

THE EFFECTIVENESS OF GMPs FOR CONTROL OF FOOD HAZARDS IN MAE FAH LUANG UNIVERSITY, THAILAND

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Abstract

The objective of this study is to examine the effectiveness of the GMPs' practical guideline' to reduce food hazards in MFU food shops. The research used a Quasi-Experimental Approach with a group pretest-posttest and 66 food shops in MFU were included in the sample size for this study. The methodologies consists of 1) the creation of GMPs' practical guidelines 2) GMPs' practical guidelines for the training of food handlers 3) the first stage of food hazard assessments including physical, chemical, and biological hazards 4) a public meeting; 5) a second stage of food hazard assessments and 6) an activity called "show and share for food sanitation and safety". The findings illustrate that food hazards and contamination were reduced by up to 76% after the implementation of the GMPs. However, some *E.coli* contamination was found on the hands of food handlers and food containers and utensils. Therefore, programs should be introduced for food handlers at MFU to increase their awareness of food sanitation and safety. Moreover, the impact on customers, who are the students and staff at MFU, may provide an important motivation for food handlers to improve their awareness of the necessity of hygiene according to the principles in the GMPs' practical guidelines. In addition, MFU should advise the food shops which are responsible for a high standard of hygiene to adopt the necessary procedures to reduce food hazards and contamination at MFU.

Keywords: Good manufacturing practices, food sanitation and safety, food hazard control

Introduction

Food is an important element for life because several nutrients are essential for the maintenance of including proteins, carbohydrates, and lipids which are crucial substances to provide energy and repair human tissues. Although food can be made from many sources, for example, natural sources and agriculture, foodborne diseases occur as major public health problem around the world. As can be seen in the statistics recorded by the World Health

Organization (The World Health Organization, 2018), several harmful pathogens and chemical substances lead to more than 200 types of food and waterborne diseases. Meanwhile, the number of hospitalizations in U.S. was nearly 130,000 cases as a result of eating contaminated food (Marchado and Cutter, 2017). Similarly, in Europe, it was estimated that more than 23 million people became ill from contaminated food, resulting in 4,656 deaths in

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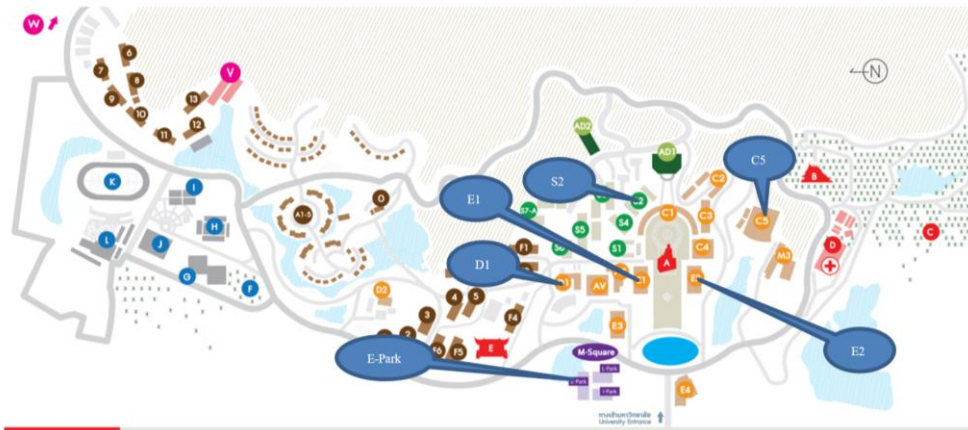


Figure 1. Location of the cafeteria area containing several food shops in Mae Fah Luang University

Europe (The World Health Organization, 2017). Moreover, 7.4 % of the total number of deaths was caused by diarrhea in Africa in 2016 (The World Health Organization, 2019). In Thailand, the total number of hospital cases caused by food Contamination reported by the Department of Disease Control, Ministry of Public Health (Department of Disease Control, Ministry of Public Health, 2017) concluded that more than 1,000,000 hospital cases were characterized by the symptoms of foodborne diseases. It is therefore clear that the relevant sectors responsible for the preparation and serving of food, including restaurants, wayside restaurants, and cafeterias or food courts in schools and universities may be at risk of food hazards including physical, chemical, and biological contamination. Good Manufacturing Practices or GMPs is one of the solutions that can help to reduce food contamination which affects the health. GMPs is a system for ensuring that products are consistently produced and controlled according to quality standards. In fact, GMPs have existed for decades. They consist of hygienic rules and regulations for the purpose of limiting the contamination of food by any microorganisms or pathogens (Lebert *et al.*, 2003). The study of Costa Dias *et al.* (2012) concluded that the concept of GMPs is based on the PDCA cycle (plan-do-check-act) which can be divided into these steps: initial diagnosis, elaboration of GMPs map, addressing of non-conformities, and re-evaluation of corrective measures implemented. Therefore, the GMPs practical guidelines may be the most suitable solution to reduce any food hazards and contaminants including physical objects, harmful pathogens, and chemical substances in food processing which could affect students and staff at Mae Fah Luang University in the north of Thailand. It will not only save lives out of the nearly 13,000 students and approximately 700 staff at MFU, but it

will help develop an awareness of the value of food sanitation and food safety and personal hygiene in the preparation, cooking, and serving of food among food handlers at MFU. The objective of this study is to examine the effectiveness of the GMPs' practical guidelines to reduce food hazards at MFU food shops at MFU which received the highest score for international outlook in Thailand (The Times Higher Education, 2019).

Materials and Methods

The research design of this study uses a Quasi-Experimental approach with a one group pretest-posttest design (Kirk, 2013). The total number of food shops in Mae Fah Luang University (MFU), and Chiang Rai province includes 66 restaurants which were included in the sample size of this study which consists of 39 ready-to-eat shops, 19 beverage shops, and 8 dessert or snack bar shops. These shops are located in D1, E1, E2, E-Park, C5, and S2 Building as can be seen in Figure 1. The program of GMPs' practical guidelines was developed on the principle of 'clean food with a good taste' (Department of Health, Ministry of Public Health, 2013) and the World Health Organization (The World Health Organization, 2006). The GMPs' practical guidelines were published for the training of all food handlers at Mae Fah Luang University to provide them with the knowledge and the proper procedures for handling food based on the principles of food sanitation and food safety. These guidelines were used for the training of food handlers at MFU for a month. After the implementation of the practical guidelines, the first stage of food hazard assessments including the biological, chemical, and physical hazards were carried out to verify the practices of food handlers with regard to food safety

and food sanitation. To check physical hazards, a check-list developed by the Department of Health, Ministry of Public Health was used (Adapted from Department of Health, Ministry of Public Health, 2014). There are 30 items for checking physical hazards which include preparing the dining area, food utensils and equipment, raw materials for food, and personal hygiene. Moreover, five parameters for chemical hazard assessments were examined in this study using several types of chemical test-kits which consisted of borax, salicylic acid, sodium hydrogen sulfide, formalin, and pesticide contamination (Department of Medical Science, Ministry of Public Health, 2008). For the assessment of biological hazards, the most probable number (MPN method) was carried out to validate *E. coli* contamination on chefs' hands, food containers, and samples of ice from the beverage shops (Cappuccino and Sherman, 2008). These assessments were included in the next stage of the methodologies which included a public meeting to find out if there were any obstacles affecting the application of the guidelines and find suitably concrete solutions for reducing the food hazards in their shops. After a month, the second stage of assessment of food hazards was then applied to check the results of the application of the guidelines. In addition, descriptive statistics, and inferential statistics, such as a paired samples t-test, was used to describe the demographic status of food sanitation and safety at Mae Fah Luang University. Moreover, the differential average between the fecal coliform bacterial numbers in the samples of ice, and the average knowledge of basic GMPs for each type of restaurants located in Mae Fah Luang University were compared using inferential statistics. The methodologies used in this study are shown in Figure 2.

Results and Discussion

GMPs' Practical Guidelines for Food Sanitation and Safety

With regard to the GMPs' practical guidelines in this study, 12 principles were created established to train food handlers at MFU which were (Keawdoungek, 2019): 1) always clean the dining and food preparation areas 2) provide a distance of more than 60 cm from the floor for food preparation 3) approve the food seasoning using the safety standards 4) to avoid cross-contamination, store the raw materials including poultry, raw meat, and seafood in a refrigerator before cooking them and keep them at a temperature lower than 5 degrees Celsius 5) keep the ready-to-eat foods in cupboards at least 60 cm' distance from the floor, 6) keep some ice in clean containers and always use ice pincers

7) use suitable detergents for cleaning any utensils 8) separate the cutting boards for ready-to-eat food and the raw materials 9) wash the hands with suitable soap before the food preparation and cooking 10) install basins and provide soap for washing hands in the toilets of restaurants 11) wear gloves and cover hair during the preparation of food and cooking and 12) food handlers must not work and they must consult a doctor physician immediately if they experience the symptoms of any infectious disease, for example, Typhoid, or COVID-19.

The First Stage for the Assessment of Food Hazards in the Restaurants at Mae Fah Luang University

With regard to the assessment of physical hazards, all of the food shops in this study were found to have a low standard because several of the materials and equipment related to food preparation and serving as found by the assessment and management office. This office not only provides the equipment and utensils for food sanitation and food safety, they are also responsible for showing that all materials used follow the principles of food sanitation and food safety including the food container cleaning system, proper dining tables, fire prevention equipment, and air ventilation system for food preparation. Moreover, there is an official member who is responsible for conducting a physical assessment of for each of the restaurants at MFU.

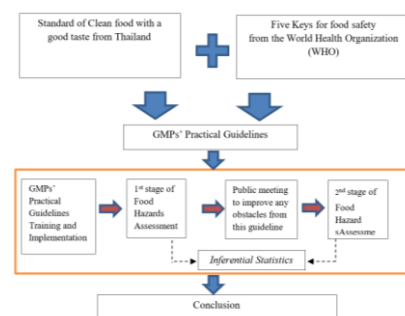


Figure 2. The study design

In the stage of the assessment of biological hazards using the MPN method on samples of ice and equipment for *E. coli* detection in EMB agar, it was found that 28 of the food shops at MFU or nearly 43% were contaminated by *E. coli* on the chefs' hands, and 4 of the food shops or nearly 15% were found to have *E. coli* in the samples of food utensils as can be seen in Table 1. As can be seen from this table, 28 shops reported *E. coli* contamination on the chefs' hands at 19 ready-to-eat shops, 7 beverage shops, and 2 dessert and snack bar shops. On the other hands *E. coli* was detected in the

Table 1. Number and type of samples contaminated with *E.coli* at the first stage

Type of MFU food shop	Number of samples	Number of samples contaminated with <i>E. coli</i> (percentage)	Type of samples contaminated with <i>E.coli</i> (percentage)*	
			Hands of Chef	Food container
Ready-to-eat	39	19 (48.71)	19 (100.00)	4 (21.05)
Beverage	19	7 (36.84)	7 (100.00)	0 (0.00)
Dessert and snack bar	8	2 (25.00)	2 (100.00)	0 (0.00)
Total	66 (100.00)	28 (42.42)	28 (100.00)	4 (14.28)

Note: *is defined as all of restaurants where *E.coli* contamination was detected in all types of samples

Table 2. Number and type of samples contaminated with *E.coli* at the second stage

Type of MFU food shop	Number of samples	Number of samples contaminated with <i>E. coli</i> (percentage)	Type of samples contaminated with <i>E.coli</i> (percentage)*	
			Hands of Chef	Food container
Ready-to-eat	39	12 (30.76)	12 (100.00)	2 (16.66)
Beverage	19	2 (10.53)	2 (100.00)	0 (0.00)
Dessert and snack bar	8	2 (25.00)	2 (100.00)	0 (0.00)
Total	66 (100.00)	16 (24.24)	16 (100.00)	2 (8.33)

Note: *is defined as all of restaurants where *E.coli* contamination was detected in all types of samples

food containers at 4 ready-to-eat shops. Moreover, in the samples of ice the number of fecal coliform contaminations for 2 of the beverage shops were 648.53 mpn/100 ml in which the lowest number of fecal coliform bacteria were 3 mpn/100 ml, and the highest numbers of fecal coliform bacteria were 2,400 mpn/100 ml. These results show that the level of fecal coliform contamination for all of the beverage shops was higher than the official standard of the Ministry of Public Health which states that the fecal coliform bacteria in ice should not be lower than 2.2 mpn/100 ml. Additionally, the assessments of chemical hazards in the food shops at MFU found that 2 of the ready-to-eat shops had pesticide contamination in the samples of vegetables which represented a high risk to health.

The Public Meeting

From the results of the first stage of food hazard assessments, all of the food handlers at MFU were invited to a public meeting to be informed of important information affecting the obstacles to the implementation of the GMPs practical guidelines. After this meeting, the research team found that several of the food handlers were not following the proper hand washing procedures to prevent *E.coli* contamination of the chef's hands. Moreover, there was no proper procedure to disinfect food utensils and food containers. Furthermore, several of the food handlers in the beverage shops were not aware of the recommended ice bucket cleaning procedures and they were reusing some of the ice for the beverages on other days. With regard to pesticide contamination, they lacked any information related to correct procedures for washing raw materials to reduce the risks of pesticide concentration and they

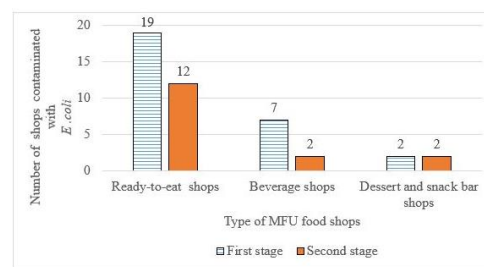


Figure 3. Numbers of *E.coli* detected in separated types of food shops from the first stage to the second stage

did not know about the pesticide tests raw materials. Consequently, the food handlers were retrained in the use of the GMPs' practical guidelines to ensure they were all aware of the importance of good personal hygiene to reduce the risks of food hazard contamination, especially biological and chemical contamination.

The Second Stage for the Assessment of Food Hazards in the Restaurants at Mae Fah Luang University

After the public meeting to improve food sanitation and safety procedures associated with the GMPs' practical guidelines, the numbers of *E.coli* detection in the food shops were reduced from 28 to 16 food shops or nearly 25% of the total number of food shops at MFU as can be seen in Table 2. Almost all of these 16 shops revealed *E.coli* contamination on the chefs' hands; furthermore, the *E.coli* contamination of food containers decreased from 4 to only 2 restaurants. According to the Figure 3, the reduction of *E.coli* numbers was better than

the results from the first stage of reducing food hazards. It can be seen that the overall reduction of *E.coli* at MFU restaurants increased from 57% to nearly 76%. Moreover, ready-to-eat and beverage shops in this study had a higher percentage of *E.coli* reduction than at the first stage, namely, from 17.95% to 26.31, % respectively. The results of the inferential statistics test illustrated that the number of *E.coli* detections from the first stage assessment were at a different level from the number of *E.coli* detections from the second stage of food hazard assessments at the 0.05 level of significance ($t_{df} = 3.849_{65}$, $P\text{-Value} = 0.000$). Furthermore, the dessert and snack bar restaurants had the same percentage of *E.coli* reduction from the first and the second stages of food hazard assessments.

As regards the fecal coliform bacteria in the samples of ice, it was found that the number of fecal coliform bacteria from the second stage of assessment was lower than in the first stage with the number of fecal coliform bacteria in the second stage at only 5.13 mpn/100 ml. In addition, the lowest of number fecal coliform bacteria in the samples of ice from the second stage did not show any fecal coliform bacteria for 3 of beverage shops, and the highest number of fecal coliform bacteria in the samples of ice from the second stage was 11 mpn/100 ml. This finding corresponds to the results of the inferential statistics test that showed the different levels of fecal coliform bacteria number in the samples of ice at the first stage of assessments were different from those in the samples of ice from the second stage of assessments at the 0.05 level of significance ($t_{df} = 2.910_{19}$, $P\text{-Value} = 0.009$). With regard to the chemical hazard assessments at the second stage, none of the restaurants showed any harmful chemical substances including borax, formalin, salicylic acid, sodium hydrosulfide, and pesticides.

Conclusions

From these results it can be seen that the training in the GMPs' practical guidelines was successful in reducing chemical and biological contamination. According to the study of Auad *et al.* (2019), it was found that food sanitation and food safety programs can lead to a decrease in food contamination. Nonetheless, it was found that 19 of the ready-to-eat food shops at MFU out of 39 shops still showed that *E.coli* was detected on the chefs' hands at the first stage of food hazard assessment following the training on the GMPs practical guidelines. These results suggest that some of the food handlers use only a little water for hand washing (Ghatak, and Chatterjee, 2018). Moreover, they use kitchen rags

as hand towels which is the main cause of cross contamination from the environment to the chefs' hands (Madaki, and Bavorova, 2019). For the detection of *E.coli* in the food containers and utensils, 4 of the food shops in MFU revealed *E. coli* contamination because of a lack of sanitization procedures for food containers and utensils including heating sanitizers for maintaining a temperature of 77°C for at least 15 min, and chemical sanitizers containing quaternary ammonium compounds, iodine, and chlorine (McSwane *et al.*, 2005). As shown in the section on the public meeting, food handlers admitted that they did not know the correct procedures for hand-washing and sanitizing utensils. It is therefore not surprising to see that the results of the first stage of the food hazard assessments, especially with regard to biological contamination, affected nearly half of all the food shops at MFU.

Regarding the number of fecal coliform bacteria in the samples of ice, it was found that the highest numbers of fecal coliform bacteria were up to 2,400 mpn/100 ml which is above the standard of Ministry of Public Health (Ministry of Public Health, 1984; 2004). In a study of samples of ice in Las Vegas, Nevada, Wills (2016) stated that most of the samples had a larger number of microorganisms than the regulation standard of the Environmental Protection Agency in the US. EPA. Moreover, a study of the Government of the Hong Kong Special Administrative Region (2005) concluded that the manufacture of ice can lead to many problems related to the *E.coli* contamination such as 1) some of the equipment was not properly cleaned 2) there was a deficiency of suitable transportation to the retail shop 3) there was a deficiency of cleanliness, especially in the production line, and 4) safety rules were not imposed on the workers. Moreover, the inefficiency of human excreta management and the control of animal vectors (e.g. flies, cockroaches) may lead to the contamination of ice at the source of the ice manufacturing.

In the section on chemical assessments, 2 of the food shops were found to have pesticide contamination which represents a high risk to health because they did not have any information related to the washing of raw materials to reduce pesticide concentration and they did not have any information on the pesticide tests for raw materials. As can be seen from the statistics on pesticide contamination in samples of hydroponic vegetables as reported by the Thai Public Broadcasting Service (2018), more than 50% of hydroponic vegetable samples were found to have pesticide contamination at a high risk to public health. In addition, pesticides can collect from a wide area and they are toxic to the environment as shown by the results of Tran *et al.*,

(2019) who concluded that more than 80% of the samples of marine fish living in the Cau Hai lagoon of central Vietnam were found to contain organochlorine pesticides (e.g. DDT) and polychlorinated biphenyls (PCBs) at a high level. Therefore, the principles of Good Agricultural Practices or GAPs (Food and Agriculture Organization of the United Nations, 2007), recommended the use of physical methods for the pest control such as traps or the lighting lamps, which should be widely promoted to reduce the amounts of pesticide usage in used in agriculture. Vegetable washing solution or baking soda should be provided to wash vegetables and fruit to reduce the concentration of pesticide contamination (Reuters Health, 2017).

From this study, it can be seen therefore that the implementation of the GMPs' practical guidelines in the food shops and restaurants at MFU was effective in improving the standards for reducing food contamination safety, especially with regard to chemical and biological contamination control. According to the number of fecal coliform bacteria in the samples of ice taken from the beverage shops, the number of fecal coliform bacteria was considerably reduced so that fecal coliform bacteria was no longer detected at a significant level after the implementation of the GMPs' practical guidelines. Furthermore, the number of food shops where the chefs' hands were contaminated with *E.coli* was reduced from 28 to only 16. In addition, the percentages for *E.coli* reduction overall increased from 57.57% to 75.75%. These results are similar to those found in the study of Allata *et al.* (2017), in which the researchers found that several ice cream factories located in Algeria had a higher quality of food sanitation and safety after the implementation of a hazards analysis and critical control points (HACCP), especially with regard to physical, chemical and biological hazards. Moreover, these results are further corroborated by the study of Costa Dias *et al.* (2012), who stated that the percentage of conformity increased from 32% to 66% after a GMP implementation. However, the dessert and snack bar shops at MFU showed no improvements in standards after the GMPs' implementation as there was 0% improvement. This may be the result of a deficiencies in knowledge, awareness, and attitudes regarding the importance of food sanitation and safety (Sibanyoni *et al.*, 2017). On the other hand, some of the customers such as the students and staff at MFU may not be sufficiently concerned about food sanitation and safety at MFU (Liu, and Niyongira, 2017). It is therefore recommended that personal awareness of food sanitation and safety among food handlers of dessert and snack bar shops,

as well A customer behavior attitudes towards food sanitation and safety at MFU should be focused on in a further study to improve level of food sanitation and safety at MFU. Any further research should apply the implementation of the GMPs' practical guidelines by meand of "*Show and Share for food sanitation and safety*" activities which include 1) always washing their hands and using only clean hand towels before the preparation and serving of food; 2) washing food containers and utensils when they have been used and using disinfection procedures to reduce some of the pathogensby placing food containers in sunlight; 3) choosing safe food ingredients including organic vegetables to avoid the pesticide contamination; 4) separating the ice used for beverage and not reusing it for other customers; and 5) always cleaning the ice bucket and containers with proper detergents and warm water to reduce the pathogen in the ice containers.

From this study, it is concluded that the GMPs' practical guidelines related to the reduction of food hazard can improve the quality of food sanitation and safety at the university. Although food hazards, especially the chemical and biological contamination, were reduced, *E.coli* was detected on the chefs' hands and it was reduced in a number of the dessert shops and snack bars. Hence, such the program was able to motivate some of the food handlers at MFU by increasing their awareness of the importance of food sanitation and safety especially in regard to personal hygiene. In the future, the impact on the customer who are the students and staff at MFU may become an important tool to increase the awareness of food handlers and to improve their behavior according to the principles of the GMPs' practical guidelines. Moreover, they should advise the food shops to ensure they maintain a high standard of hygiene with regard to food hazards which will lead to the reduction of food hazards and contaminationat MFU. In particular, we recommend thatthey should put into practice the procedures the *show and share* activities as listed below: 1) they should always wash their hands and use only clean hand towels before the preparation and serving of food; 2) when they wash the food containers and utensils, they should follow a disinfection procedure to reduce some of the pathogens by placing the food containers in sunlight; 3) they should choose safe food ty ingredients including organic vegetables to avoid pesticide contamination; 4) they should separate some of the ices for beverages and not reuse any for other customers; and 5) they should always clean the ice buckets and containers with the proper detergents and warm water to reduce the pathogens to in the ice buckets and containers.

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