Microbiological Quality and Sanitation of Food Stalls and Drinking Water Vending Machines

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ABSTRACT

Consumption of food from food stalls and water from vending machines has recently increased in Sakon Nakon Province, Thailand. This study investigated the microbial quality of food stalls and the sanitation of drinking water distributed through water vending machines. *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, and *Vibrio cholerae* were detected using polymerase chain reaction. In total, 33 food samples were collected from food stalls and 63 drinking water samples were collected from water vending machines. The results identified *E. coli* in 6.06% of the food and 11.11% of the drinking water samples. *Salmonella* spp., *S. aureus*, and *V. cholerae* were not detected in any of the food or drinking water samples. Food sanitation assessment indicated 21 (63.64%) of the food stalls did not meet the standards for drinking water as it was not stored in clean and closed containers equipped with a tap or nozzle. Regarding the sanitation of the water vending machines, the businesses failed to inspect the physical, chemical and biological aspects of water quality and never used a simple bacterial test kit to check water quality. It is concluded that the relevant government officials should educate the vender on food safety and hygiene as well as enforcing regular monitoring of the quality of food stall and drinking water vending machines.

1. INTRODUCTION

At present, the expansion of food stalls and water vending machines is growing to respond to the increasing needs of people, as these outlets provide convenience, are time saving, and offer goods at a cheaper price compared to bottled water. Additionally, the food items sold by food stalls are highly popular because of the limited time for cooking and the daily rush in many modern lifestyles. Therefore, if people choose non-standard drinking water and food contaminated with germs, they may encounter illness. According to data from the Bureau of Epidemiology (USA) in 2017, 1,038,349 patients had diarrhea with two deaths. Furthermore, eight patients had cholera and 110,396 patients had food poisoning with three deaths, with the causes being poisonous or pathogenic bacteria, possibly in food or drinks initially, or from contamination from the surrounding environment, especially due to personal hygiene. In 2017, the most detected pathogenic bacteria were *Vibrio*, *Staphylococcus*, *Salmonella* spp., and *Escherichia coli* (Feng et al., 2022; CDC, 2022).

Foodborne illnesses are usually infectious or toxic in nature and are caused by bacteria, viruses, parasites, or chemical substances entering the body through contaminated food. Chemical contamination can lead to acute poisoning or long-term diseases, such as cancer, while many foodborne diseases may lead to long-lasting disability or death. *Salmonella* and enterohaemorrhagic *Escherichia coli* are some of the most common foodborne pathogens that affect millions of people annually, sometimes with severe and fatal outcomes. Symptoms include fever, headache, nausea, vomiting, abdominal pain, and diarrhea. Foods involved in outbreaks of salmonellosis include eggs, poultry, and other products of animal origin. Enterohaemorrhagic *Escherichia coli* is associated with unpasteurized milk, undercooked meat, and contaminated fresh fruits, vegetables, and drinking water. *Vibrio cholerae* can infect people

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through contaminated water or food. Rice, vegetables, millet gruel, and various types of seafood have been implicated in cholera outbreaks (WHO, 2022).

Of most concern for health is naturally occurring toxins and environmental pollutants. Naturally occurring toxins include mycotoxins, marine biotoxins, cyanogenic glycosides, and toxins occurring in poisonous mushrooms. Staple foods, such as corn or cereals can contain high levels of mycotoxins, such as aflatoxin and ochratoxin, produced by mold on grain and long-term exposure can affect the immune system and normal development, or cause cancer. Persistent organic pollutants are compounds that accumulate in the environment and human body. Known examples are dioxins and polychlorinated biphenyls, which are unwanted by-products of industrial processes and waste incineration. They are found worldwide in the environment and accumulate in animal food chains. Dioxins are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones, and cause cancer. Other chemical hazards in food can include radioactive nucleotides (that can be discharged into the environment from industries and from civil or military nuclear operations), food allergens, residues of drugs, and other contaminants incorporated in the food during the process (WHO, 2022).

Chiang Khruea Sub-District, Mueang District, Sakon Nakon Province surrounds the Kasetsart University Chalermphrakiat, Sakon Nakon Province Campus, where there are many student dormitories; consequently, entrepreneurs and residential owners have installed water vending machines and food stalls to gain more income (Yongyod, 2018). Food and drinking water stores that open for service will focus on food quantity and speed to meet the limited time and the daily rush in many modern lifestyles, especially of students. As a result, the quality of food and drinking water served may be neglected.

Food and drinking water quality are essential to human health. Therefore, for the safety of consumers, contamination with *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, and *Vibrio cholerae* in food stalls and water from drinking water vending machines was examined using polymerase chain reaction (PCR) analysis. Furthermore, sanitation was evaluated in accordance with the requirements regarding food sanitation for food stalls and drinking water vending machines. The results could be used as fundamental information and for the development of guidelines for the sectors responsible for supervising and monitoring food and drink quality. The development and enforcement of guidelines regarding sanitation standards for food stall vendors and drinking water vending machine providers should provide assurance to consumers that these products are safe and clean.

2. METHODOLOGY

In order to evaluate the microbial quality of food stall and drinking water in Chiang Khruea Sub-District, Mueang District, Sakon Nakon Province were selected (Figure 1). Thirty three food samples were collected from food stalls and 63 water samples were collected from drinking water vending machines using a standard method (APHA, 2012) and examined for *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, and *Vibrio cholerae* by multiplex PCR method.

2.1 Study area and sampling sites

The study area for sampling was the Chiang Khruea Sub-District, Mueang District, Sakon Nakon Province, Thailand (Figure 1). Sample sites were selected to represent different locations of drinking water and of various type of foods (ready-to-eat items, such as curry, soup, and broiled and fried products).

In total, 63 water samples were collected from drinking water vending machines and tested for *E. coli*, *Salmonella* spp., *S. aureus*, and *V. cholerae*, while 33 food samples were collected from food stalls using a standard method (APHA, 2012) and examined for *E. coli*, *Salmonella* spp., and *S. aureus*.

At each sampling point, approximately 500 mL of water was collected in two plastic bottles of 600 mL each, while 50 g of food was collected in a plastic bag. All samples were transported to the microbiology laboratory in a cold box within 24 h.

2.2 Microbiological analysis

2.2.1 Food samples were prepared following Kim et al. (2007)

2.2.2 Enrichment and identification of bacterial pathogens

For isolation of *E. coli*, 25 g of food sample was homogenized with 225 mL of EC broth (HIMEDIA, Nashik, India) for two minutes with a stomacher (BagMixer, interscience, France). The suspension was first incubated at 35±2°C for 16 h, then 100 µL of suspension was streaked on RAPID' *E. coli* 2 agar (Bio-Rad, CA, USA) and further incubated at 35±2°C for 24 h. Violet colonies were selected as presumptive *E. coli* and confirmed by using multiplex PCR. *E. coli* ATCC 25922 was used as a positive control.

For the isolation of *Salmonella* spp., 25 g of food sample was homogenized with 225 mL of buffered peptone water (BPW; Oxoid, Hampshire England) in a stomacher apparatus for two minutes. The mixture was incubated at 35±2°C for 18 h and 100 μL of suspension was streaked on *Salmonellla Shigella* Agar (HIMEDIA, Nashik, India) and was further incubated at 35±2°C for 24 h. Black colony were presumptive as *Salmonella* and confirmed by using multiplex PCR. *Salmonella Typhimurium* ATCC14028 was used as a positive control.

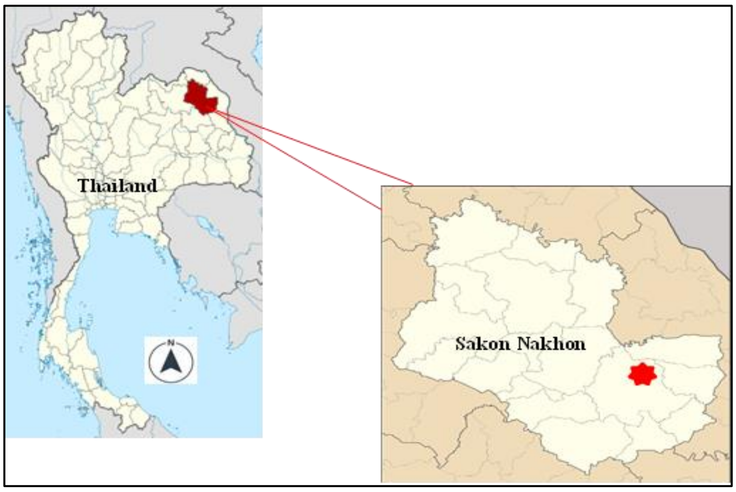

Figure 1. Map of the study area in Chiang Khruea Sub-District, Mueang District, Sakon Nakon Province, Thailand

S. aureus was isolated by homogenizing 25 g of food sample with 225 mL of tryptic soy broth with 10% NaCl (TSB; HIMEDIA, Nashik, India) for two minutes with a stomacher. The suspension was incubated at 35±2°C for 18 h, then 100 μL of suspension was streaked on mannitol salt agar (MSA; SIGMA-ALDRICH, Switzerland) incubated at 35±2°C for 24 h. Yellow colonies were selected as presumptive *S. aureus* and confirmed by using multiplex PCR. *S. aureus* ATCC 25923 was used as a positive control.

2.2.3 Water samples

A standard membrane filtration technique was used for the isolation of *E. coli*, *Salmonella* spp., and *Vibrio cholerae* by modifying APHA 9222 (2012), the presence. Briefly, 1,000 mL of water samples were filtered through a 0.22 μM pore size membrane filter (Millipore, MA, USA), then pre-enriched in BPW for *E. coli* and *Salmonella* spp., and incubated in alkaline peptone water (APW; HIMEDIA, Nashik, India) for *V. cholerae*. All enrichment samples were incubated at 35±2°C for 18 h. A loop full of broth culture was streaked on RAPID' *E. coli* 2 Agar, SS Agar, and thiosulfate citrate bile salts sucrose (TCBS; Sigma-Aldrich, Switzerland) for isolation of *E. coli*, *Salmonella* spp., and *V. cholera*, respectively. Suspected colonies (5-10 colonies) were sub-cultured on those media again. All isolates were cultured on TSA to extract genomic DNA and confirmed by multiplex PCR.

2.2.4 Identification of E. coli, S. aureus, Salmonella spp., and V. cholerae by multiplex PCR

DNA form all isolates were extracted using the heat-lysis method (Liu et al., 2002). All primers used in this study were shown in Table 1. An in-house multiplex PCR reaction mixture was performed using a total volume of 25 μL containing 1X PCRBIO Taq Mix Red (12.5 μL) (PCR Biosystemm, London, UK.), 0.2 μM of each primer for *E. coli*, *S. Typhimurium*, *V. cholerae* and 0.5 μM of each primer for *S. aureus*, sterile deionized water 5 μL, and the 50-100 ng DNA sample. A negative control containing the same reaction mixture except the DNA template was included in every experiment. The PCR amplifications were conducted using a T100 Thermal cycler (BioRad, Singapore). The PCR condition consisted of initial denaturation at 95°C for five min, followed by 30 cycles of denaturation at 95°C for one min, annealing at 56°C for 30 s, extension at 72°C for one min, and final extension at 72°C for five min. PCR products were evaluated in 1.5% agarose gels (Bioline Reagents Ltd, UK) at 100 V for 30 min. Gels were stained with ethidium bromide (Wako pure chemical industries, Ltd., Japan) for 20 min. Amplicon sizes were estimated by comparison with a DNA ladder (GeneRuler 100 bp Plus DNA Ladder, Thermo-scientific, Lithuania), visualized and photographed under ultraviolet light using gel documentation (Syngene, UK).

Table 1. Sequences of primers and expected product size used in this study

Bacterium	Primers	Sequence (5'→3')	Product size (bp)	Reference
E. coli	EC uidA-F	AAAACGGCAAGAAAAAGCAG	147	Bej et al. (1991)
	EC uidA-R	ACGCGTGGTTAACAGTCTTGCG		
V. cholerae	VC-F	GAATTAGGGTCCTGTGCAGG	248	Kong et al. (2002)
	VC-R	ATCGCTTGGCGCATCAGTGCCC		
Salmonella spp.	Salmo-F	GAGGAAAAAGAAGGGTCG	780	Radhika et al. (2014)
	Salmo-R	CTCAACTTCAGCAGATACCA		
S. aureus	FamA-F	CGATCCATATTTACCATATCA	450	Al-Talib et al. (2009)
	FamA-R	ATCACGCTCTTCGTTTAGTT		

2.3 Drinking water and food sanitation evaluation

Evaluation of the water from the drinking water vending machines was based on six items and the food sanitation requirements for food stalls were based on 12 items specified by the Bureau of Food and Water Sanitation, Department of Health, Ministry of Public Health, Thailand (Ministry of Public Health, 2013). The six water vending machine items were: (1) Location; (2) Characteristics of the vending machine; (3) Water source and water quality improvement; (4) Drinking water quality control; (5) Maintenance and hygiene; and (6) Recording and reporting.

The criteria for assessing the sanitation and the vending machine surrounds were categorized as: covering all items listed=good level; covering some items listed=poor level; and covering none of the items listed=should-improve level.

3. RESULTS

The results from the PCR testing of the 33 food stalls for the three types of bacteria (*E. coli*, *Salmonella* spp., and *S. aureus*) and the 63 drinking water samples for three types of bacteria (*E. coli*, *Salmonella* spp., *and V. cholera*) are shown in Tables 2 and 3, respectively.

Some food samples contained *E. coli* at a level exceeding the standard (Figure 2). All food samples were negative for the presence of *Salmonella* spp. or *S. aureus*. The drinking water samples were generally within the WHO standard levels, except for seven (11.11%) samples that exceeded the standard for *E. coli*. No *Salmonella* spp. or *V. cholera* was found in any of the drinking water samples.

Table 2. Presence of tested bacteria in samples of food stalls (N=63)

Indicator bacterium	Number of food samples tested (%)	Food standard*
Escherichia coli	2 (6.06)	Not detected
Salmonella spp.	0	Not detected
Staphylococcus aureus	0	Not detected

*Food stalls standard from the Ministry of Public Heath, Thailand

Table 3. Presence of tested bacteria in samples of drinking water (N=33)

Indicator bacterium	Number of drinking water samples tested (%)	Drinking water standard*
Escherichia coli	7 (11.11)	Not detected
Salmonella spp.	0	Not detected
Vibrio cholera	0	Not detected

*Drinking water standard from WHO

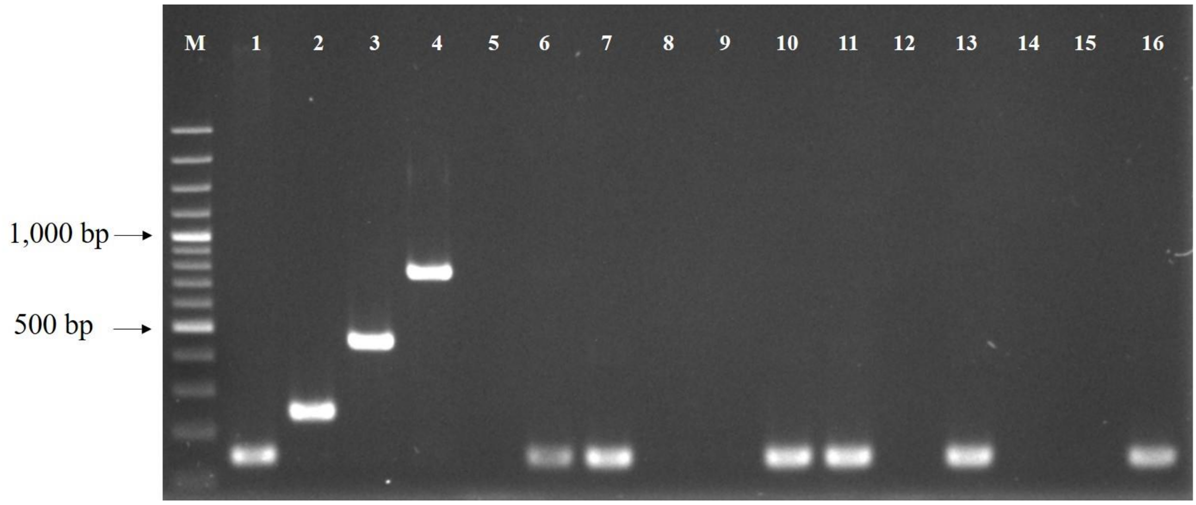

Figure 2. Multiplex PCR reaction of four pathogens detection. Lane M: DNA marker 100 bp, Lane 1: *E. coli* ATCC25922 (147 bp), Lane 2: *V. cholerae* ATCC 14035 (248 bp), Lane 3: *S. aureus* ATCC25923 (450 bp), Lane 4: *Salmonellas Typhimurium* ATCC14028 (780 bp), Lane 5: Negative control, Lane 6-16: samples isolated from food and water

3.1 Evaluation of sanitation conditions of food stalls

Table 4 shows the food sanitation evaluation for the 33 food stalls based on the 12 physical criteria from the food sanitation manual and sanitation requirements for food stalls produced by the Bureau of Food and Water Sanitation, Department of Health, Ministry of Public Health, Thailand (Ministry of Public Health, 2013).

The food sanitation evaluation in accordance with the requirements for food sanitation for food stalls requires stalls to be made from easily cleaned materials and to be kept in good and orderly condition and at least 60 cm above the ground. Food additives with FDA (Food and Drug Administration) number are required, and containers must be cleaned with dishwashing liquid and rinsed in clean water twice, with the washing equipment being at least 60 cm above the ground. It was found that solid waste was gathered and disposed of daily, and entrepreneurs must have any wound covered tightly and must use utensils to handle cooked food. It was found that 32 stalls (96.96%) had equipment for picking up food and the entrepreneurs were cleanly dressed and used an apron with a hat or hair net in 28 stalls (84.84%). Furthermore, 27 (81.81%) stalls had a container for spoons, forks or chopsticks with the handles upward in a transparent container kept at least 60 cm above the ground. The requirement that the stalls adhered to the least was not having cooked food covered or protected from insects, with 16 stalls (48.48%) at fault regarding this point (Figure 3).

Table 4. Evaluation of sanitation conditions of food stalls (N=33)

Item	Food sanitation	
	Number (%) Passed	Number (%) Not passed
1. Food vendor stall must be made of non-toxic and non-corrosive materials and installed to be easily cleaned. Food preparation areas must be at least 60 cm above the floor.	33 (100)	0
2. All cooked food must be kept in covered containers to protect from dirt, vermin, and other contamination.	16 (48.48)	17 (51.52)
3. All food additives or seasonings must be approved and registered with an FDA food number.	33 (100)	0
4. Drinking water must be stored in a clean and closed container equipped with a tap or nozzle.	12 (36.36)	21 (63.64)
5. Beverage or other drinks must be stored in clean and closed containers equipped with a tap or nozzle, or use a long-handled spoon/scoop for serving.	17 (51.52)	16 (48.48)

Table 4. Evaluation of sanitation conditions of food stalls (N=33) (cont.)

Item	Food sanitation	
	Number (%) Passed	Number (%) Not passed
6. Potable ice must be supplied and kept in a clean and closed container placed at least 60 cm above the floor. The ice must not be used to store raw or other food in the same container. Proper utensil (long handle spoon/scoop) must be used to pick up ice for serving.	13 (39.39)	20 (60.61)
7. All equipment and utensils must be washed with detergent and rinsed twice with clean tap water. The washing area must be set at least 60 cm above the floor.	33 (100)	0
8. Spoons, forks, and chopsticks must be kept with handle up or laid down neatly in a clean and covered container or basket, placed at least 60 cm above the floor.	27 (81.81)	6 (18.19)
9. Food waste and garbage must be disposed of in a sanitary manner.	33 (100)	0
10. Food handlers must wear suitable protective clothing including short or long sleeves clothes, apron and hair covering (hat or net).	28 (84.84)	5 (15.16)
11. Proper utensils (tongs, spoon, spatula, or any other utensil) must be used for picking up food.	32 (96.96)	1 (3.04)
12. Any cut or wound on food handlers' hands or skin must be completely protected by waterproof covering to avoid transmission of diseases.	33 (100)	0

Figure 3. Food stalls in study area around Kasetsart University Chalermphrakiat, Sakon Nakon Province Campus

3.2 Evaluation of sanitation conditions of drinking water vending machines

The 63 vending machines in operation were evaluated for sanitation and surrounding conditions detrimental to health according to the Public Health Act 1992 and the Ministry of Public Health announcement (No. 362) of 2013 (Ministry of Public Health, 2013), The results are shown in Table 5.

Table 5. Evaluation of sanitation conditions of drinking water vending machines (N=63)

Item	Number of machines (%)			Evaluation level
	Good	Poor	Should improve	
Location				
1. Should be at least 30 m away from water drainage	62 (98.41)	1 (1.58)	0 (0)	Good
2. There should be no drainage around the water vending machines	35 (55.56)	14 (22.22)	14 (22.22)	Good
3. The vending machines should be covered with a cap on the inlet to prevent insect entry	44 (69.84)	13 (20.63)	6 (9.52)	Good
4. The vending machines should be installed at least 10 cm above the ground as indicated by stability, to prevent short-circuit	24 (36.36)	34 (53.97)	5 (9.09)	Good
5. The container should be above the ground	39 (61.90)	22 (34.92)	2 (3.17)	Good

Table 5. Evaluation of sanitation conditions of drinking water vending machines (N=63) (cont.)

Item	Number of machines (%)			Evaluation level
	Good	Poor	Should improve	
Condition of machines				
6. No rust and stable to prevent a short-circuit	26 (41.27)	30 (47.62)	7 (11.11)	Poor
7. Parts exposed directly to the water are made of suitable materials without odor, color, or taste that may affect water quality	40 (63.49)	20 (31.74)	3 (4.76)	Good
8. The outlet and container resting at least 60 cm above the ground so that neither insects nor infectious animals could enter	40 (63.49)	13 (20.63)	10 (15.87)	Good
9. Parts exposed directly to the water have no evidence of thallophytic plants	30 (47.27)	20 (32.72)	13 (20.00)	Good
Water resources and quality improvement				
10. Water resources and quality are clean with no contamination, adverse color, smell, or taste	53 (84.13)	10 (15.87)	0 (0.00)	Good
11. Water resources are satisfactorily clean (water supply and ground water)	45 (71.43)	18 (28.57)	0 (0.00)	Good
12. Water quality meets the standards for drinking water	28 (44.44)	31 (49.21)	4 (6.35)	Poor
Drinking water standardized quality control				
13. Water sampling testing for physical and chemical characteristics and bacteria carried out at least once per year	12 (19.05)	2 (3.17)	49 (77.78)	Should improve
14. Use of a simple test kit to check for coliform bacteria at least once per month	10 (15.87)	3 (4.76)	50 (79.37)	Should improve
Maintenance and servicing				
15. Machines checked by the machine company	20 (31.75	25 (39.63)	18 (28.57)	Good
16. Machines cleaned every day to prevent dust spreading	25 (39.68)	26 (41.27)	12 (19.05)	Poor
17. Outlet and water container cleaned every day to prevent dust spreading	19 (30.16)	26 (41.27)	18 (28.57)	Poor
18. Water storage cleaned at least once per month	15 (23.81)	20 (31.75)	28 (44.44)	Should improve
19. Cleaning and changing filter by the machine company	20 (31.75)	14 (22.22)	29 (46.03)	Should improve
Recording and reporting				
20. Water quality record and maintenance record	5 (7.94)	10 (15.87)	48 (76.19)	Should improve
21. Inform customers of water quality	3 (4.76)	20 (31.75)	40 (63.49)	Should improve
22. Monitor drinking water quality	8 (12.70)	10 (15.87)	45 (71.43)	Should improve

3.2.1 Location

The sanitation evaluation for the location of drinking water vending machine was at the good level, with the location of the drinking water vending machine stable being strong and stable with no waterlogged or dirty surfaces. The water drainage was sanitarily suitable, with the machines were installed at least 10 cm above the ground and water pick-up point closure was provided to control and prevent contamination from insects and animals as disease carriers from entering the machine (Figure 4).

3.2.2 Characteristics of water machine

The evaluation result of the characteristics of the drinking water vending machines was at the good level except for poor wiring (47.62%) which could be dangerous due to a short circuit affecting users of the water vending machine (Figure 5).

Figure 4. Typical location of drinking water vending machine

Figure 5. Characteristics of water machine

3.2.3 Water source and water quality improvement

The evaluation result for water sources and water quality improvement of the water vending machines was at the good level (84.13%), with good quality, clean water without any undesirable color, odor, or flavor. Most water in the vending machines was from a local water supply.

3.2.4 Drinking water quality standard control

The entrepreneurs were unaware of water quality analysis for physical, chemical, and biological aspects (77.78%) and were also uninformed about an easy test kit for examining coliform bacteria for biological water quality testing by themselves (79.37%).

3.2.5 Maintenance and cleaning

The evaluation result for maintenance and cleaning of the water vending machines was at the fair level because the entrepreneurs were uneducated about cleaning water tanks and changing filters and so had to wait for the drinking water vending machine company to replace the filter annually. Additionally, some machines had never been cleaned and their filters had never been replaced (Figure 6).

Figure 6. Maintenance and cleaning of water vending machines

3.2.6 Recording and reporting

The evaluation result of the recording and reporting for the drinking water vending machines was at the poor level because most entrepreneurs had failed to identify the date of filter replacement and record water quality inspections for service users. There was only identification of the filter system and the brand of the manufacturer.

4. DISCUSSION

While only a few cases of *E. coli* (a bacterium indicating below-standard drink and food sanitation) were identified, this was dangerous because the standard for drink and food quality requires zero presence. In fact, *E. coli* inhabits the intestines of humans and warm-blooded animals, and some kinds of *E. coli* can result in illnesses, such as diarrhea (WHO, 2022). Food contamination with *E. coli* may result from the distribution of uncovered cooked food that is not protected from dust or animals as disease carriers, or be present in nearly cooked, uncooked, or unheated food which could be more exposed to bacteria or microorganisms than thoroughly cooked food (Ghosh et al., 2007). Food stalls usually operate in small units, perhaps lacking hygiene, and appropriate food management, such as preparation, storage, and handling practices (Seo and Lee, 2021).

Most entrepreneurs did not have containers covering the cooked food which may cause contamination from insects and dust, while some stalls provided spoons, forks, and chopsticks without the handle up, so that when the cooks used them, contamination of the food could result in adverse effects on consumers (Pratum and Khananthai, 2017). Additionally, the cooks at some stalls failed to wear an apron, hat, or hairnet, which may have resulted in contamination by loose hairs and dirt in food, which again may have affected consumers (Bereda et al., 2016). Despite there being only a few observed occurrences, such failures could negatively affect the consumers. Cooked food should be clean and safe for all consumers.

Some aspects regarding the sanitation of the water vending machines required improvement as entrepreneurs failed to inspect the physical, chemical, and biological aspects of water quality and never used a simple bacterial test kit to check the water quality (Dorothy et al., 2010). Furthermore, there were some factors affecting water quality, such as cleaning and filter replacement on time based on water quality data records, and vending machine repair and maintenance (Tan et al., 2016; WHO, 2017; Phusomya and Yongyod, 2022). At present, there is no law clearly controlling food and water quality, as only water quality is monitored (Yongyod, 2018).

We concluded that food safety and hygiene interventions with embedded hand washing with soap at critical times could have important effect on reducing publicly transmitted diarrheal disease (WHO, 2019). As such, the promotion of food hygiene practices using a behavior-centerd approach should be integrated into nutrition, such as the “Scaling Up Nutrition” and “WASH” (Community Led Total Sanitation)” intervention policies and programming. Although limited benefits were seen from the addition of feces and water management interventions, it should be considered that these may have been impacted by the existing environmental contamination in the household yard. Integration can be achieved through existing structures using locally available expertise with appropriate support and supervision (Morse et al., 2020).

5. CONCLUSION

Out of the total of 63 drinking water samples taken from the vending machines, seven samples (11.11%) were positive for *E. coli* and two food samples (6.06%) were detected with *E. coli*. There was no contamination of *Salmonella* spp., *Staphylococcus aureus*, or *Vibrio cholera* in any of the drinking water samples. All of food samples were negative for *Salmonella* spp., and *Staphylococcus aureus.* Generally, drinking water sanitation was at the good level; however, improvements were needed in cleanliness, orderly wiring to prevent electric shock, and recording and monitoring water quality. Sanitation at a level below the standards could lead to bacterial contamination in food and drinks.

The sanitation evaluation revealed that 14 stalls (42.42%) met the relevant standards for food sanitation of food stalls, while 19 stalls (57.58%) failed to meet the standards. The stall practice that was at the least achieved level was the failure to use covered containers for cooked food to protect the food from animals. Therefore, the concerned authorities should monitor the stalls and strictly impose the regulations to ensure safe drinking water quality and food safety.

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REFERENCES

Al-Talib H, Yean CY, Al-Khateeb A, Hassan H, Singh KK, Al-Jashamy K, et al. A pentaplex PCR assay for the rapid detection of methicillin resistant *Staphylococcus aureus* and Panton-Valentine Leucocidin. BMC Microbiology 2009; 9(1):1-8.

American Public Health Association (APHA). Standard Methods for the Examination of Water and Wastewater: Volume 22nd. Washington, DC, USA: American Public Health Association; 2012.

Bej AK, Dicesare JL, Haff L, Atlas RM. Detection of *Escherichia coli* and *Shigella* spp. in water by using the polymerase chain reaction and gene probes for uid. Applied and Environmental Microbiology 1991;57(4):1013-7.

Bereda TW, Emerie YM, Reta MA, Asfaw HS. Microbiological safety of street vended foods in Jigjiga City, Eastern Ethiopia. Ethiopian Journal of Health Sciences 2016;26(2):163-72.

Center for Disease Control (CDC). Waterborne diseases [Internet]. 2022 [cited 2022 Oct 28]. Available from: https://www.cdc.gov/healthywater/surveillance/drinking-surveillance-reports.html.

Dorothy YM, Grace SK, Moses A, Langbong B. Bacteriological quality of ready to eat foods sold on and around university of Ghana Campus. Research Journal of Microbiology 2010; 5(2):130-6.

Feng P, Weagant SD, Jinneman K. Diarrhea genic *Escherichia coli* [Internet]. 2022 [cited 2022 Oct 28]. Available from: https://www.fda.gov/food/laboratory-methods-food/bam-chapter-4a-diarrheagenic- escherichia-coli.

Ghosh M, Wahi S, Kumar M, Ganguli A. Prevalence of enterotoxigenic *Staphylococcus aureus* and *Shigella* spp. in some raw street vended Indian foods. International Journal of Environmental Health Research 2007;17(2):151-6.

Ministry of Public Health. Handbook of Drinking Water Vending Machines. Business Detrimental to Health, in Public Health Act 1992 and the Ministry of Public Health. Bangkok, Thailand: Ministry of Public Health; 2013 (in Thai).

Kim JS, Lee GG, Park JS, Jung YH, Kwak HS, Kim SB, et al. A novel multiplex PCR assay for rapid and simultaneous detection of five pathogenic bacteria: *Escherichia coli* O157:H7, *Salmonella*, *Staphylococcus aureus*, *Listeria monocytogenes*, and *Vibrio parahaemolyticus*. Journal of Food Protection 2007:70(7):1656-62.

Kong RY, Lee SK, Law TW, Law SH, Wu RS. Rapid detection of six types of bacterial pathogens in marine waters by multiplex PCR. Water Research 2002;36(11):2802-12.

Liu L, Coenye T, Burns JL, Whitby PW, Stull TL, LiPuma JJ. Ribosomal DNA-directed PCR for identification of *Achromobacter (Alcaligenes) xylosoxidans* recovered from sputum samples from cystic fibrosis patients. Journal of Clinical Microbiology 2002;40(4):1210-3.

Morse T, Tilley E, Chidziwisano K, Malolo R, Musaya J. Health outcomes of an integrated behaviour-centred water, sanitation, hygiene and food safety intervention: A randomised before and after trial. International Journal of Environmental Research and Public Health 2020;17(8):Article No. 2648.

Phusomya P, Yongyod R. Application of hazard analysis and critical control points concept for rural bottled drinking water production process. Urban Water Journal 2022;19(10):1060-5.

Pratum C, Khananthai N. Assessment of factors affecting drinking water quality from free water dispenser in the higher education institution. International Journal of Environmental and Science Education 2017;12:787-97.

Radhika M, Saugata M, Murali HS, Batra HV. A novel multiplex PCR for the simultaneous detection of *Salmonella enterica* and *Shigella* species. Brazilian Journal of Microbiology 2014;45: 667-76.

Seo KH, Lee JH. Understanding risk perception toward food safety in street food: The relationships among service quality, values, and repurchase intention. International Journal of Environmental Research and Public Health 2021;18(13): Article No. 6826.

Tan EY, Arifullah M, Soon JM. Identification of *Escherichia coli* strains from water vending machines of Kelantan, Malaysia using 16S rRNA gene sequence analysis. Exposure and Health 2016;8(2):211-6.

World Health Organization (WHO). Guidelines for Drinking Water Quality. 4th ed. Geneva, Switzerland: The World Health Report; 2017. p. 110-2.

World Health Organization (WHO). Water, Sanitation, Hygiene, and Health: A Primer on WASH and Health for Health Professionals. Geneva, Switzerland: WHO; 2019.

World Health Organization (WHO). Food safety [Internet]. 2022 [cited 2022 Jan 24]. Available from: https://www.who.int/news-room/fact-sheets/detail/food-safety.

Yongyod R. Drinking water quality and evaluation of environmental conditions of water vending machines. Asia-Pacific Journal of Science and Technology 2018;23(1):1-5.