Interdisciplinary Research Review
Volume 17, Number 2, Pages 31 – 36

Developing a traceability system for safe vegetables of smart farmers in Nakhon Pathom Province

Sompon Sukcharoenpong[1,*], Dech Thammasiri[1], and Kasamol Chanasuk[1]

[1]**Business Computer, Faculty of Management Science, Nakhon Pathom Rajabhat University, Nakhon Pathom, Thailand**

Abstract

The purposes of the research on "Developing a Traceability System for Safe Vegetables of Smart Farmers in Nakhon Pathom Province" were to: 1) develop a traceability system for the safe vegetables of the smart farmers in Nakhon Pathom; 2) evaluate the satisfaction with the performance of the traceability system of the safe vegetables of the smart farmers in Nakhon Pathom; and 3) compare the satisfaction with the performance of the traceability system of the safe vegetables of the smart farmers in Nakhon Pathom, classified by personal factors. A mixed-methods approach, combining qualitative and quantitative research, was used in the study.

The findings revealed that: 1) the farmers growing safe vegetables in Nakhon Pathom wanted to use the safe vegetable traceability system to help them manage data and provide relevant information to consumers via QR codes in order to increase their purchasing confidence. In addition, the results of the development and evaluation of the system's performance by experts showed that the overall efficiency of the system was at the highest level ($\overline{x}$ = 4.75, S.D.= 0.48); the efficiency of the performance by function ($\overline{x}$ = 4.83, S.D.= 0.38) and the efficiency of the ease of use of the system ($\overline{x}$ = 4.70, S.D.= 0.53) were all at the highest levels. 2) The 36 safe vegetable farmers had overall satisfaction with the traceability system at a high level ($\overline{x}$ = 4.10, S.D.= 0.17). In the descending order of satisfaction, the aspects were functionality of the system ($\overline{x}$ = 4.20, SD = 0.27), meeting the needs of system users ($\overline{x}$ = 4.09, SD = 0.34), ease of use (= 4.08, SD = 0.24) and information security in the system ($\overline{x}$ = 4.04, SD = 0.43). In addition, 400 consumers of safe vegetables in Nakhon Pathom expressed high levels of overall satisfaction with the system ($\overline{x}$ = 4.29, SD = 0.31). They showed satisfaction with system efficiency at a high level ($\overline{x}$ = 4.29, SD = 0.36), and were highly satisfied with the system's suitability ($\overline{x}$ = 4.29, SD = 0.44). 3) As for the comparison of satisfaction with the traceability system for safe vegetables of 36 smart farmers classified by personal factors, there was a statistically significant difference in satisfaction at the 0.05 level by sex, residence, and age.

Keywords: Traceability system, QR code, safe vegetables, smart farmers

Article history: Received 6 November 2021, Revised 24 March 2022, Accepted 24 March 2022

1. Introduction

In terms of the variety of food consumed today, vegetables are readily available for human consumption since the cost is low, but they are high in nutrients required by the body. In particular, they contain calcium, iron, and antioxidants, which help in maintaining and improving the health of the heart, blood vessels, and immune system. The wide range of vegetables is more than just food because some vegetables are classified as herbs, they can also be used to treat a variety of diseases [1]. As current consumers trends focus more on the consumption of safe agricultural products, especially vegetables and fruits, the products that are grown in a safe environment in the market are not enough for consumer demands [2]. As a result, it is critical to promote safe vegetable cultivation and add value to vegetables through a traceability system in order to increase consumer confidence in purchasing decisions. It will also benefit farmers producing vegetables and other agricultural products to have higher incomes as well. Regarding the data from the Kasikorn Research Center (2020), it is claimed that the traceability system will play an important role in building credibility over the next ten years and contribute to the expansion of marketing opportunities for Thai organic products in both domestic and international markets. It is expected that between 2020 and 2024, the average will be 6.5 percent and will be 8.7 percent between 2025 and 2029, the average. As a result, the opportunity to expand the export market will focus on tropical fruits and vegetables that are "Super Foods," as well as intermediate to advanced processed and additive-free agricultural products. The next generation of farmers will be the driving force behind the expansion of the export market. At the same time, in the domestic market, the emphasis will be on fresh organic vegetables [3]. This is consistent with the research of Madeena Noitubtim and Kanokwan Sukkajornwong (2013). The study concluded that the food safety system is a system created to provide consumers' confidence in their purchases in terms of contaminants free, residues free, and safety for consumption. The product's manufacturing path can be examined from the cultivation process, processing, storage, and food preservation, as well as the process of transporting and distributing products to consumers [4].

Moreover, in case uncertainties or problems occur with the product, the traceability system allows consumers to check the product's details and provides them the opportunity to quickly recall the correct item. It also lowers the possibility of loss of expenses that may be incurred [5]. In accordance

*Corresponding author; email:sompon@webmail.npru.ac.th

with Chalermjirarat [6], she suggested that traceability and product recall, as well as counterfeiting prevention, are topics that are brought up at various conferences. Many countries around the world have included these issues as a practice in their requirements, regulations, and laws. As a result, product manufacturers, owners, or exporters must study and follow the further regulations. The heart of the traceability process must be started by identifying items, places, or things in the supply chain that are associated with a unique name and then collecting physical events data from the manufacturing plant, shipments, distributors, as well as retailers.

Therefore, the development of smart farmers is regarded as an adjustment in the agricultural sector to enhance competitiveness in alignment with the country's future development. The agricultural sector must have more potential and expertise to expand learning opportunities and access to information required for a career, as well as to transmit knowledge and needs by area and time. As a result, it is a significant issue that will force the next generation of Thai farmers to compete on a global scale and effectively move above the poverty line.

As aforementioned, the research team, therefore, recognizes the need to utilize technological knowledge and skills to help smart farmers in Nakhon Pathom develop their work processes through the use of technology in agricultural data storage and presentation of product information to consumers, resulting in the increase of consumer credibility through the use of safe vegetable traceability system for smart farmers in Nakhon Pathom Province.

2. Research Methodology

This study employed mixed methodology research, which included both qualitative and quantitative research methods, to achieve the research objectives. The methodology consisted of: 1) qualitative research for gathering insights through non-participant observation, in-depth interviewing technique, and focus-group, as well as a conversational approach during interviewing to find out if the traceability system was required, and 2) quantitative research was employed for evaluating the performance of the developed system and exploring whether the smart farmers in Nakhon Pathom were satisfied with the safety vegetables traceability system.

2.1 Population and samples

The population used in the research was a group of 917 smart farmers growing safe vegetables in Nakhon Pathom and a group of 137 safe vegetable consumers in Nakhon Pathom. Random sampling was used to select the research samples as follows:

2.1.1 The first sample group consisted of a group of smart farmers and a group of safe vegetable growers. Their required qualifications were: 1) being a smart farmer in the Nakhon Pathom Provincial Agriculture Office's Smart Farmer Project in 2016, residing in seven districts, namely Mueang Nakhon Pathom, Kamphaeng Saen, Don Tum, Nakhon Chai Si, Bang Len, Phutthamonthon, and Sam Phran; 2) being between the ages of 20 and 40, and having knowledge and experience of growing safe vegetables for at least one year; 3) possessing leadership and creativity, as well as the ability to participate in the research project in Nakhon Pathom; and 4) being willing to participate throughout the research project. The number of samples was 36 derived by stratified sampling together with the quota sampling method from seven districts, namely Mueang Nakhon Pathom, Kamphaeng Saen, Don Tum, Nakhon Chai Si, Bang Len, Phutthamonthon, and Sam Phran.

2.1.2 The second sample group consisted of safe vegetable consumers. Purposive sampling was used to select the sample of consumers who purchased safe vegetables in Nakhon Pathom Province for consumption. In addition, convenience selection in conjunction with time period random sampling was used for selecting safe vegetable consumers in Nakhon Pathom who purchased safe vegetables for two months during January and February 2021, using the Cochran formula [7], which is used to estimate the population proportion when the precise population size is unknown, but knowing that there are many. The formulas are as follows:

In case of knowing the proportion of the population, the following formula is applied.

$$n = \frac{p(1-p)Z^2}{e^2} \tag{1}$$

If the proportion of the population is unknown, $p = 0.5$, the following formula is used.

$$n = \frac{Z^2}{4e^2} \tag{2}$$

Where:
n = the desired sample size
p = the proportion of traits interest in the population
e = the allowable sample error level
Z = z-value at confidence level or significance level
−95 percent confidence level or 0.05 level of significance with $Z = 1.96$

According to the calculations at a 95 percent confidence level, the allowable error was 5 percent and the proportion of traits of interest in the population was 0.5 of the desired population sizes. As a result of the sample calculation, the sample group consisted of 384 people. In addition, to substitute the error from the questionnaires, 400 sample questionnaires were distributed to the safe vegetable consumers in Nakhon Pathom to collect preliminary data and check system quality.

2.1.3 The third sample group consisted of three experts in the traceability system. Purposive sampling was used for this sample group selection. The experts must specialize in information technology systems and must have qualifications, including an academic position or at least five years of working experience in information technology.

2.2 Research instruments

2.2.1 For the qualitative method, in-depth interview, focus-group, and non-participant observation were used as data collection tools.

2.2.2 For the quantitative investigation, the questionnaires for satisfaction with the traceability system for safe vegetables, which were developed with a 5-level estimation scale and evaluated by three experts, were used to obtain data. They were as follows:

2.2.2.1 The satisfaction questionnaire with the traceability system for safe vegetables for a group of experts;

2.2.2.2 The satisfaction questionnaire with the traceability system for safe vegetables for a group of smart farmers in Nakhon Pathom Province; and

2.2.2.3 The satisfaction questionnaire with the traceability system for safe vegetables for a group of safe vegetable consumers in Nakhon Pathom province

2.3 Data analysis

Descriptive statistics were employed for data analysis in this study, i.e., distribution, percentage, mean, standard deviation (SD), including independent t-test, and one-way ANOVA. In case there was a difference, data were tested in pairs using Scheffe's method and content analysis.

3. Results

3.1 The development of a safe vegetable traceability system for smart farmers in Nakhon Pathom Province was divided into three main parts as follows:

3.1.1 A study of the problems and demand for a safe vegetable traceability system among smart farmers in Nakhon Pathom Province by interviewing and observing was carried out with a sample of 36 smart farmers. 19 of them were males and 17 were females. 21of farmers were from Mueang District, four from Kamphaeng Saen District, four from Bang Len District, three from Nakhon Chai Si District, two from Don Tum District, and one each from Phutthamonthon and Sam Phran. Most of them, 29 farmers, were between the age of 41 and 60, while four were between the age of 21 and 40 and three were over 60. For education, 18 of the samples had a bachelor's degree, 13 held a vocational/high vocational diploma, three graduated primary education level, and two had a master's degree or higher. The monthly income of the samples ranged from 10,000 to 30,000 baht. It was found that the smart farmers had a need for a safe vegetables traceability system. They suggested that the system must be able to store data that support the smart farmers' work as follows: 1) having information about farmers who grew safe vegetables, e.g., name-surname, garden name, address, area size of safe vegetable cultivation, vegetable variety, contact information, and certification of cultivation standards; 2) having certification information for production standards, including GAP certificate, organic agriculture certificate, other standard certificates, and awards; 3) having information on safe vegetable cultivation sites; 4) having information on soil and fertilizer used in agriculture, pesticide detail, and water source used from cultivation to harvesting; 5) being an easy to use system with accurate and complete information display; and 6) being capable of producing QR codes.

3.1.2 The data obtained from a sample group of 36 people were processed by the research team. The data was analyzed, synthesized, drawn conclusions from, and used to develop a safe vegetable traceability system for smart farmers in Nakhon Pathom Province. The development was done together with the SDLC concept, (System Development Life Cycle), which consisted of seven steps to ensure that the system worked as intended and met the needs of smart farmers. An easy-to-use system was created by developing the system with a computer language named Hypertext Preprocessor (PHP) in conjunction with java script. For the part of QR code generating, it was developed with the library PHP Qrcode and connected the system to the MySQL database, which the developed system could be used on the operating system via a link, http://npruonline.com/qrveg/ and provided support to work on smartphones in the form of apps. The system also supported the work on the Android operating system by developing such applications with the Kodular program and providing services via links like http://1ab.in/bbAS.

3.1.3 The performance of the safe vegetable traceability system for smart farmers in Nakhon Pathom Province was evaluated. The system's performance was evaluated and given recommendation by three experts. The investigation of the safety vegetable traceability system for smart farmers in Nakhon Pathom Province is showed in Table 1.

Furthermore, the experts suggested improvement of the safe vegetable traceability system for smart farmers in Nakhon Pathom province. The following are brief summaries of the items:

1. It was necessary to create a page that displays system statistics in the form of graphs.

2. A page showing the location on the map should be created with pictures of vegetables being grown.

3. Additional images, such as logos, related images, etc., should be included in QR Codes.

3.2 The satisfaction with the performance of the safe vegetable traceability system was divided into two groups: that of 36 smart farmers and that of 400 safe vegetable consumers, as follows:

3.2.1 According to the satisfaction survey of users of the safe vegetable traceability system, it was found that the respondents comprised 19 males (52.78 percent) and 17 females (47.22 percent). 21 people live in Mueang District (58.33 percent), while four each come from Kamphaeng Saen and Bang Len Districts (11.11 percent). 29 of them were between the age of 41 and 60 (80.56 percent), and four were between the age of 21 and 40 (11.11 percent). Moreover, 18 of them had a bachelor's degree (50.00 percent), followed by a vocational/high vocational diploma (13 people, 36.11 percent). 26 of them had a monthly income between 10,000 and 20,000 baht (72.22 percent) and 10 people had an income ranging from 20,000 to 30,000 baht (27.78 percent). The majority of respondents, 25 people, had a primary occupation as farmers (69.45 percent), followed by seven people (19.44 percent) who had a primary occupation as private business owners. Overall and in specific aspects, their satisfaction with the system was high ($\overline{x}$ = 4.10, S.D. = 0.17). The following aspects are listed in descending order:

According to the function of the system ($\overline{x}$ = 4.20, S.D. = 0.27), the first three aspects were 1) the accuracy of QR code printing, 2) the speed of the system's operation, and 3) reliability. Following that was the response to the needs of system users ($\overline{x}$ = 4.09, S.D. = 0.34), which consisted of the first three areas, namely 1) the ability to manage members, 2) traceability, and 3) information adding to the system. Next, the ease of use of the system ($\overline{x}$ = 4.08, SD = 0.24) was comprised

Table 1. System performance assessment results.

System Performance Assessment Results	$\bar{x}$	S.D.	Interpretation
The efficiency in working according to function	**4.83**	**0.38**	**the highest level**
1. The accuracy in adding vegetable garden information	5.00	0.00	the highest level
2. The accuracy in printing QR code	5.00	0.00	the highest level
3. The system reliability	5.00	0.00	the highest level
The efficiency of system use	**4.70**	**0.53**	**the highest level**
1. The system's ease of use	5.00	0.00	the highest level

of the first three items as follows: 1) the appropriateness of symbols used to convey meaning, 2) the appropriateness of color used in letters and figures, and 3) the same standardization in the design of image screen. The last one is the security of information in the system ($\overline{x}$ = 4.04, S.D. = 0.43) was comprised of effective control over the use of user rights, pre-authentication of system users at various levels, as well as the assignment of user codes and password authentication for system users.

3.2.2 According to the satisfaction survey on the safe vegetable traceability system of safe vegetable consumers in Nakhon Pathom Province, it was revealed that the majority of respondents were 233 females (58.25 percent) and 167 males (41.75 percent), with 395 people having the status of consumer (98.75 percent) and 5 of them having other status (1.25 percent). The majority were between the age of 21 and 40 (339 people, 84.75 percent), followed by those between the age of 41 and 60 (55 people, 13.75 percent), those aged 60 and over (5 people, 1.25 percent), and those under the age of 20 (1 person, 0.25 percent). The majority of respondents (180 people, 45.00 percent) held a bachelor's degree, followed by 171 people (42.75 percent) holding a vocational /high vocational diploma, 36 people (9.00 percent) graduating secondary education, eight (2.00 percent) graduating primary education, and five of them (1.25 percent) holding a master's degree. The majority of the sample (285 people, 71.25 percent) earned $10,000 - 20,000$ baht per month, followed by 55 people (13.75 percent) having $5,000-10,000$ baht and $20,001-30,000$ baht monthly income, and 5 people (1.25 percent) earning more than 30,000 baht per month. Furthermore, the majority of respondents (176 people, 44.00 percent) worked for private companies, followed by private business owners (113 people, 28.25 percent), government officials/state enterprises (56 people, 14.00 percent), employees (28 people, 7.00 percent), housewives (20 people, 5.00 percent), students/undergraduate students (5 people, 1.25 percent), and doing other jobs (2 people, 0.50 percent). These consumers had a high level of overall satisfaction in all aspects ($\overline{x}$ = 4.29, SD = 0.31). Specifically, the satisfaction with system performance was at a high level($\overline{x}$ = 4.29, SD = 0.36), comprising the top three: 1) appropriate placement of components on the monitor, 2) up-to-date information, and 3) the speed of the application system. Following that, there was a high level of satisfaction in suitability ($\overline{x}$ = 4.29, SD = 0.44), with the top three aspects: 1) the appropriateness of images used to convey meanings; 2) the appropriateness of colors used in the images. 3) the same standardization in the visual screen design.

3.3 Regarding the comparison of smart farmers' satisfaction with the performance of the safe vegetable traceability system, the satisfaction with the performance of the safe vegetable traceability system among 36 modern farmers classified by personal factors was examined. The results were analyzed by inferential statistics, i.e., independent t-test, one-way ANOVA, and Scheffe's method, in order to find out if there was a difference. Gender, place of residence, and age were all considered personal factors. The satisfaction classified by these factors was divided into the following aspects: 1) meeting the needs of system users, 2) working in accordance with the system's function, 3) system's ease of use, and 4) security of information in the system. The analysis revealed that the smart farmers' satisfaction was significantly different at the 0.05 level. The results are presented in Table 2.

However, there was no difference in satisfaction as classified by personal factors of education level, monthly income, and primary occupation.

4. Discussion and Conclusion

The findings of a study on developing a traceability system for safe vegetables for smart farmers in Nakhon Pathom Province were discussed in accordance with the research objectives as follows:

4.1 In developing a safe vegetable traceability system for smart farmers in Nakhon Pathom Province, it was revealed that the system had been developed to meet the requirements of farmers. The system could store and manage data, including deleting, adding, and editing farmers' information. In addition, the QR codes could be printed and the system was easy to use, quickly operated, and reliable. The system's use was also restricted based on the permission level that had been set. This was consistent with Tantidontanet and SBoonying's [2] who conducted research on a prototype for the traceability of safe food crops in the community using RFID technology. The study's findings revealed that the developed system consisted of three main sections: one for administrators who could add, delete, and edit; one for farmers who could save, delete, and edit; and one for customers or consumers, who could come in and inspect the community's safe food growing process before deciding to purchase a product. Moreover, the developed safe vegetable traceability system for the smart farmer group in Nakhon Pathom Province was also concerned with the safety of data storage, with no risk of loss or copying for unauthorized use. Furthermore, the information displayed by the system was accurate, complete, and fast, and the system could clearly display pictures as well as accompanying characters following

Table 2. The results of the comparison of smart farmers' satisfaction with the performance of the safe vegetable traceability system.

The performance of the safe vegetable traceability system	Gender	Sig. Place of residence	Age
1.Meeting the needs of the system users	0.24	0.02*	0.90
2. Working in accordance with the system's function	0.34	0.47	0.54
3. Systems ease of use	0.08	0.11	0.62
4. Security of information in the system	0.02*	0.01*	0.03*
Overall average	**0.15**	**0.32**	**0.45**

the standard to increase consumers' trust in purchasing safe vegetables of the smart farmers in Nakhon Pathom. When the system's efficiency was evaluated, it was discovered that the system's overall efficiency was at the highest level, with the highest level of performance according to function and ease of use. This could be supported with Jaidee and Seresangtakul's [8] research on mushroom cube trace and traceability system. This study described the process of developing a system for monitoring and tracing mushroom cubes. When put into practice, the developed model of this study could help Thai agricultural businesses meet international standards. It was also a system that allowed consumers to obtain the information they needed before making a purchase decision on agricultural products. The results were also consistent with Tantidontanet and Boonying's [2] research, which proposed that a prototype for community-safe food crop traceability using RFID technology could be used to meet the needs of users and consumers who wanted to effectively trace the safety of locally grown vegetables.

4.2 The satisfaction assessment of the safe vegetable traceability system of smart farmers in Nakhon Pathom province showed that, in descending order, the farmers were highly satisfied with the system in all aspects ($\overline{x}$ = 4.10, S.D. = 0.17). The highest aspect was performance in accordance with the system's function, which included the first top three items: 1) the accuracy of QR code printing, 2) the system's speed of operation, and 3) its reliability. Following that, the aspects of meeting the needs of system users were consisted of the first three areas: 1) capabilities for managing members, 2) traceability, and 3) adding information to the system. Next, the system's ease of use comprised the first three items, namely 1) the appropriateness of symbols used to convey meaning, 2) the appropriateness of colors used in letters and images, and 3) the same standardization in terms of screen design. The last aspect was the security of information in the system comprised the ability to use it correctly in accordance with user rights, preauthentication of system users at various levels, and user ID assignment and password to verify the system user. This corresponded to the Digital Government Development Agency's (DGA)[9], which stated that proposal regarding application standards must prioritize the security of personal information (privacy) as well as the security feature (security functional requirement), sensitive information, which must always be encrypted. The results were also consistent with Wuthipanchai[10] research on mobile application platform prototypes for digital agriculture that provided the option of creating a mobile application for farmers and durian buyers as a source of information and to expand trading channels. In addition, the study's findings could be used as a guideline for developing a mobile application platform as a source of knowledge in the field of agriculture, as well as supporting durian trading to help reduce problems in Thailand's agricultural sector. This was linked to the consumer satisfaction assessment of safe vegetables who had evaluated the traceability system of the current study in the form of an application. It was found, according to the evaluation results, that the consumers who used the service had a high level of overall satisfaction in all aspects ($\overline{x}$ = 4.29, S.D. = 0.31). The consumers were pleased with the system's high performance, which included the top three aspects of: 1) the appropriateness of component placement on the monitor, 2) the accuracy of the information, and 3) the application system's speed. Following that, there was a high level of satisfaction in terms of suitability, comprising the first top three, namely: 1) the appropriateness of images used to convey the meaning; 2) the appropriateness of color used in the images to convey the meaning; and 3) the same screen design standard. The results of the present study also aligned with the research of Kettapunt *et al*. [11] on the development of the ORGANIC LEDGER application for participatory organic agriculture (PGS) certification which proposed that the ORGANIC LEDGER application received a rating of 4.88 out of 5 from farmers. As a result, it was clear that the paperless farm practice recording application was effective. It could be used in place of notetaking on paper. The application was a tool for organic agriculture participatory certification that made organic products and the certification system reliable, transparent, accurate, convenient, and appropriate for small farmers.

4.3 As for the comparison of smart farmers' satisfaction with the safe vegetable traceability system, personal factors included sex, place of residence, and age were considered in the following aspects: 1) meeting the needs of the system users, 2) performance according to the system function, 3) the ease of use of the system, and 4) the security of information in the system. The results of the analysis revealed that smart farmers had different levels of satisfaction at the 0.05 level of statistical significance. On the other hand, when considering personal factors of education level, monthly income, and primary occupation, the analysis showed that there was no significant difference in satisfaction at the 0.05 level. The results could be related to the concept of seven steps of System Development Life Cycle (SDLC) proposed by Udomthanatira [12] that the system development process consisted of: 1) identifying problems and needs, studying the suitability, 2) analyzing the needs to develop and design a system for solving the problems, 3) developing and testing the functionality of the system, installing and running the system, and continuous

improving and developing. Therefore, according to the results of the study, it can be said that individual factors affected the development of the system. To develop a system to meet these needs, the concept of the system development cycle should be applied to study and develop various systems.

References

[1] N. Kaewduang, B. Yooprasert, P. Tangwiwat, Organic safe vegetables production of good agricultural practice of farmers in Nong Khai province, Khon Kaen Agriculture Journal 45(1) (2017) 1590-1596. (in Thai)

[2] N. Tantidontanet, S. Boonying, Traceability model for growing food safety in community using RFID technology, Journal of Applied Information Technology 6(1) (2020) 83-96. (in Thai)

[3] Kasikorn Research Center, Traceability and crop tracking system expanding opportunities in the Thai organic market, https://www.kasikornresearch.com/th/analysis/k-econ/business/ Pages/z3045.aspx (accessed 3 March 2020).

[4] M. Noitubtim, K. Sukkajornwong, Application of Traceability System in Food Industry, Princess of Naradhiwas University Journal 5(4) (2013) 206-215.

[5] K. Wongsricharoenchai, Traceability towards Safe Consumption in the Future, GS1 Thailand Newsletter 26(2) (2019) 17-19. (in Thai)

[6] Jiraporn Chalermjirarat, GS1 The Traceability Process 22(1) (2015) 8-11. (in Thai)

[7] W.G. Cochran, Sampling Techniques. 3rd ed. New York: John Wiley & Sons, 1997.

[8] A. Jaidee, P. Seresangtakul, Mushrooms Cube Tracking and Traceability System. Master's Degree Thesis, Khon Kaen University, 2014. (in Thai)

[9] P. Khannarat, Study report on mobile application system development, Ministry of Labor (smart labour 2) and suggestions on mobile application development with Responsive Web technique, 2018, http://library.md.chula.ac.th/guide/vancouver2011.pdf (accessed 5 March 2020).

[10] K. Wuthipanchai, Mobile prototyping application platform for digital agriculture age. Master's Degree Thesis, Thammasat University, 2016. (in Thai)

[11] S. Kettapunt, D. Athinuwatand, C. Phonprapai, Development of ORGANIC LEDGER application for Participatory Guarantee Systems (PGS) organic standard certification system, Thai Journal of Science and Technology 7(4) (2018) 355-370. (in Thai)

[12] K. Udomthanatira, System Development Life Cycle: SDLC, 2019, https://dol.dip.go.th/th/category/ (accessed 5 March 2020).