requirements. Food access refers to the ability to access that food (e.g. at an affordable price). Food utilization refers to the body's metabolic ability to take up and utilize the nutritional value of the food consumed. Finally, food stability refers to people's ability to consume food at all times, without risk of food shortages or a sudden famine. Despite Thailand's status as a global food producer, 5-15 percent of its population still suffers from hunger due to poverty and lack of education on how to fully utilize their crops.

Food safety measures are designed to ensure that our food is free from dangerous substances as defined by legislation and pursuant regulatory provisions covering food and consumer safety. Food hazards may be categorized as biological, chemical or physical in nature. Biohazards include pathogenic microbial contaminants that cause gastronomic, and other diseases. Chemical hazards include residues of pesticides, antibiotics, heavy metals, food additives as well as allergens such as seafoods, peanuts and wheat. Finally, physical hazards include danger from foreign substances such as metal, or glass particles.

Improving Thailand's economic competitiveness with food safety innovations

"...When consumers are assured of food quality and safety, with food safety guarantee, testing with international standard, Thailand's agricultural products can improve their value for exports..."

At a time of increasingly intense global competition, Thailand can use food safety innovation to improve the value of its agricultural exports product and thereby enhance international competitiveness.

Food safety can only be addressed through consideration of the whole supply chain. Upstream processes refer to primary production of raw materials, including cultivation or rearing, management of soil, water, fertilizers, pesticides, herbicides, harvesting and post-harvest management. Poor post-harvest crop management in particular is estimated to cause from 10-40% loss of harvested produce. In the livestock sector, upstream processes include animal husbandry, feeds, medicines, and slaughterhouse processes. Slaughterhouses need to fulfil with appropriate legally mandated risk assessment and Good Agriculture Practice (GAP) standards. Risk for Livestock facilities must be assessed and monitored periodically for notifiable diseases using test kits or by internationally accredited laboratories.

Midstream processes refer to post-production treatment of raw food produce that require standard controls, good manufacturing practice (GMP), and compliance with the internationally recognized system of Hazard Analysis Critical Control Points (HACCP). As essentially industrial processes, processing facilities are required to be subject to regular external inspection to ensure that the produce is processed by approved processes and is free from prohibited additives, preservatives, colouring or other synthetic chemicals used to artificially prolong the product shelf life, anti-fat substances, or growth hormones used to boost muscle mass in animal bodies. Apart from ensuring food quality and safety, production methods must also be environment-friendly, particularly in regard to waste production.

Downstream processes refer to post-production activities such as packaging, transport, storage and retailing. During this stage, food products fall under the legal purview of the Food and Drug Administration

(FDA), and need to undergo ISO 17025 certification. For example, canned fruit needs to be checked for pulp weight, nitrate, nitrite, and heavy metal residues. Their containers might need to be proven to be free from heavy metal and dangerous can sealing chemicals that may migrate into the contents. The results from these analysis are to be sent to FDA for consideration to receive a nutrition labelling license. Other requirements include a clear description of storage life, any food allergen content and presence of genetically modified organism (GMO) in the food.

To ensure control over any hazardous contaminant found in a food product on a retail shelf, a traceability system is required to identify the original source back up the supply chain to transportation, processing facility and often to the individual farmer. Traceability systems vary in sophistication depending on the nature and value of the commodity and the supply chain structure, but in all cases, data must be fully recorded in a traceability system and be available for inspection in the event of a food safety incident. Currently, NGOs and public interest groups such as the Thailand Pesticide Alert Network (Thai – PAN) also work to provide checks and balances on official government safety and inspection systems.

Food safety measures build consumer confidence and increase the value of Thailand's food exports in international markets, counter attempts by destination markets to use food safety regulations as trade barriers to entry, and reduce government cost of the food poisoning patients treatment.

Development of food safety

"...From past to present, a number of measures, criteria, controls, and warning have been enforced in order to keep pace with competition in the global market..."

With tough competition in the global market and the emergence of trade barriers to food imports in destination markets, it is important that Thailand establishes and maintains trust with trade partners in term of product quality and safety by applying comprehensive control measures throughout the chain of custody from upstream, midstream to downstream. Thailand's Food Control Act was enacted in B.E. 2502 (A.D. 1959) and amended in 2009. In 2001, GMP has been implemented with 57 food products manufactured in Thailand. The Ministry of Agriculture and Cooperatives is in charge of supervising food exports while the Ministry of Public Health oversees and regulates food products manufactured and distributed in Thailand, including those imported. Following consultation with government and private sector organizations, the Thailand National Food Committee (TNFC) was established to propose policies and strategies to ensure food quality, safety and stability, and encourage farmers as well as manufacturing and processing factories to apply international standards and innovations such as smart food sensors and smart packaging. The Committee also offers guidance on branding and notifies the industry on forthcoming regulatory changes to be issued by international organizations as announced by the Department of International Trade Promotion so that they can prepare to ensure compliance and compete effectively on the global stage.

The application of food safety control measures in Thailand became evident to the public following a serious outbreak of avian influenza (bird flu) in 2003. The outbreak severely impacted Thailand's frozen chicken exports. By swift implementation of quarantine and control measures, Thailand was able to control the outbreak and ensure the quality of its chicken exports, maintaining trust among its trade partners, and ensuring Thailand's place in the world's top 5 frozen chicken exporters. In 2016 Thailand exported 47,190 tons of frozen chicken and salted chicken to Europe, valued at 3.768 billion baht.

In recent years Thailand also faced the prospect of EU bans on its exported vegetables when prohibited pesticides or excessive levels were detected. Since then, Thailand has tightened its control over imported pesticides to be used domestically. Pesticide imports are likely to be further restricted under a draft bill on pesticides (expected to come into force in 2018) listing types of pesticides permitted, preventive measures, and defining restrictions on usage.

Obstacles to obtain food safety in Thailand

"...Consumers still lack awareness, knowledge and understanding about the dangers of unsafe food. Should they be aware, they would reject those foods. Eventually, the manufacturers would need to adapt, otherwise they would not be able to sell their products..."

Lack of consumer awareness among consumers and food sellers represents a major barrier to food safety, particularly in regard to food handling and sanitation to prevent microbial contamination. Perhaps more seriously, many unscrupulous business owners and manufacturers do not care about the dangers of residues, additives, and preservatives and their potential impacts on consumer health and safety. Many SME manufacturers fail to install adequate standard controls and safety measures in their production facilities since these will increase production costs. This is where the government should step in to ensure compliance and protect consumers.

In order to address the gap, awareness and knowledge about food safety society should be instilled during childhood, especially at school; children need to know how to read, interpret and act on food nutrition and expiry details on food labels. Information about food safety should be regularly provided by the government and private sector alike as public information 'infomercials' (e.g. video clips, billboards, posters and other announcements to warn people about the dangers of unsafe food. For example, information about melamine detection in powdered milk for babies should be announced publicly. When consumers are informed of such knowledge, they can make the right decision to not buy the product. Naming and shaming unscrupulous manufacturers or distributors would quickly incentivize implementation of more stringent food safety measures, in order to avoid potentially unrecoverable business loss and even bankruptcy.

Within the public regulatory system, redundancies in tasks are frequent among agencies. An integrated coherent system is required to address such redundancies and boost effectiveness. Other problems such as inefficient traceability systems and insufficient manpower to assess risks, inspect production facilities, monitor production processes and conduct chemical analyses. Businesses, therefore, opt for testing by private accredited laboratories because of long delays in governmental inspection processes.

At manufacturing and distribution levels, training on food safety and storage provided to employees requires upgrading, including periodic retraining. However, for cost reasons manufacturers are generally unwilling to do more than the minimum legal requirement for staff safety training. It is recommended that the government intervenes to address this shortcoming.



The importance of food safety viewed by Thailand and other countries

"...If imported products are found unsafe, they may be suspended, rejected, or even banned from future exports. Modern research and development on safety analysis and root cause identification will certainly save Thailand's export sector..."

In many countries, safety measures are very strict because their consumers understand the importance of food safety. Label information in such countries requires much more than food nutrition, but also a listing of substances that may be dangerous to some consumers, including allergens (peanut, wheat, soy, seafood). Although export products are subject to random checks and certified by the government, when they arrive at the entry point of the destination country, the products again undergo random inspection. Thailand is among many countries whose projects have been rejected at the destination point of entry on the basis of such analysis, where microbial or chemical contaminants are detected at proscribed levels. In such cases, the products are rejected or returned, and the country of origin may be subject to a warning or if the violation is repeated, banned altogether from future exports to that market.

Food analysis laboratories and researchers in government organizations should work to develop modern techniques to identify food safety issues in order to assist Thailand's export sector.

Currently, controls over food product standards in Thailand are less stringent than in some other countries. This is partly because of a lack of consumer and producer awareness, and partly because food safety requirements impose additional costs to manufacturers. Moreover, the lack of control in the domestic market incentivizes manufacturers to require lower safety standards for produce destined for domestic products, compared with very stringent requirements for export products. Although the government has insufficient manpower, it is found that the government has always recognized the importance of food safety. For example, in the past, there was a case of school students suffering from diarrhea from their daily milk consumption at school. The government responded to that case by promoting the replacement of pasteurized milk at schools with UHT milk, which has a longer shelf life.

Direction of food safety development in Thailand to support economic structure in the new era

"...There are many dimensions about the direction of food safety development and value adding to support economic structure of Thailand, starting from the upstream, midstream, and downstream stages..."

There are many aspects to the direction of research development for food safety and value adding to support economic structure of Thailand starting from the upstream, midstream, and downstream stages. The upstream stage starts from growing to harvest that prevent losses. This may also include the development of stronger strains of plants that are more adaptable to the weather, resistant to diseases and insects. The upstream stage can cover good care and inspection of soil, water, stress-free animal husbandry, development of livestock that is disease resistant and grow better meat, the research on herbal use instead of chemical pesticides or fungicides.

The midstream stage focuses on development of safe production processes. Some key challenges include the need for research on packaging that preserves freshness and flavour, in which Thailand lags other countries. Midstream development can also include research on natural products to replace chemical additives, preservatives and colouring, and development of alternative foods for people who have allergies or sensitivities, for instance, using wheat, or corn instead of rice, or soybean milk instead of dairy milk. Some other research projects may tackle health issues for certain illnesses such as kidney disease, diabetes, or food for obese people. Research topics on local foods with background stories and on texture, smell, flavour, and colour, or faster cooking times also have room for improvement.

For downstream development, research projects could explore new techniques for analysis and minimizing sample preparation steps in order to achieve specific methods with high sensitivity that can detect the problem quickly and detect even low levels of contamination. The new methods should also be able to detect contamination of foreign, unwanted, or dangerous plant or animals such as BSE (mad cow disease). There could be a technology specifically for inspecting halal food. A cost-effective technique for detecting GMOs in foods would also be valuable as an analysis tool for foods destined for Europe. At present, in order that domestic consumers can analyze food safety easily and cheaply, some test kits have been developed by department of medical sciences to allow producers, farmers and individual consumers to inspect food. However, researchers are still working on the paper-based check, using polymer films or probes which are cheap, easy to use, visible, and able to detect even low levels of contamination. These tests are based on cross-disciplinary applications of domains including chemistry, molecular biology at DNA and RNA level, and materials science.

However, despite the availability of handy test kits, export products or those requiring quantitative data still need to use the services of laboratories accredited to ISO/IEC 17025 Standard in order to conform to the requirements of the importing county and to be competitive in the global market.

Food Research and Testing Laboratory (FRTL) of Chulalongkorn University is situated on the 16th floor, Mahamakut Building, Faculty of Science. FRTL provides the analysis service on microbe, chemistry, molecular biology, food storage life, and certification for food products to be listed on the website of the following government agencies.

- ISO/IEC 17025 : 2005 Accreditation accredited by the Bureau of Laboratory Quality Standards, Department of Medical Science, Ministry of Public Health (22 January 2010)
- Registration by the Food and Drug Administration, Ministry of Public Health March 2009 as a melamine and melamine analogues testing laboratory
- Registration in the recommend laboratory list for food formulation and labelling registration of the Food and Drug Administration (6 August 2012)
- Registration as a ISO/IEC 17025: 2005 accredited laboratory by the National Bureau of Agricultural Commodity and Food Standards (8 February 2011)
- Registration in the recommend laboratory list for health certification approval by the Bureau of Quality Control of Livestock Products, Department of Livestock
- The Ministry of Health, Labour, and Welfare (MHLW) of Japan
- Department of Livestock Development Ministry of Agriculture and Cooperatives (21 April 2017)

Prof. Sirirat Kokpol, Ph.D.

is the director of the Food Research and Testing Laboratory, Faculty of Science, Chulalongkorn University; former deputy dean in research and head of the Chemistry Department, Faculty of Science, Chulalongkorn University, and chair of the Bachelor of Science in Applied Chemistry Programme.

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"Around us"

Assoc. Prof. Thavivongse Sriburi, Ph.D.

Food Security

Food security is emerging as an increasingly critical issue for all countries, particularly as the impacts of climate change become more apparent. The agricultural sector is most vulnerable to such impacts, and countries need to enact preventive and defensive measures as a top priority. Food security is impacted by a range of interacting factors including loss in productivity due to excessive use of chemicals, environmental damage caused by exploitation of natural resources and associated ecosystem damage, amongst many other anthropogenic causes. Despite these grave, widespread and intensifying impacts, most people have a limited awareness and understanding of climate change, its drivers and consequences.

Increasing global population imposes ever-increasing demands on a finite production area to feed the world. Forecasts suggest that the world population will increase from its 2010 level of 6.5 billion to 9 million by 2050. Do we have a plan? According to the Food and Agriculture Organization of the United Nations (FAO) food security comprises five key aspects: 1) Availability; 2) Accessibility; 3) Distribution; 4) Safety; and 5) Sustainability. FAO (Food and Agriculture Organisation) defines food insecurity as *"A situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life"*.

Global population growth and the increasing frequency and severity of natural and man-made disasters impose increasing threats to food security. Without the ability to produce be self-sufficient in food, countries and their populations – and especially the poor- are at the mercy of global markets.

Although many countries, particularly in developing regions, are striving to find ways to increase the quantity and nutritional value of the food they


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produce as a means of achieving food self-sufficiency, productivity growth his threatened by multiple factors such as declining soil fertility, environmental contamination, loss of agricultural land and declining returns to crop breeding. Excessive agrochemical use and abuse is a particularly serious concern, affecting the environment, ecology and human health in multiple ways. Inadequate management of crop residues poses an additional challenge in many countries, with open field burning making a major contribution to airborne pollution as well as deteriorating soil conditions. As witnessed in the annual recurrence of haze from Indonesian forest burning, airborne pollution can carry over vast distances and result in international disputes.

Thailand has been fortunate in the abundance of its natural resources and favourable climate, and food security has been an issue for a relatively small minority. However, recent changes in annual weather patterns, including rising coastal and inland salinity, rising sea levels and the frequency and intensity of extreme weather events such as floods and droughts have highlighted the country's vulnerability. Declining availability of prime agricultural land due to urbanization, together with competing demands for water for residential and industry impose further pressure on an already fragile production area.

To address these intractable challenges, the current government has set new national goals and guidelines for Thailand. The "*Thailand 4.0*" blueprint comprises four key elements: 1) a transition from traditional farming to adopt innovative methods (known as Smart Farming) to transform small subsistence farmers into SMEs and entrepreneurs; 2) an evolution from traditional small and medium enterprises supported by the State to Smart Enterprises and Startups with high potential for growth; 3) a transition from *Traditional Services* with relatively low value-added into *High-Value Services* with increasing value creation; and 4) the transition from low-skilled workers towards a skilled workforce with knowledge, expertise and high levels of relevant skills for the new era.

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As part of the *"Thailand 4.0"* policy, food security will be a fundamental driver. However, this will need to be addressed in a sensitive way to preserve traditional cultures and landscapes while enhancing livelihoods and employment opportunities both in agriculture and off-farm, while at the same time ensuring that the production sector is market-led and not subject to highly damaging price crashes in perishable produce seen today, caused by poor planning and resulting periodic production gluts.

The government has devoted substantial efforts to address current issues in the agriculture sector, including the establishment of a balance between agriculture and nature, and also ensuring that crops are grown within their optimal zone, particularly considering water availability. However, such programmes have met with limited success due to inadequate and delayed public information and the limited options available for farmers. Farmers for the most part remain in a cycle of low production and indebtedness, focusing more on production rather than on quality.

Compounding the declining productivity of agriculture, labour availability is a constraint in almost all areas of the country. Farmers are leaving the land in record numbers and the average age of Thailand's farmers is now over 56. Agriculture is becoming more commercialized and dependent on contracted services e.g. for planting, spraying and harvesting. The traditional family farm, while not yet dead, is most certainly in serious decline.

Natural resource degradation is a fundamental issue that affects food security. Continuous availability of previously abundant resources such as water can no longer be taken for granted. Although successive governments have created many small reservoirs to increase local water storage capacity on the farm and retain water during the rainy season, such measures were opposed by certain influential elements. Poor coherence among government agencies has compounded the uncertainty felt by farmers in heeding the advice of government officers. A much greater degree of integration and cooperation among government agencies will be required in order to seriously address the problems of Thailand's poorest farmers.

A further problem facing farmers results from poor linkages between producers and the market,

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and deliberate manipulation by brokers and consolidators to cause price slumps for farmers. Middlemen may encourage over-production in the knowledge that at harvest, the market will be flooded and farmers will have no choice but to sell their perishable product immediately at highly discounted prices by the buyer i.e. economically, they will be price-takers. Such over-production occurs in crops such as pineapple, where an additional problem is seen. Pineapples are grown in open-field monocultures often under intensive management. Initial high productivity soon falls off in later years due to declining soil fertility, loss of organic matter and erosion. In many cases, the land is rendered unproductive for any crop after just a few years. The vicious cycle continues as farmers are forced to use more and more chemicals to reach the same yields.

Energy crops have found increasing interest as an alternative to food crops in Thailand- for example the production of cassava and sugar for ethanol production. Such energy crops need to be grown over wide areas and compete not only with food crops for land, but also other scarce resources such as water and labour. Therefore, to define a policy for *"food security"* need to analyze and consider the relevant factors including the possibility of future measures both in the short and long term and publicity and educate farmers to the general public. The sustainability of agricultural output needs to be considered from now because global shortages are imminent, competition higher, and food quality standards more stringent.

Food security is therefore an issue not only for farmers, but affects us all. Thailand remains fortunate in its abundant natural resources and conducive geographical conditions for agriculture. However, with current trends we cannot be complacent and it will be vitally important to secure Thailand's food supply and natural resources for its future population.

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Project

Biosensors for Rabies Virus Detection in Companion Animals

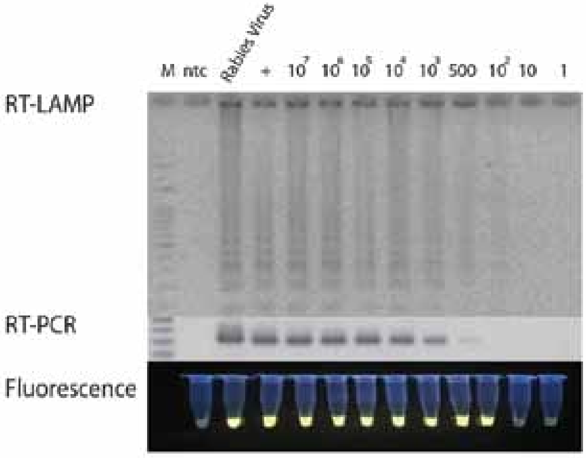
Assist. Prof. Piyasak Chaumpluk, Ph.D.
and Annop Suriyasomboon, DVM.

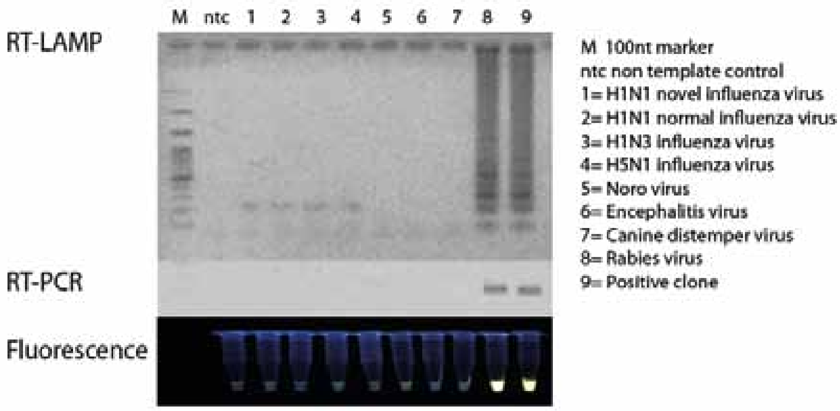
The live-threatening rabies disease caused by viruses in the Rhabdoviridae family is found in both livestock and poultry, causing tens of thousands of deaths worldwide annually. Dogs and cats are the most common source (zoonosis). The virus infects the central nervous system in particular, causing brain inflammation and eventual death. Rabies is the cause of encephalitis which was frequently seen in developing countries where stray dogs are uncontrolled or that have no rabies vaccine programme for animals. Thailand's vaccine programme itself cannot cover the country's dog population, resulting in a major reservoir of infection.

Currently, several rabies detection techniques have been developed; however, all are time-consuming and require sophisticated laboratory facilities, making them unsuitable for on-site assay, which is essential for effective control. **Chula Unisearch** has cooperated with Pro Test Kits Co., Ltd. In a research project to develop a biosensor for rabies virus detection in companion animals, as a basis for a test kit that can be easily used in the field for prevention, control and monitoring.

The development of a DNA sensor kit for rabies in companion animals began with the design of a method to extract and analyze samples for subsequent laboratory analysis using a sample from Queen Saovabha Institute.

Amplification technologies were compared to establish the optimal technique. The *Reverse Transcription Loop-mediated Isothermal Amplification (RT-LAMP)* which offered an advantage over other techniques such as the popular polymerase chain reaction (PCR) method was employed. Using a constant temperature of approximately 60-65 degrees Celsius. The temperature increase also complies with the temperature of the extract of genetic materials and the specificity of the primer set to 6 areas of target gene making the reaction specificity with 1,000 times higher than that obtained using PCR. The technique was also effective in increasing the quantity of genetic materials from the sample source. Moreover, reaction time was reduced from approximately 3 hours to only 25-40 minutes. The constant temperature eliminated the need to rely on a temperature controller, making it suitable for field application.





The product obtained from DNA enrichment was delivered in a long continuous zigzag pattern. The development of techniques for detection of DNA targets has also better in sensitivity. For signal detection, this project focused on developing an innovative model using physics' principles, especially biosensor approach. As a result, the analysis result can be achieved with more accuracy, easier and faster.

The application of biosensors evolved from their specificity and ability to convert biological processes into electrical signals in numeric format using a transducer. Biosensors allow greater specificity in DNA detection through complementary reactions between the probe and the target DNA.

The transducer may either convert the signal into electricity, e.g. by measuring conductivity, or by measuring changes in optical properties such as luminescence. The latter is a simple and rapid process that can be quantitatively calibrated to measure the concentration of DNA and in many cases can be measured continuously.

In this study, researchers have focused on the development of techniques and methods to amplify the quantity of genetic virus material obtained from a sample by comparing the genetic pattern of the virus strains with Thai and foreign reference strains on the basis of N gene and its nucleotide sequence information to provide a reference of primers designed to make RT-LAMP and methods of analysis results by using color molecules with a fluorescent probe. This enables accurate readings and allows more rapid DNA testing than it was via methods currently in use. Importantly, the developed method can be used in field, anywhere, anytime, and signals can be read and uploaded via mobile phone to a central database. The method thus offers an easy-to-use, accurate and practically useful tool for preventive control and monitoring. Research still continues to develop a market-ready product in the near future.

Sustainable Energy & Technology Asia (SETA 2017)

The Ministry of Energy and Chulalongkorn University by **Chula Unisearch** recently convened the ***"Sustainable Energy & Technology Asia (SETA 2017)"*** conference and exhibition at the Bangkok International Trade & Exhibition Center (BITEC). The event showcased the latest developments in energy, environment, science and technology in Asia. The event's four main themes were 'Sustainable energy policy and planning', 'Green transport and logistics', 'Low-carbon electricity generation', and 'Smart cities and green industry'. The event was honored to have ACM Prajin Juntong, Deputy Prime Minister presiding over the opening ceremony; Assoc. Prof. Thatchai Sumit, Ph.D., Chairman of the SETA 2017 Organising Committee, delivered the welcome address. Over 600 delegates representing energy businesses, public and private sector technology and environmental organizations attended SETA 2017 each day, as well as researchers, students and the general public.

First public hearing in preparation of the Rattanakosin Conservation and Development Master Plan

The Office of Natural Resources and Environmental Policy and Planning (ONEP) and **Chula Unisearch** recently held the first public hearing in the preparation of the Rattanakosin Conservation and Development Master Plan at Rachadamnoen Hall, Royal Princess Hotel, Larn Luang. Phutthipong Surapruk, Deputy Secretary General of ONEP presided over the opening ceremony, while Prof. Wannasilpa Peerapun, Chairman of the Masters Programme on Urban and Regional Planning Program (Project leader) reported on the progress of the project. The public hearing aimed to provide information on the project and to hear views and recommendations from members of the public and relevant agencies. The discussions were structured in three parts, as follows: **1) Urban Landscapes**, led by Assist. Prof. Komgrit Thanapet, Department of Urban and Regional Planning and Assoc. Prof. Nilubol Klongvessa, Department of Landscape Architecture; **2) Tourist and Community Economy**, led by Pornsan Vichienpradit, Ph.D., Department of Urban and Regional Planning; **3) Traffic, Public Utility, Public Assistance and the Physical Environment**, led by Sirirat Sornprasit, Ph.D., Department of Urban and Regional Planning and Peamsook Sanit, Ph.D., Department of Urban and Regional Planning. These three discussions resulted in many comments and recommendations that will help guide the development of the Master Plan, taking into account all key aspects raised by stakeholders. Altogether, the hearing was attended by more than 180 representatives including government agencies, private sector, and educational institutions.

Seminar: "An important opportunity to bring Thailand industrial sector towards Industry 4.0"

On Friday 5 May, 2017, the Federation of Thai Industries (FTI), Industrial Estate Authority of Thailand (IEAT) with Chulalongkorn University by **Chula Unisearch** recently held a seminar: ***"An important opportunity to bring Thailand industrial sector towards Industry 4.0".*** The event was held at Chulalongkorn University Research Building, and was honored by the presence of Prof. Kiat Ruxrungtham, M.D., Vice President for Research and Innovation, Chulalongkorn University, who presided over the seminar. Executives of IEAT, including Miss Krittayaporn Dabbhadatta (Deputy Governor, Operation Function 2) and Miss Somchint Pilouk (Deputy Governor) also attended.

The seminar's objective was to provide relevant agencies with information and knowledge about sources, detailed and benefits from adjustment of industry according to the government's *"Industry 4.0"* policy. Khattiya Kraikarn, Ph.D., President of the Institute of Research Development and Innovation for Industry (IRDI) delivered a lecture on the topic ***"Roadmap Development to Industry 4.0: How Can Thai Industry Adapt?"*** Narukamol Phukhao, Ph.D., IRDI Director, also addressed participants on the topic of ***"PR Projects Supporting Industrial Sectors to Industry 4.0".*** Assist. Prof. Pramual Suteecharuwat, Ph.D., Department of Industrial Engineering, Faculty of Engineering, Chulalongkorn University, spoke on the topic of ***"The World towards Industry 4.0"*** and ***"Industry 4.0 and the Thai Context".*** The seminar was attended by over 50 participants from Thailand's industrial estates, in order to gain knowledge and understanding about the *"Industry 4.0"* concept, as well as the many supporting projects initiated by the government.




Continuing Cooperation on Occupational Standards and Professional Qualifications

On Monday 29 May, 2017, **Chula Unisearch** was welcomed by Noppadol Piyatrapoomi, Ph.D., Deputy Director of the Thailand Professional Qualification Institute; TPQI (Public Organization). **Chula Unisearch** has been selected to continue implementation of a major project to support professional development in the medical technology sector. The visit marked the signature of a contract between the two agencies under which **Chula Unisearch** will manage occupational standards and professional qualifications for the Public Health Care Management Program for medical technologists. The two agencies were represented by Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch and Assoc. Prof. Pongsak Yuktanadana, M.D., Department of Orthopaedics, Faculty of Medicine, Chulalongkorn University.

Innovation for One Health



On Monday 29 May, 2017, **Chula Unisearch** and Pro Test Kit Co., Ltd., convened a seminar: ***"Innovation for One Heath"*** at the Monet Room, Novotel Bangkok, Siam Square Hotel. The event aimed to showcase the latest research on ***Biosensors for Rabies Virus in Companion Animals***. Biosensors show great promise as tools for rapid and easy disease prevention, control and monitoring. Signals can be detected and monitoring via smart phone apps, and the technology is now market-ready. Yukol Limlamthong, DVM., Former Deputy Prime Minister and Minister of Agriculture and Cooperatives, and Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch, presided over the opening ceremony.

This research kits has won global accolades, including four international awards: a Gold Medal award of Honor in Medicine and Health from Spain, a Special Prize in Medicine and Health from Spain, the Special Award for Innovation from Romania, and the Special Award for Innovation from Iran.

Industrial R&D Fund Fair

Chulalongkorn University assigned **Chula Unisearch** to convene the ***"Industrial R&D Fund Fair"*** on Wednesday 31 May 2017 at Chulalongkorn University Research Building to share information on sources of research funding. Supichai Tangjaitrong, Ph.D., Deputy Managing Director, Chula Unisearch, presided over the opening ceremony, and also briefed participants on the 'Talent Mobility' project initiated by the National Science Technology and Innovation Policy Office (STI).

Representatives from various funding offices participated in the event, including Assoc. Prof. Prasert Pavasant, Ph.D., Director of Research and Researchers for Industries (RRI), the Thailand Research Fund (TRF), Mr. Worawut Prasitwuttisak, Coordinator of TRF Industry Division, Ms. Suwansa Thongyu, Coordinator of Innovation Developer, National Innovation Agency (NIA) and Thongpol Munkongsucharit, Ph.D., Industrial Technology Development Division, National Science and Technology Development Agency (NSTDA). All of these experts explained details and answered questions on accessing funds from various projects to participants. More than 90 people attended the event, including faculty members, researchers and representatives from various companies. The event included an important discussion on presenting research proposals, improving the practical relevance of research and enhancing working linkages between researchers and the private sector.






Rice Donation

Chula Unisearch is supporting the government's policy to help solve the current crisis of low prices for Thailand's rice farmers by buying rice from some of the most-affected farmers in Sisaket and Nakhon Ratchasima. The rice was then donated rice to needy causes such as the Rajvithi Home for Girls, Ratchathewi, Bangkok, Mae Pra School, Amphoe Omkoi, Chiang Mai, Mae La Noi School, Amphoe Mae La Noi, Mae Hong Son, School For The Blind And The Blind With Multi-Handcapped, Muang Lopburi, Lopburi as well as to the Chet Sao Noi Waterfall National Park, Muak Lek, Saraburi.

Water pouring ceremony Thai New Year's Day 2017

On 5 April 2017, to mark the Thai New Year's Day, or Songkran, the **Chula Unisearch** board of directors convened at the Atrium Lounge, Chulalongkorn University Research Building to perform a water pouring ceremony on Buddha statues. The tradition expresses gratitude, purification and the washing away of one's past sins. Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch delivered an address and gave a blessing to all executives and staff present at the event.

Chula Unisearch staff volunteer to make funeral wood flowers for His Majesty the late King Bhumibol Adulyadej

Chula Unisearch has joined with all sectors of Thai society in making funeral wood flowers in keeping with our Nation's deep reverence and love for His Majesty the late King Bhumibol Adulyadej. Altogether, Chulalongkorn University has made 1 million funeral wood flowers for public mourners in preparation for the Royal Cremation Ceremony for His Majesty.

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