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Evaluation of Street Food Safety and Hygiene Practices of Food Vendors in Can Tho City of Vietnam

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Abstract

The objective of this study was to investigate the food safety status of street foods in the city of Can Tho, Vietnam. A total of 410 consumers was interviewed to get an insight into the popular street foods in the studied area. Vietnamese sandwich (34.63%) and sugarcane juice (24.51%) were consumed popularly according to the survey. A total of 263 street food samples (i.e.Vietnamese sandwich, n=131 and sugarcane juice, n=132) were collected from different locations such as schools, hospitals, markets, and other locations in four districts (i.e. Ninh Kieu, Cai Rang, Phong Dien and O Mon) of Can Tho city for microbiological analysis. Total aerobic mesophilic counts (TMC), yeast and mold, coliform, *E. coli*, and *Staphylococcus aureus* were assessed. Microbial contamination of Vietnamese sandwich was 5.7-9.2 log CFU/g (TMC), 2.0-7.4 log CFU/g (yeast and mold), 2.5-7.9 log CFU/g (coliform), 1.0-5.9 log CFU/g (*E. coli*), and 1.7-6.6log CFU/g (*Staphylococcus aureus*). There was a significant difference in Vietnamese sandwich sampling among districts ($p<0.05$). In contrast, the contamination of sugarcane juice samples with regards to total aerobic mesophilic counts,yeast and mold, coliform, *E. coli*, and *Staphylococcus aureus* were 7.53±0.74, 5.56±0.71, 6.02±1.21, 2.26±1.31, 1.47±0.77 log CFU/mL, respectively. No statistically significant difference ($p>0.05$) was observed in sugarcane juice samples among districts and locations. The observation of the handling practices of street food vendors showed inadequate hygiene practices, assessment of the street foods safety showed that they do not satisfy the

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Vietnam hygiene standard of specific foods. These findings give an insight into the safety status of sampled street foods and may provide needed information for Vietnam's authorities to further improve the safety of street food and create food safety awareness among consumers and handlers, thereby preventing risk to public health.

Introduction

Street food vending is largely an informal nature of enterprise which is a common practice all over the world.[1] Street foods are very familiar and sold as quick meals or snacks,[2] they are very popular among urban dwellers in developing countries because they are usually perceived to be inexpensive, convenient and attractive.[1] As the urban population increases especially in developing countries, the number of people who consume street foods may also increase.[3] Vietnam is a developing country, most famous for its delicious and varied street food. Vietnam television online newspaper (http://www.vtv.vn) reported there are about 5000 street food vendors in Can Tho city (population of 1.569 million in 2019 and an area of 1,409 km^2). In addition, the street food in Can Tho city accounts for up to 95% of urban consumer purchases (mainly by more than 60 thousand students studying in universities located in Can Tho city); 51% consuming for the main dish daily and 82% for breakfast. Even though street foods are beneficial, serious concerns were raised regarding food safety, the risk of food poisoning outbreaks linked to street foods remains a threat in many parts of the world, with microbiological contamination as a major problem.[4] In addition, eating out and eating uncooked or cooked food have become a trend in many countries while rules governing the safe handling and preparation of food have not been updated.[5] The issues of an increase in foodborne illnesses have become a global concern.[6] However, foodborne outbreaks were markedly underreported in most countries.[8] Samapundo *et al*.[3] also reported that over 80% of consumers interviewed in Portau Prince, Haiti were not aware of *Salmonella* spp., hepatitis A virus, and *Staphylococcus aureus* to be pathogens responsible for foodborne illness outbreak. Globally, foodborne and waterborne diseases kill around 2.2 million people annually.[8] In Greece, there were approximately 370,000 patients due to the consumption of contaminated foods between 1996-2006.[9] In the United States, the consumption of contaminated food resulted in about 1,000 food outbreaks and approximately 48 million patients.[10]

Additionally, some issues related to street foods may cause foodborne diseases by microbial contamination.[11] A considerable proportion of street foods has shown a poor microbiological quality and a potential cause of outbreaks.[2] Poor quality of raw materials, unhygienic conditions during food preparation and awareness about food safety and sanitary practices among food vendors are possibly the main reasons for food poisoning outbreaks.[12] As a result of unsafe food, public health and economic development will be affected greatly.[13] However, information on the quality and safety of these street foods, especially in Can Tho city, Vietnam is very limited. Actually, food safety problems may result from poor knowledge about food safety and improper practice among vendors.[14]

The objective of this study was to investigate the food safety status of street foods in the city of Can Tho, Vietnam including the observation of the handling practices of street food vendors.This study will give an insight into the safety status of street foods in Can Tho city and create food safety awareness among consumers and handlers, and may provide needed information for Vietnam's authorities to further improve the safety of street food, there by preventing risk to public health.

Materials and Methods

Food Consumption Surveys

Food consumption survey was carried out in four districts of Can Tho city (i.e.Ninh Kieu, Cai Rang, Phong Dien, and O Mon) to get an insight into popular street foods in these districts. A questionnaire was developed and administered to 410 consumers, to gain the necessary information regarding the favorite street food consumed. The questionnaire consisted of four parts: (i) respondent information (gender, age, education level, marital status); (ii) attributes (i.e. convenient, delicious, cheap, other reasons) of street

food consumption, (iii) behavioral characteristics (frequency of purchasing, belief and concern about safety of street food) and (iv) consumption surveys for street foods and beverages, this was done by giving out a prepared list containing different street foods and beverages from which the respondents can select.

Observation Checklist and Interview of the Street Food Vendors

Food vendors from the four districts mentioned above were observed and interviewed. A total of 263 vendors participated in the interview. Demographic information (i.e. gender, age, district, and location) of the vendors was obtained using a questionnaire. In addition, observation of vendors was done using four important checklists: (i) information on facilities, (ii) environment around the stall, (iii) personal hygiene and (iv) food storage.

Sampling

Two popularly consumed street foods (i.e. food and beverage items) according to survey results were selected in the surveyed districts. A total of 263 samples consisting of Vietnamese sandwich (n = 131) and sugarcane juice (n = 132) were bought from locations such as schools, hospitals, markets, and other locations in four districts (i.e. Ninh Kieu, Cai Rang, *Phong Dien* and O Mon) of Can Tho city. Samples were transferred aseptically into stomacher bags between 7-10 a.m., stored in Styrofoam boxes containing ice packs (4°C) and then transported to the Laboratory of Microbiology and Biotechnology of Food Technology Department, Can Tho University, Vietnam for microbiological analysis. All the samples were analyzed for microbial quality (total mesophilic counts, yeast and mold) and hygiene indicators (coliform, *E. coli*, and *Staphylococcus aureus*) within 4 h.

Microbiological Analysis

Twenty-five (25) gram of food samples were taken using sterile scalpels and tweezers and placed in a stomacher bag. 225 mL of Maximum Recovery Diluent (MRD, Merck, Germany) was added and the mixture was homogenized for 1 minute. Beverage samples were vortexed during 10 s. 1 mL of homogenized sample was aseptically transferred to 9 mL of MRD. Subsequently, a tenfold serial dilution was then made in MRD.Three appropriate and consecutive dilutions were enumerated by pour-plating of 1 mL on Plate Count Agar (PCA, Merck, Darmstadt, Germany) for total aerobic mesophilic counts (TMC) followed by incubation at 37°C for 48-72h.

Total yeast and mold counts were enumerated by pour plating 1 mL of the decimal dilutions on Yeast Extract Glucose Chloramphenicol Agar (YGC, Merck, Darmstadt, Germany) followed by incubation at 37°C for 48-72 h. Coliform and *E. coli* were enumerated by pour plating 1mL of the decimal dilutions on Coliform agar Enhance Selectivity (ES, Merck, Darmstadt, Germany) and later incubated for 18-24 h at 37°C after which pink to red and dark blue to violet colonies were counted as coliform and *E. coli* respectively.[15,16] *Staphylococcus aureus* was enumerated by spread plating the decimal dilutions (1 ml/5 plate) on Baird Parker Agar (BPA, Merck, Darmstadt, Germany) plates with 25 ml/500 ml Egg Yolk Tellurite Emulsion (Merck, Darmstadt, Germany) added. After an incubation period of 48 h at 37°C, confirmation of *S. aureus* was done using Coagulase test, Staphytect Plus (Merck, Darmstadt, Germany).[17]

Statistical Analysis

The results of the microbial analysis of the popular street food samples (i.e. food and beverage items) were expressed as log CFU/g and log CFU/mL, respectively.[18] The results of the survey on the food consumption of the consumers and observation checklist of the vendors were reported as mean value ± standard deviation and the range of all independent replicates samples. Statistically significant differences were performed at a 5% significance level using the SPSS statistics version 20.0 (IBM Inc, Chicago, IL, USA).[19,20]

Results and Discussion

Food Consumption Surveys

A total of 410 consumers participated in the survey and based on the results from the demographic profile, the majority of them were female (62%) while the remaining 38% were male with an age range of 14-64 years. 65.4% of them were university students, 15.6% were high school students and 19% were either graduates, secondary school students or with no education. With regard to the marital status of consumers, 82% were single while 18% were married.This demographic profile is to some extent representative of the status and attitudes

of consumers to street food consumption in the surveyed communities. The results from the survey on attributes of street food showed that the percentage of consumers consumed street food based on convenient (65.1%), delicious (20.5%), cheap (9.5%) and other reasons (4.9%).

These results correspond with the report of Bereda *et al*. [21] who found that the consumers prefer to eat street food based on convenience and easily available to get, as well as it being delicious and cheap. Also, there are varieties of street foods available from which the consumers can easily buy and conveniently eat while going along their businesses, this might be part of the factors that influence their decision in purchasing such foods.[22] Similarly, regarding the characteristics of frequency of purchasing street foods, neutral showed the highest (35.4%), followed by more often purchased street foods (28.3%), less often (17.6%), always (12.9%) and 5.9% of respondents do not purchase street foods (Fig 1). The results may reflect the lifestyle of Vietnamese people preferring cooked food at home, also, Unusan[23] reported that many people were mostly confident buying foods from supermarkets to ensure a safe food supply. Regarding the concern about street food contamination, the highest number (41%) of respondents were always concerned, 30% showed more concern, 18.3% were neutral, 4.9% were less and 5.9% were never concerned. In contrast, the highest number (29.5%) of respondents never or has less belief about food safety of street foods (Fig 1). These findings showed that consumers were concerned about the unhygienic practices of vendors and the unclean vending locations which may cause food contamination, but the need for fast and ready to eat food gives them no other choice but to patronize the vendors. Wilcock *et al*.[24] reported that 49% of consumers were of great concern with regards to food safety, including 17% concern on bacterial contamination and 8% on food spoilage.Tambekar *et al*.[25] also reported that the conditions of preparation and distribution of street food were of concern. it should be were of concern to the consumers.

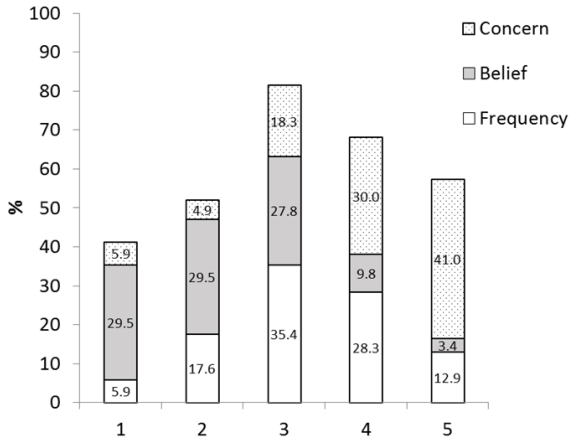

Fig.1: The characteristics of frequency of purchasing, belief and concern about safety of street foods of consumers (n = 410) using a scoring scale from 1 to 5 corresponding to 1: never, 2: less, 3 neutral, 4: more and 5: always

Figure 2 (a: food items) and Figure 2 (b: beverage items) showed the result of the consumption survey of street foods. According to the street food surveyed by types of food items, 34.6% of respondents consumed Vietnamese sandwich, 28.3% hot soup, 13.4% mixed rice paper salad, 5.6% sticky rice, 2.7% bakery products and 15.4% of consumers appreciated other street foods (Figure2 a). These results support those of previous findings that have looked at the eating habits of Vietnamese people. Sandwich (pâté) and other bread were more frequent in the list of eating out of home, hot soups including meat associated with noodles were relatively more frequently consumed in Vietnam.[26]

Furthermore, Figure 2 (b) shows the arrangement of beverage types of street food from the highest to the lowest consumption as follows: sugarcane

juice (24.1%), milk tea (21.2%), fruit juice (9.5%), soya milk (9.3%), pennywort juice (5.1%), ice tea (3.2%), squash tea (1.2%), and other (6.8%). These data represent the behavior of Vietnamese people towards the consumption of different types of beverages for relaxation. Khairuzzaman *et al*.[27] reported that fresh sugarcane juice with ice was sold by hawkers in the streets and other similar public places making it easy to find and consume.

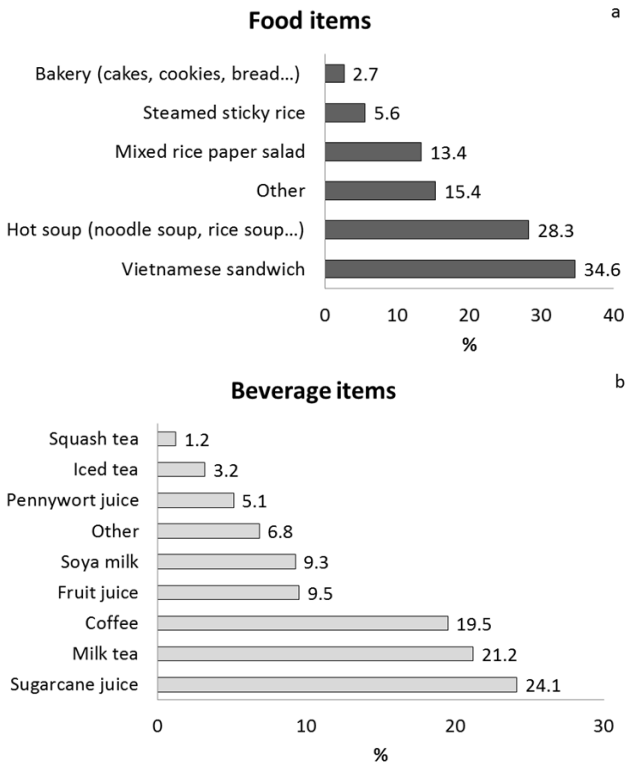

Fig. 2: The percentage of consumption survey of street foods in Can Tho city (a) Food items (b) Beverage items (n = 410)

In this study, the Vietnamese sandwich (34.6%) and sugarcane juice (24.1%) were likely preferred but with great concerns on food safety by the consumers. The high frequency of consumption as well as the high potential of risk with harmful microorganisms was considered on sandwich and sugarcane juice; hence, these samples were selected for microbial analyses.

Microbiological Analysis

Microbial Counts of Vietnamese Sandwich

Table 1 shows the total aerobic mesophilic count in the Vietnamese sandwich (n = 131) from four districts and different locations in Can Tho city. The total aerobic mesophilic counts (TMC) of sandwich at Ninh Kieu, Cai Rang, *Phong Dien*, and O Mon were 5.7-8.5, 6.5-8.9, 6.5-9.1 and 6.0-9.0 log CFU/g, respectively. The results of TMC at the different locations were 7.7±0.8 log CFU/g at school, 7.3±2.8 log CFU/g at the hospital, 7.6±0.7 log CFU/g at the market and 5.8±3.4 log CFU/g at other zones. There were significant differences in TMC of Vietnamese sandwich sampled in Ninh Kieu, Cai Rang and *Phong Dien* districts ($p<0.05$).The TMC of Vietnamese sandwich sampled in Cai Rang and *Phong Dien* had much higher counts than those sampled in Ninh Kieu and O Mon ($p<0.05$) while no significant difference ($p>0.05$) was observed among the different sampling locations. These results correspond with a previous study of Campos *et al*.[28] who collected hamburger from vending trailers and reported that they did not satisfy microbiological quality, 90% of the ready to eat hamburgers had TMC more than 5 log CFU/g. This also confirmed the study on the

Vietnamese sandwich (7.2 ± 0.7 log CFU/g of TMC) vended in Ho Chi Minh city as reported by Thanh.[29] According to Thanh,[29] Vietnamese sandwich is eaten without cooking or heating, therefore microbial contamination can occur due to poor handling during preparation and service by vendors. It also reported that microorganisms can contaminate food due to poor handling when street food is being prepared or served. In addition, handling food with bare hands, which is common among vendors can be a high-risk source of contamination.[30]

Table 1. Microbiological counts contaminated on Vietnamese sandwich by different sampling districts and locations (n = 131)

	District			Locations				
Sandwich Log CFU/g	**Ninh Kieu (n= 40)**	**Cai Rang (n =30)**	**Phong Dien (n=31)**	**O Mon (n= 30)**	**Shool (n=26)**	**Hospital (n =23)**	**Market (n=40)**	**Other (n=42)**
TMC	5.5±3.3 (5.7-8.5)	7.8±0.6 (6.5-8.9)	8.8±0.7 (6.5-9.1)	7.3±0.7 (6.0-9.0)	7.7±0.8 (6.0-9.1)	7.3±2.8 (5.7-8.9)	7.6±0.7 (6.0-9.0)	5.8±3.4 (6.4-9.2)
Yeast &mold	4.3±0.8 (2.3-5.4)	5.3±1.0 (2.8-7.4)	5.5±0.8 (4.2-6.8)	4.6±1.2 (2.0-6.7)	4.7±1.2 (2.3-6.8)	4.8±1.1 (3.1-6.5)	4.8±1.1 (<2.0-7.4)	4.9±1.0 (2.8-6.5)
Coliform	5.2±1.3 (2.5-7.1)	6.5±0.9 (3.8-7.9)	6.5±0.6 (5.3-8.0)	5.6±0.8 (4.2-7.9)	5.7±1.1 (2.8-7.7)	5.9±1.1 (3.8-7.6)	6.1±1.0 (2.5-7.9)	5.8±1.3 (3.8-8.0)
E. coli	3.2±1.3 (<2.0-6.8)	3.9±1.2 (2.3-5.9)	4.0±1.0 (2.6-5.8)	3.5±0.9 (2.0-5.7)	3.7±1.2 (<2.0-6.8)	3.7±1.3 (<2.0-5.7)	3.6±1.0 (<2.0-5.9)	3.6±1.2 (<2.0-6.6)
S. aureus	2.5±0.9 (<2.0-5.7)	3.2±1.5 (<2.0-6.4)	2.6±1.2 (<2.0-6.1)	3.1±1.2 (2.3-6.6)	2.8±1.2 (<2.0-5.6)	3.2±1.5 (<2.0-6.1)	2.9±1.3 (<2.0-6.4)	2.6±1.1 (<2.0-6.4)

The yeast and mold counts in Vietnamese sandwich samples collected from Can Tho city ranged from <2.0 to 7.4 log CFU/g (Table 1). The results were 2.3-5.4 log CFU/g at Ninh Kieu, 2.8-7.4 log CFU/g at Cai Rang, 4.2-6.8 log CFU/g at *Phong Dien*, and 2-6.7 log CFU/g at O Mon. There was a significant difference ($p<0.05$) in the counts of yeast and mold in Cai Rang and *Phong Dien* compared to Ninh Kieu and O Mon district, whereas no statistically significant difference ($p>0.05$) was observed among the sampled locations. It is clear that this food is prone to contamination since it's a mixed food type containing vegetables, meat, and sauce with the main ingredient being bread. Any of these ingredients can be a source of mold contamination.[31] Adjrah *et al*.[32] also reported that yeast and mold were present on vegetables collected from different sources showing a high-level of contamination.

Table 1 shows the results of coliform and *E. coli* contamination in Vietnamese sandwich (n=131) samples collected from the different districts. Coliform in the sandwich was 2.5-7.1 (Ninh Kieu), 3.8-7.9 (Cai Rang), (5.3-8.0) (Phong Dien), and 4.2-7.9 log CFU/g (O Mon). The trends observed for coliform and *E. coli* counts were similar to those described above for the TMC and yeast and mold counts.Coliform contamination in the sandwich at Cai Rang and Phong Dien were significantly higher ($p<0.05$) than those at Ninh Kieu and O Mon district. In contrast, there were no significant differences among the locations sampled ($p>0.05$).These results were in agreement with a study in Ho Chi Minh city in which the presence of coliform, *E. coli*, and other pathogenic microorganisms was considered to be a threat to the safety of street foods.[29] *E. coli* were the most well-known of the food borne pathogens,[33] this bacteria has been recognized as the cause of a serious health problem in Greece and linked with consumption of contaminated food.[9] These microorganisms are hygiene indicators and their presence indicates poor hygiene practices during or after food production.[34] Although most types of coliform bacteria are harmless to humans, some can cause mild illnesses and a few can lead to serious water borne diseases.[35] In addition, the microbial contamination in Vietnamese sandwich was dependent on the districts sampled due to

probably different practice during food production. Therefore, it is suggested that food handlers should be equipped with the necessary knowledge and skills to enable them to handle food hygienically. In addition, food safety standards should be developed for street foods with monitoring officers recruited to ensure implementation and compliance with these standards by food handlers and vendors to ensure the safety of street foods.

The contamination *Staphylococcus aureus* in the Vietnamese sandwich sampled at Ninh Kieu, Cai Rang, *Phong Dien*, and O Mon with *S. aureus* was 2.5±0.9, 3.2±1.5, 2.6±1.2, and 3.1±1.2 log CFU/g, respectively. For the different sampling locations, *S. aureus* counts were 2.8±1.2 log CFU/g at schools, 3.2±1.5 log CFU/g at hospitals, 2.9±1.3 log CFU/g at markets, and 2.6±1.1 log CFU/g at other locations (Table 1). The contamination of *S. aureus* in the Vietnamese sandwich was not significantly different between the different sampling districts and locations ($p>0.05$). The results may result from the handling practices of street food vendors. *S. aureus* is found in the nostrils and on the skin of warm-blooded animals, and the primary source of food contamination is the hands of food handlers.[36] In addition, these bacteria had the potential to grow and produce Staphylococcal enterotoxins (SE), the causative agent of staphylococcal food poisoning (SFP) over an extensive range of temperature, pH, sodium chloride concentration and water activity. According to Argudín *et al*. [37] although the bacteria can be eliminated during conventional cooking of the raw materials, the enterotoxin is heat stable and therefore cannot be eliminated by cooking or heat treatment. The presence of *S. aureus* in the Vietnamese sandwich sampled in this study represents a great risk to public health, most especially if there is the production of enterotoxins by bacteria, coupled with the fact that this sandwich is usually eaten without cooking or heating.

Microbial Counts of Sugarcane Juice

As can be seen in Table 2, TMC in sugarcane juice (n = 132) was 7.3 ± 0.7 log CFU/mL (Ninh Kieu), 7.4 ± 0.7 log CFU/mL (Cai Rang), 7.7 ± 0.9 log CFU/mL (*Phong Dien*), and 7.7 ± 0.6 log CFU/mL (O Mon). There were no significant differences in TMC in sugarcane juice among the four sampled districts ($p>0.05$). With regards to the different sampling locations, the TMC counts was 7.5 ± 0.7 log CFU/mL (school), 6.9 ± 0.8 log CFU/mL (hospital), 7.5 ± 0.7 (market) and 7.6 ± 0.8 (other zones). Whereas, a statistically significant difference ($p<0.05$) exist in TMC between at hospital and at other locations (i.e. residential zone, street foods zones, etc). Sugarcane juice extraction is not a heat-treated process,[29] therefore high microbial counts with contamination by pathogens can occur and these pathogens can survive and persist in the juice.[38] A previous study also reported the contamination of drinking water and/or beverages with diarrhea-causing bacteria.[39] Microbial contamination of food and drinks can be caused by factors such as the use of unhygienic equipment and utensils, poor effluent disposal and infrequent hand washing during food processing.[40,41]

As the results showed in Table 2, there was no significant difference ($p>0.05$) in total yeast and mold counts from both the different districts and sampling locations. According to Mosupye *et al*.,[42] street foods may be contaminated with environmental yeast and mold spores, or by food handlers. In addition, yeast and mold may grow on the sugarcane stalk used for juice production during storage because of its high sugar and mineral content[43] and may be transferred into the juice during processing as observed in this study.

Coliform count in sugarcane juice sampled at the different sampling districts and locations ranged from<1.0 to 7.8 log CFU/mL. *E. coli* counts, on the other hand, both ranged from <1.0 to 6.2 log CFU/mL (Table 2). There were no statistically significant differences ($p>0.05$) in coliform and *E. coli* counts in sugarcane juice samples collected at different sampling locations. In contrast, the samples collected at O Mon district had higher significant Coliform and *E. coli* counts than Ninh Kieu and *Phong Dien* district ($p<0.05$).The contamination of sugarcane juice with both coliform and *E. coli* represents fecal contamination because these bacteria are hygiene indicators. Although the sugarcane juice is always consumed with ice (flake or cubic), the current study examined the microbial contamination in sugarcane juice without ice to avoid the interference of ice contamination. The contamination with microorganisms can occur during handling by vendors as a result of poor sanitation practices during or after food production. *E. coli* and coliform contamination of juice, raw foods

and vegetables from unhygienic practices among food handlers have also been reported in previous studies showing that these foods are a great source of foodborne pathogens.[12,25,28,42,44]

Table 2: Microbiological counts contaminated on sugarcane juice by different sampling districts and locations (n = 132)

	District			Locations				
Sugarcane juice Log CFU/mL	**Ninh Kieu (n= 40)**	**Cai Rang (n =32)**	**Phong Dien (n=30)**	**O Mon (n= 30)**	**Shool (n=19)**	**Hospital (n =20)**	**Market (n=30)**	**Other (n=63)**
TMC	7.3±0.7 (5.8-9.3)	7.4±0.7 (5.8-9.0)	7.7±0.9 (5.3-8.8)	7.7±0.6 (6.2-9.1)	7.5±0.7 (6.4-8.8)	6.9±0.8 (5.6-8.0)	7.5±0.7 (5.9-8.5)	7.6±0.8 (5.3-9.0)
Yeast &mold	5.6±0.8 (4.0-7.0)	5.6±0.7 (4.0-6.9)	5.6±0.7 (3.9-6.8)	5.5±0.7 (3.9-6.8)	5.7±0.7 (4.0-7.0)	5.4±1.0 (3.9-6.9)	5.6±0.7 (4.0-6.6)	5.6±0.7 (3.9-6.9)
Coliform	5.8±1.1 (4.4-7.1)	6.4±0.8 (5.2-7.8)	5.2±2.2 (2.7-7.5)	6.8±0.8 (4.5-7.8)	5.6±1.9 (<1.0-7.5)	5.8±1.0 (4.2-7.1)	6.0±1.7 (<1.0-7.7)	6.1±1.4 (<1.0-7.8)
E. coli	2.0±1.0 (<1-3.5)	2.1±1.3 (<1-5.6)	2.0±1.3 (<1-6.2)	2.9±1.6 (<1-6.2)	2.3±1.4 (<1.0-6.2)	1.5±1.0 (<1.0-4.1)	1.9±1.0 (<1.0-4.0)	2.4±1.4 (<1.0-4.1)
S. aureus	1.3±0.7 (<1-3.5)	1.2±0.6 (<1-3.7)	1.6±0.8 (<1-4.1)	1.8±1.0 (<1-4.1)	1.6±0.8 (<1.0-3.4)	1.8±1.2 (<1.0-4.1)	1.3±0.6 (<1.0-2.8)	1.4±0.7 (<1.0-4.1)

Furthermore, Table 2 shows the contamination of sugarcane juice samples from the different districts and locations with *S. aureus*. The *S. aureus* count for both sampling districts and locations ranged from <1.0-4.1 log CFU/mL. There were no significant differences between the different sampling districts and locations (p>0.05). *Staphylococcus aureus* is the most common food poisoning bacteria.[45] Tambekar *et al*.[46] also reported that 93% of water samples being used to prepare street foods in their study had high loads of *S. aureus* (31%), it was suggested then that regular monitoring of the quality of street foods must be practiced to avoid food-borne illnesses. The serving utensils used at the vending site are often contaminated with Staphylococcus which may have originated from the vendors hands when they touch the food preparation areas, dishes, clothes, and the water during dish and hand washing.[25,47,48].

Generally, based on the results of the microbiological analysis of the two popular street foods (i.e. Vietnamese sandwich and sugarcane juice) samples with regards to microbial quality and safety, a high level of contamination was determined and this suggested that further risk assessment and management plans be implemented to ensure the safety of these street foods which will promote the health of the public. In addition, a microbiological standard exists for non-alcoholic beverages such as sugarcane juice according to standards of Vietnam Ministry of Health regulations 05/2012/TT-BYT[49] but none exist for food such as Vietnamese sandwich, it is therefore suggested that microbiological standard be established that can be used in monitoring the safety and quality of such street food.

Interview and Observation of Food Handling Practices among Street Food Vendors

Interview of Street Food Vendors

263 street food vendors of Vietnamese sandwich (n=131) and Sugarcane juice (n=132) from four districts and locations were interviewed in this study (Table 3). 92.4% (121/131) of Vietnamese sandwich vendors were female with a mean age of 46 years ranging from16 to70 years. Regarding sugarcane juice vendors, 71.2% (94/132) were female while 28.7% (38) were male with an overall age range of 15-70 years.

Observation Checklist of Street Food Vendors

A total of 131 Vietnamese sandwich vendors were observed (Table 3). Based on the observation of facilities, 72.5% of vendors do not prepare food on-site because sandwich ingredients are composed of cooked meat (prepared from home) and fresh and fermented vegetables which will be mixed on-

site during vending. Regarding access to potable water, it was observed that only 31.3% of vendors had it close to the site, on the other hand, hand washing facilities was not available (43.5%), this showed that the majority of the vendors did not follow the correct hygienic practices for cleaning stuffs used. It was also observed that 89.3% of vending stalls environment was not protected from sunlight, dust, and wind. 98.5% of vendors do not store previously cooked food ingredients under cool temperature. This might provide a good condition for microorganisms to grow and multiply in the food prior to the sale of such foods which can cause contamination of food and subsequently result in foodborne illness if such contaminated food is consumed. From our observation, 45.8% of food vending stalls use waste bin collector while 54.2% do not use this, therefore they throw food wastes in nearby places, and this may be a source of food contamination.

Table 3: Facilities and observed food safety practices of Vietnamese sandwich (n = 131) and sugarcane juice vendors (n = 132)

Observation checklist item	Sandwich (n = 131)		Sugarcane juice (n = 132)	
	Observation (%)			
	Yes	No	Yes	No
Facilities				
1. Is the food prepared on-site	36 (27.5)	95 (72.5)	16 (12.1)	116(87.9)
2. Is vending stall protected from sunlight, dust, and wind	14 (10.7)	117 (89.3)	23 (17.4)	109(82.6)
3. Is there access to potable water at the site or close to the site	41 (31.3)	90 (68.7)	86 (65.2)	46 (34.8)
4. Are there adequate hand washing facilities available	74 (56.5)	57 (43.5)	70 (53)	62 (47)
5. Is there food disposal facilities available	60 (45.8)	71 (54.2)	80 (60.6)	52 (39.4)
Environment around the stall				
6. Is the stall closed to community-operated wastewater and waste disposal sites	11 (8.4)	120 (91.6)	45 (34.1)	87 (65.9)
Personal hygiene				
7. Are the operator's clean clothes and presentable	110 (84)	21 (16)	93 (70.5)	39 (29.5)
8. Does the operator use an apron when handling, preparing and serving of food	19 (14.5)	112 (85.5)	7 (5.3)	124(94.7)
9. Does the operator handle food with bare hands	122 (93.1)	9 (6.9)	128 (97)	4 (3)
10. Is the hair of the operator covered when handling preparing and serving of food	19 (14.5)	112 (85.5)	41 (31.1)	91 (68.9)
11. Does the operator handle money while serving food	131 (100)	0 (0)	120 (90.9)	12 (9.1)
12. If answer to Q11 is yes: are the hands washed after handling money before handling food again	11 (8.4)	120 (91.6)	6 (5.0)	114(95.0)
13. Does the operator wear jewelry during handling food	80 (61.1)	51 (38.9)	61 (46.2)	71 (53.8)
14. If answer to Q13 is yes: is the jewellery adequately covered	0 (0)	80 (100)	1 (1.6)	60 (98.4)
15. Is cough, pick the nose, touch hair...when handling, preparation and serving of food	9 (6.9)	122 (93.1)	2 (1.5)	130(98.5)
Food storage				
16. Are previously cooked foods kept cool (i.e. icebox) or refrigerator	2 (1.5)	129 (98.5)	73 (55.3)	59 (44.7)

This was also reported in previous studies of street foods in developing countries where 80% of vendors had easily removable stalls, which can be easily dragged on wheels from one location to the other thereby limiting the availability of adequate washing facilities.[12,50] A study in Ethiopia reported environmental pollution due to poor waste management i.e. 74.2% of the waste were disposed wrongly.[21] Therefore vending sites can result in street food contamination with microorganisms.[46] Additionally, 91.6% of the stalls were not close to community-operated wastewater and general waste disposal sites, this is considered good for the stalls because there will be limited disturbance from flies which can perch on the food to cause cross-contamination. Regarding personal hygiene practices of vendors, results showed that 84.0% of vendors used clean clothes, 85.5% do not use jewelry, 85.5% do not cover their hair, 93.1% used bare hand during food preparation and serving, 100% handle money with bare hands while serving foods and 91.6% do not wash the hands after handling money before serving foods again. 6.9% of food vendors were observed to breathe/cough, pick the nose and touch the hair while handling foods. Foods and ingredients may be subjected to cross-contamination from unwashed hands.[27] Also, lack of good personal hygiene practices can predispose food to microbial contamination. Some previous studies reported that poor personal hygiene in the street or market and among food handlers poses a considerable risk to public health.[51,52]

In Table 3, the result observation of the handling practices among 132 vendors of sugarcane juice showed that 87.9% do not extract the juice prior to sales on-site due to the fact that vendors use fresh sugarcane stalk and extraction of juice can easily be done for sale immediately. However,12.1% of vendors store excess extracted juice in an icebox for subsequent sales to consumers. Differently, 65.2% of vending sites had potable water close to them as some stalls were close to vendor's homes. In addition, it is very important for the vendors to have sufficient potable water for use in the preparation of juice and in washing operations.[29] Generally, 65.9% of operators had waste bin collectors which were kept carefully. Additionally, 54.5% of the sugarcane juice vending stalls was not close to the community-operated waste water and general waste disposal sites while 34.1% were close. According to the FAO, the place of food preparation should be kept clean at all times and should be far from any source of contamination such as rubbish, wastewater, dust and animals.[53] In Taiwan, it was reported that 36% of food handlers hand-washing practices were unsatisfactory, with 22.9% touching money, and 19.5% continued to handle food without washing the hand.[52] Therefore, food operators should equip the adequate facilities and vend far away waste disposal sites. Omemu *et al*.[54] reported varying hand-washing and facilities cleaning practices among food vendors, with the majority of them usually ignoring personal hygiene.

In similarity to the Vietnamese sandwich vendors, personal hygiene practices of food operators showed that 97% of operators used bare hands while the remaining 3% used hand gloves. Among those observed, 90.9% of the operator handle money while serving food, also 95% of them do not wash their hands after touching money before handling food again. Additionally, a half of the operators (46.2%) wear jewelry, 98.4% among them did not cover the jewelry adequately. It is considered as a source of contamination and may cause physical hazards while preparing or rendering food service. Food handlers should have, good appearance, healthy body, clean clothes, hygienic hands, short nails, no jewelry and without beard or mustache.[55] This result showed that the majority of sugarcane juice vendors do not practice good personal hygiene, this might have resulted in the high count of microbial contamination on sugarcane juice. In contrast, over half (55.3%) of operators kept the sugarcane stalk cool in icebox before the extraction of sugarcane juice from them, while 44.7% of operators do not practice this, they only keep in buckets under normal environmental temperature. Poor storage conditions of raw material used for food and beverage may also predispose the juice to contamination. It has been reported that storing raw materials at ambient temperature (29-32^{o}C) encouraged the growth of foodborne pathogens which may pose risks to consumers if such is used for food preparation.[50]

Conclusion

It can be concluded that convenience mainly determined the choice of street food consumption, with the two most popular street food being Vietnamese sandwich (34.6%) and sugarcane juice (24.1%) compared with other street food in

the studied districts of Can Tho city. Microbiological analysis result of Vietnamese sandwich and sugarcane juice showed high contamination, with total mesophilic counts ranging from 5.7-9.2 (log CFU/g) and 5.3-9.3 (log CFU/mL), respectively. Hygiene indicator microorganisms (coliform, *E. coli* and *Staphylococcus aureus*), as well as yeast and mold, were also present in the samples taken from the different districts and locations. Observation of personal hygiene and handling practices of food vendors showed that most of them do not follow good hygiene practices, this might have possibly resulted in the high microbial load observed in this study among a host of other factors. These results showed that the quality and safety of street foods need to be strictly monitored to prevent it from being a source of foodborne illness outbreaks which can greatly affect public health. Hence, training of street food handlers in Can Tho city with regards to knowledge on proper handling of food and food safety awareness is therefore recommended.

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Conflict Of Interest

The authors declare that they have no conflicts of interest.

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