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Food safety behavior, attitudes and practices of street food vendors and consumers in Vietnam

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Abstract

Abstract

Street foods have become more popular in developing countries including Vietnam. However street food consumption has associated to higher risks of food-borne diseases. This study was conducted to investigate the food safety situation in certain districts in HoChiMinh city, Vietnam. There were three main surveys performed in this study. The first survey evaluated the food safety knowledge and attitudes of consumers and vendors by the mean of questionnaire, whilst the second part focused on observation of the food handling practices of the vendors by mean of a checklist. The last part was assessed the microbiological quality of selected street foods. A total of 40 street food vendors and 120 consumers were involved in the survey, and 71 street food samples were collected for microbiological analysis. All the surveys were conducted in four popular districts, namely District Binh Thanh, District Thu Duc, District 3 and District 8 and were based on the voluntary participation.

72.5% of the street vendors were women. The vast majority (95%) of the vendors had not received any food safety training. The surveyed consumers had adequate level of food safety knowledge and attitudes with mean score of 67 and 68, respectively. In contrast, the street vendors had poor levels of food safety knowledge and attitudes; with mean scores less than 50. The results showed that no significant difference occurred between levels of food safety knowledge of consumers on the basis of gender ($p = 0.85$). However, significant differences were shown in the food safety knowledge of the consumers occurred on the basis of age ($p = 0$), education ($p = 0$), food safety training status ($p = 0.007$) and location (district) ($p = 0.004$). The youngest consumers (18 and 35 years) had the highest food safety scores.

With regards to the vendors, no significant differences were observed in their food safety knowledge levels on the basis of gender ($p = 0.4$) and age ($p = 0.2$). However, significant differences were found in the food safety knowledge's of the vendors on the basis of food safety training ($p = 0.04$) and education level ($p = 0.001$). Regarding location, this study determined that the handlers in district Thu Duc had significantly ($p < 0.05$) the poorest food safety knowledge and attitude levels.

The observation study showed that 60% of the food was prepared on site. 52.5% of the vending sites were open air without any protection from the sun, wind and dust. Evidence of

animals and or pests/flies was observed at 62.5% the stalls evaluated. 52.5% the vending stalls had no access to potable water on-site, while 47.5% did not have adequate hand washing facilities and a further 30% lacked proper waste water and food disposal facilities. In addition, 52.5% did not separate raw, partially cooked food and cooked food products. 67.5% observed not to cover their utensils whilst 22.5% washed their utensils with clean water soapless water. These findings highlighted that vendors in HoChiMinh city generally have poor food handling practices and personal hygiene.

The microbial analysis also showed that 14.1%, 2.8% and 11.3% of the samples did not satisfy the end of shelf-life criteria for ready-to-eat foods recommended by Uyttendaele et al. (2010) on the basis of their total aerobic bacteria, total anaerobic bacteria and lactic acid bacteria counts, respectively. Alarmingly 76.1% of the samples had total coliform counts above the acceptable limit for ready-to-eat foods. With regards to the pathogens, *Bacillus cereus* spp. were confirmed in 20 and 12.5% of the stuffed pancakes and pizza samples, respectively. The mean counts (log CFU/g) of presumed *B. cereus* spp. in these two products were 2.93 (±1.13) with the value ranging between 0 and 5.9 log CFU/g. *Staphylococcus aureus* was confirmed in 4/15 (26.7%) and 2/16 (12.5%) of the Vietnamese sandwiches and pizza samples, respectively. *Escherichia coli* was confirmed in 2/15 (13.3%), 4/15 (26.7%) and 3/15 (20%) of the samples of stuffed pancakes, Vietnamese sandwiches and blended juice, respectively. None of the samples were contaminated by *Listeria monocytogenes*.

In conclusion, the results of microbial quality analysis collaborated the results of the surveys which showed that the vendors had poor safety knowledge and attitude levels and the observation study which showed that the majority of the vendors had poor food handling practices and operated under mostly unhygienic conditions. These results should provide the Vietnamese government with more reasons to increase their current efforts at improving the safety of street foods and food safety awareness of the consumers.

Keywords: Street foods, food safety attitude, food safety knowledge, handling, consumers, street vendors, microbiological quality

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Acronyms and abbreviations

CDC	Center for Disease Control
CFU	Colony Forming Units
EFSA	European Food Safety Authority
FAO	Food and Agriculture Organization
FBD	Food Borne Disease
HACCP	Hazard Analysis and Critical Control Points
INFOSAN	International Food Safety Authorities Network
ICMSF	International Commission on Microbiological Specifications for Foods
MRS	Man, Rogosa and Sharpe agar
MSA	Mannitol Salt Agar
MYP	Mannitol egg Yolk Polymyxin agar
PHO	Pan American Health Organization
PCA	Plate Count Agar
PPS	Physiological Peptone Saline solution
RTE	Ready To Eat food
TSA	Tryptone Salt agar
USDA	United States Department of Agriculture
VFA	Vietnam’s Food Administration
VRBA	Violet Red Bile Agar
WHO	World Health Organization

1. INTRODUCTION

1.1. Background information

Street foods are described as ready-to-eat foods and beverages prepared and sold by vendors or hawkers especially in streets and other similar public places (FAO, 1989). According to the FAO, street foods contribute significantly to the diets of many people in the developing world (FAO, 2007). In addition to offering business opportunities for developing entrepreneurs, the sale of street foods can make a sizeable contribution to the economies of developing countries. Moreover, street foods play an important role in developing societies as they support the livelihoods of millions of the urban poor. Traditional and exotic local street foods have emerged as new tourist attractions in developing countries.

However, street foods have in recent years become one of the most common risks associated with the increase in outbreaks of food-borne diseases in developing countries. There have been several documented cases of food poisoning outbreaks due to street foods. Street foods were responsible for 691 food poisoning outbreaks and 49 deaths from 1983 to 1992 in Shangdong Province (China) (Lianghui, 1993). In 1988, 14 deaths were reported in Malaysia because of food-borne diseases related to street foods. In the same year 300 people became ill in Hong Kong after consumption of street vended foods. In 1981 a cholera epidemic in Pune, India was linked to consumption of street vended juice, whilst an outbreak of cholera in Singapore in 1987 was attributed to the consumption of street foods (FAO, 1990).

Vietnam is a developing country largely famous for its delicious and diverse street foods. The wide variety of dishes on offer in Vietnam do not only fulfil the eating habits of urban residents, especially in low and medium income areas in the cities i.e. HoChiMinh city, but also attract the curiosity of tourists. Although the Vietnam Ministry of Health has issued some specific regulations of street foods in its Law of Food Safety, the number of food poisoning outbreaks related to street foods has significantly increased in recent years. These outbreaks have been associated with various responsible agents which range from pathogens to chemical contaminants. According to Rane (2011), the poor knowledge and improper food handling of street vendors in basic food safety measures and poor knowledge and awareness among consumers about the potential hazards associated with certain foods could explain the health and safety issues that street foods may pose (Rane, 2011). Moreover, it is important to state

that the costs of food-borne illness include the cost of medical treatment, productivity loss, pain and suffering of affected individuals, industry losses, and losses within the public health sector (Harris, 1997).

1.2. **Major objectives of the study**

This study has the major objective of analysing the safety street foods vended in HoChiMinh city and factors contributing to the safety. The results of this study can contribute to improving the policies and actions of the Vietnam government regarding the safety of street foods. In particular, the study conducted surveys to investigate the food safety knowledge and attitudes of vendors and consumers of street foods in HoChiMinh City, the biggest industrial city of Vietnam. The food handling and hygiene practices of the vendors were also evaluated in this study. In addition, an assessment of the microbiological quality of certain street food was also performed.

1.3. **Specific objectives of the study**

The specific objectives of the study were as followed:

- Evaluation of the food safety knowledge and attitude of consumers and street food vendors
- Observation of the handling practices of street food vendors in order to assess if the methods of food preparation, storage and presentation meet the required food safety standards
- Evaluation of the general microbiological quality of selected popular street foods

1.4. **Hypothesis of the study**

Two hypotheses will be tested through mentioned objectives:

- Street foods are assumed to be microbiologically unsafe,
- The consumers and vendors of street food have poor hygiene practices and limited food safety knowledge

2. LITERATURE REVIEW

2.1. Introduction

According to a rough estimate, 48 million food-borne diseases occur each year in the United States (USA) alone, leading to 128,000 hospitalizations and 3000 deaths (CDC, 2011). In Europe, it was reported that approximately 5,196 food-borne outbreaks (including water-borne outbreaks) occurred in 2013 (EFSA, 2015). It is also reported by the World Health Organization (WHO) that food-borne diseases largely reduce the health and economic growth of both developed and developing countries (WHO, 2013). According to the WHO, food- and water-borne outbreaks of diarrhea kill nearly 2.2 million people worldwide every year. Apart from diarrhea, food-borne illnesses can also trigger other serious complications such as kidney and liver failure, brain and neural disorders, reactive arthritis, cancer and death (WHO, 2013). Therefore, the causes of food-borne outbreaks need to be investigated carefully to prevent these outbreaks (CDC, 2011).

Street foods are very popular in developing countries; however, very little statistical data exists on food-borne outbreaks attributed to street vended foods in developing countries. Nevertheless, the conditions of preparation and marketing of street foods are usually unacceptable (Bryan et al. 1988; Mosupye and Holy, 2000). The common reason is that most of street vendors are often poor, uneducated and lack attention for safe food handling (WHO, 1996). Consequently, street food safety is potentially a large public health concern.

A variety of studies including different opinions and studies on food safety knowledge and attitudes will be summarized in this review. In addition, research that has been performed the on microbiological safety of street foods during recent years will be reported.

2.2. Overview of street foods in developing countries

Street foods are described as ready-to-eat foods and beverages prepared and sold by vendors or hawkers especially in streets and other similar public places (FAO, 1989). Street foods contribute significantly to the diets of many people in the developing world (FAO, 2007). In addition to offering business opportunities for local entrepreneurs, the sale of street foods can make a sizeable contribution to the economies of developing countries. Moreover, street foods

play an important role in developing societies as they support the livelihoods of millions of the urban poor. Traditional and indigenous exotic street foods have emerged as a new form of tourist attraction in developing countries.

However, street foods have become one of the most common risks associated with the increase in outbreaks of food-borne diseases in developing countries in recent years. There have been several documented cases of food poisoning outbreaks associated to street foods. Street foods were responsible for 691 food poisoning outbreaks and 49 deaths from 1983 to 1992 in Shangdong Province (China) (Lianghui, 1993). In 1988, 14 deaths were reported in Malaysia because of food-borne diseases related to street foods (Bryan, 1988). In the same year 300 people became ill in Hong Kong after consumption of street vended foods (Bhat, 2000). In 1981 a cholera epidemic in Pune, India was linked to consumption of street vended juice (Mahale, 2008). An outbreak of cholera in Singapore in 1987 was attributed to the consumption of street foods (FAO, 1990). According to Rane (2011), the poor knowledge and improper food handling of street vendors in basic food safety measures and poor knowledge and awareness among consumers on the potential hazards associated with certain foods could explain the health and safety issues that street foods may pose. Moreover, it is important to state that the costs of food-borne illness include the cost of medical treatment, productivity loss, pain and suffering of affected individuals, industry losses, and losses within the public health sector (Harris, 1997).

In 1993, the WHO through its six regional offices undertook a survey of its member states to assess the current situation with regards to street-vended food and to obtain the views of responsible authorities concerning the hazards posed by street-vended foods and contributing factors, as well as approaches for managing these hazards (WHO, 1996). The survey noted that almost all countries reported a wide variety of foods, methods of preparation, facilities and infrastructure. In addition, the WHO mentioned that street-vended foods may pose significant public health problems because of various reasons including i) lack of basic infrastructure and services, such as potable water supplies ii) difficulty in controlling the large numbers of street food vending operations because of their diversity, mobility and temporary nature iii) insufficient resources for inspection and laboratory analysis iv) general lack of factual knowledge about the microbiological status or the precise epidemiological

significance of many street-vended foods v) poor knowledge of street vendors in basic food safety measures and vi) inadequate public awareness of hazards posed by certain street foods.

According to the same survey a variety of countries reported a wide range of street foods, types of preparation, facilities and infrastructure and many magnitude outcomes of the survey were finalized as following:

i. In 74% of countries street-vended foods were a significant part of the urban food supply,
ii. Diverse type of foods such as meat, fish, fruits, cereals, frozen products and beverages were sold in the street,
iii. There were different methods of preparation varying from foods without any preparation (65%), ready-to-eat food (97%) and food cooked on site (82%),
iv. Vending facilities were also different, going from mobile carts to fixed stalls and food centers,
v. Limited infrastructure development with restricted access to potable water (47%), toilets (15%), refrigeration (43%) and washing and waste disposal facilities,
vi. The majority of the countries reported contamination of food (coming from raw food, infected handlers and inadequately cleaned equipment),
vii. Time and temperature abuse were the major factors contributing to food-borne disease;
viii. Most countries reported that there was insufficient inspection of the personnel, insufficient application of the HACCP concept and noted that registration, training and medical examinations were not part of the management strategies of street vended foods.

South East Asia is famous for its large variety of cheap and delicious food. In particular, Vietnam is largely known for delicious and diverse street vended foods ranging from quick snacks to entire meals which are an important cultural characteristic of the local people. The wide variety of dishes on offer in Vietnam do not only fulfil the eating habits of urban residents, especially in low and medium income areas in the cities (i.e. HoChiMinh city), but also attract the curiosity of tourists. However, the government is now confronted with the potential emergence of public health safety issues. Although the Vietnam Ministry of Health has issued some specific regulations to control the safety of street foods (Regulation number

51/2001/QH10), the number of outbreaks related to street foods poisoning have significantly increased in recent years (WHO Vietnam, 2015). These outbreaks have been associated with a wide range of etiological agents including pathogens and chemical contaminants.

In 2011, Vietnam adopted a revised Food Safety Law which for the first time specifically mentioned the problems related to street food. The law states some specific guidelines on how to operate a street food stall. In brief, the five key conditions for street food safety that need to be satisfied by vendors are:

- The stall must be away from a polluted place
- Clean water must be used to cook food and clean kitchen utensils
- The origin of the produce used to make the food must be clear
- Vendors must have a waste collection system in place
- Vendors can only make use of a specific list of additives.

As a result of its participation in WHO's International Food Safety Authorities Network (INFOSAN), Vietnam now has access to food safety authorities worldwide and receives useful information on new international food safety events. Vietnam's Food Administration (VFA) has made additional efforts to improve the operations of street food vendors. In particular, the VFA has started organizing training on hygiene and food safety for street food vendors. For consumers, the government tries to educate them through a variety of communication channels in order to give them a clear perception of what a hygienic and safe street food stall looks like. In this way, it is hoped that the consumers armed with this knowledge will avoid unsafe food stalls. As a result, the government expects that the improved (food safety) behavior of consumers will put pressure on unhygienic street food vendors to either improve the quality of their stalls or to withdraw from the street food market. In addition, the government has recently started conducting inspections on street food vendors in order to observe if they comply with the regulations or not. The vendors who adopt the law will be motivated while those who break the rules will be fined or forced to stop their business (WHO, 2015).

As a member of INFOSAN, Vietnam has been supported by the WHO to improve its food safety laws. It has been advised to adopt a participatory method to get all important stakeholders involved in food safety development. In addition, the WHO also supports Vietnam in the development of potential diagnostic techniques for food safety analysis in

laboratories and necessary facilities to raise awareness about food safety in consumers through community education and training programs. Moreover, participating in INFOSAN enables Vietnam to acquire new information from international food safety events and effective consultation to monitor food safety problems at a global as well as local level (WHO, 2015).

The most common food-borne diseases caused by eating street food in Vietnam are intestinal or gastrointestinal complaints, of which the most common symptom is diarrhea. Also, contaminations are the most important cause of these food-borne diseases and are a result of vendors not following the standards for hygienic handling and the Five Keys to Safer Food provided by Vietnam's government (Making street food safe in Vietnam, VFA, 2015). The Five Keys to Safer Food was widespread not only through mass media channels including television or the national radio station named "Voice of Vietnam" but also through other organizations like the Farmers Association, Women's Union and Veterans Association. On the other hand, the government also supplies flyers and broadcasts audio messages (*via* village speaker systems) so that basic safety knowledge can be reached by consumers who live in remote areas.

Vietnam is a lower middle income country and needs to deal with a lot of challenges of food safety, especially on street foods safety. In particular, the rapid development of industrialization leads to the environmental pollution in most of the big cities, which also negatively affect the safety of street foods. One of the biggest factors that influence street food safety is provision of clean water at street food stalls. The other significant challenge is that the poor knowledge and attitudes on street food of local consumers. In addition, most of street food vendors tend to use unsafe and unhygienic produce or ingredients due to either high profit or limited knowledge.

2.3. **Food safety knowledge and attitudes**

Henson and Traill defined food safety as the inverse of food risk - the probability of not suffering some hazard from consuming a specific food (Henson and Traill, 1993). Food safety is considered as a concept of central importance because it plays an essential public health function (WHO, 2000). The attitude of consumers also has a big important impact on food safety issues, which are themes of interest to food producers and retailers, public authorities and health educators. This interest has been reflected in discussions about how food safety

should be defined and how consumers perceive food safety and choose food. The comparatively lower number of studies conducted on consumer attitudes towards food safety in the third world countries suggests that this issue may not be of as much interest (Wilcock, 2004).

This reduced interest towards food safety may be due to a lack of consumer education and training, and a low consumer impact on food safety. In general, it is assumed that the majority of consumers probably do not understand the crucial role of food safety regulations. In order to offer supportive benefits to consumers, it is important to first examine their attitudes toward food safety. Attitudes, which are relatively permanent and stable evaluative summaries about an item, are an important psychological construct because they have been found to influence and predict behaviors (Kraus, 1995). Literature indicates that consumer attitudes towards food safety in general differ according to demographic and socio-economic factors such as gender, age, educational level and economic status. An American multi-state survey conducted in 1995/1996 found that men were more likely to report risky practices than women (Altekruse et al. 1999). The survey results also indicated that the prevalence of risky behaviors increased with increasing socio-economic status. On the other hand, a study carried out to measure knowledge, risk perception and practices of food safety of consumers in the Caribbean (Jamaica, St. Vincent and Grenadines, Belize and Barbados), revealed that consumers had an acceptable awareness of appropriate safety practices; however, a considerable number of consumers did not attribute certain illnesses to being food-borne and believed that it was possibly due to their own actions (Jackson et al. 2003).

Knowledge is defined as "a complex process of remembering, relating, or judging an idea or abstract phenomenon (cognitive abilities)" (Gotsch et al. 2012). Knowledge of the street food vendors has a crucial impact on food safety. In addition to this is the fact that street food vendors are often unlicensed, untrained in food hygiene and sanitation and work under crude unsanitary conditions (Muinde and Kuri, 2005). According to the WHO, street food vendors in most developing countries should be educated as they are currently not sufficiently organized and responsive to undertake the responsibility of their own training (WHO, 1996). Food vendors should be adequately educated on the role of food in disease transmission as well as on rules of personal hygiene and approved practices in handling street food.

According to the WHO, education of food handlers and consumers is considered as an effective strategy for reducing food-borne illness and economic losses associated with food-borne diseases (WHO, 2000). In particular, the education programmes should focus on microbiological, chemical and physical food risks so that consumers and vendors will change their behaviour associated with poor food hygiene practice. For examples, generic educational materials on safe food handling and food-borne diseases (FSIS Fact Sheets, 2004), a five keys manual entitled ‘Bringing Food Safety Home‘ (WHO, 2004) and Essentials of Serving Safe Foods (NRA, 2002) could be considered as an effective guidance for food safety training. Moreover, consumer education should focus on the safe practices in good food hygiene, common causes as well as related factors to food-borne illness, basic safety of food-handling principles such as cross-contamination, and the principles of the Hazard Analysis and Critical Control Points (HACCP).

2.4. **Food handling practices**

According to WHO (1989), food handlers play an important role in ensuring food safety throughout the food production chain. In particular, food vendors who have poor handling practices or disregard hygienic practices may increase the risk of pathogens coming into contact with foods. These pathogens in some cases can survive and multiply to numbers sufficient to cause illness in consumers. Several studies conducted to assess the quality of street foods in several countries have indicated that street foods are positive vectors of food-borne illnesses (Edema and Omemu, 2004; Freese et al. 1998; Mosupye and von Holy, 1999; Omemu et al. 2005; Umoh and Odoba, 1999).

This is mainly explained by the poor practices on hygienic measures associated with the production and vending of street foods. As an example most of the vendors arrange both raw and cooked food items together, a consequence of which is an increased risk of cross contamination (WHO, 1989). In addition, the hands are the most important vector for the transfer of organisms from faeces, nose, skin or other parts of body to food (WHO, 1989). Epidemiological studies of *Salmonella typhi*, non-typhi *Salmonella*, *Campylobacter* spp. and *Escherichia coli* have demonstrated that these organisms can survive on finger tips and other surfaces for varying periods of time and in some cases after hand washing (Pether and Gilbert, 1971; WHO, 1989). Moreover, food handlers can contaminate food either passively or actively. The biological hazards may be introduced from a sick handler, from organisms on

the food handlers skin or faeces, from their respiratory tract or by cross contamination after handling raw materials (WHO, 1989).

Physical hazards may be introduced by food handlers wearing jewelry, bandages or by careless food handling practices (WHO, 1989). Furthermore, street food vendors have frequently been considered to use improper food preparation and selling practices (Bryan et al. 1988; Ekanem, 1998; Mosupye and von Holy, 1999). In particular, previous studies in some developing countries have highlighted the lack of clean (potable) water at vending sites resulting in hand washing often being done in buckets of water (without soap); waste water and garbage are discarded in the streets, which provides food for insects and rodents; food material is usually not effectively protected from dust and flies which may harbour harmful pathogens; and safe food storage is difficult to maintain (Bryan et al. 1988; Ekanem, 1998). In lower middle income countries including Vietnam, preparing and processing street foods is often done by traditional methods using kitchen utensils which are produced by handmade bamboo wood without any quality control (WHO, 2015). Instead, vendors should be motivated by government to replace the traditional utensils by modern plastic or stainless steel utensils. Moreover, the government should monitor and give advice to vendors to wear gloves and masks during the preparation and processing street foods (WHO, 2015).

Many studies have reported that school-based street vendors with higher education levels had a positive impact on food hygiene practices. On the other hand, vendors with a high income may be less attentive to their hygiene practices in that the greater their earnings, the more time they tend to spend on their sales and customers (Mamun et al. 2013). Therefore, education and training of street food vendors can contribute to a marked improvement of their food handling practices, which may be the most cost-effective way to reduce the incidence of food-borne diseases by contaminated street vended foods (INFOSAN, 2010). Some studies have revealed that although vendor training in good practices in food hygiene by local authorities was widespread, most vendors do not translate the acquired basic hygiene knowledge into safe food practices (FAO, 2013). This lack of translation of acquired knowledge has been explained the fact that there are usually large numbers of small street food units which need to be attended to by the local authorities, the low educational level of the majority of street food vendors and their generally poor knowledge of good practices in food hygiene; and the crude conditions under which the vendors often operate (Subratty, 2004). In some cases, street

vendors may completely ignore basic food hygiene practices but consumers probably do not pay much attention to demand safe food (Subratty, 2004). In addition, as one of the major factors contributing to unhygienic practices among street food vendors is the absence of sanitary amenities at vending sites. Therefore, it is urgently required to redesign and organise street food stalls following sanitary guidelines combined with vendor training and consumer sensitisation programmes so that a sufficient provision of food safety and nutritional quality of street foods can be ensured (WHO, 1996).

Therefore, the street food sector deserves official attention from local authorities in developing countries regarding to planning, investments, regulations and education. Furthermore, local governments need to provide support for street vendors with regards to adequate infrastructure in terms of well-designed vending structures, water supply, toilet facilities and waste disposal facilities. It is emphasized that the availability of safe and clean water plays as a crucial and vital contribution to reduce food-borne disease associated with consumption of street vended foods, whilst education plays as a potential strategy to improve the safety of street vended foods. In conclusion, food safety training to the street vendors and consumers as well as develop food safety strategies, procedures and guidelines should be in charge of local governments in collaboration with academia to minimize the problems associated with street vended food contaminations in urban poor recently.

2.5. **Microbial quality of street foods**

The contribution of the street food sector to socio-economic growth is considerable; therefore, the requirement of safety in this sector must be emphasized especially in developing countries (Holy and Makhoane, 2006). Otherwise, street food consumption of a large population may increase the burden for public health. Many studies on the microbiological quality of street foods have identified high levels of coliforms and the presence of various pathogens such as *Escherichia coli, Salmonella* spp., *Staphylococcus aureus, Bacillus cereus, Clostridium perfringens* and *Vibrio cholerae* (Cho et al. 2011; Hanashiro et al. 2005; Mankee et al. 2005). Moreover, street foods have been reported to be an appropriate medium for the transmission of antimicrobial-resistant pathogenic bacteria including *Salmonella* spp., *E. coli*, and *S. aureus* to people (Guven et al. 2010; Harakeh et al. 2005).

Bacterial pathogens pose a great challenge in street foods where they have the ability to grow rapidly from very low numbers in food (Tent, 1999). Furthermore, it is evident that there are many potential health risks associated with the initial contamination of raw foods with pathogenic bacteria as well as subsequent (cross)-contamination by vendors during preparation, improper handling and storage before vending. HACCP studies on street vended foods in many developing countries indicated that there is a high correlation between long holding times at ambient temperatures and high bacterial counts even when the food had been cooked at temperatures high enough to kill harmful vegetative forms of most bacteria (Bryan et al. 1988; Ekanem, 1998). In some Latin American cities, the frequency of fecal contamination in street foods ranged from 9.4% to as high as 56.7% above the acceptable standard (Almeida et al. 1996). A study in Latin America showed that 87.5% of food products containing meat or fish were contaminated by coliforms (Almeida et al. 1996). In a study carried out on street foods in Zaria (Nigeria), 26.3% and 15% of the samples were contaminated with *B. cereus* and *S. aureus*, respectively (Umoh and Odoba, 1999). In a study conducted in Johannesburg (South Africa), *B. cereus* and *S. aureus* were detected in 17% and 3% of the street food samples, respectively (Mosupye and Holy, 2000).

In many developing countries, concern exists as street foods are also consumed by school going children who are at particular risk of food-borne diseases (WHO, 1996). For many years, vendors normally sell local street foods including light snacks and drinks with attractive and colourful food items near school-based locations under the poor hygienic conditions. Therefore, bacterial contamination of the local food and beverages sold by street food vendors surrounding the schools areas has been a common occurrence in developing countries, and the level of the contamination should be paid more attention by food safety authorities (WHO, 1996). A study in Dhaka, Bangladesh carried out to assess the microbiological quality of the food items sold by the school-based street food vendors concluded that nearly half (44.5%) of the tested foods samples unsatisfactory and one third were unsuitable for consumption (Hanashiro et al. 2005). In particular, the food samples were analysed for coliform counts and followed the coliform criteria for foods for infants and children recommended by ICMSF. Other studies have reported high levels of coliforms in street foods (Faruque et al. 2010; Hanashiro et al. 2005; Kruy et al. 2001; Mosupye and Holy, 2000). Elevated counts of coliforms in ready-to-eat foods indicated inadequate processing or cooking and/or post-processing contamination as a result of unhygienic practices and

surroundings (Kornacki and Johnson, 2001). Faruque et al. (2010) also showed many contaminated factors such as contaminated water, unclean towels, dirty water for washing utensils, and cross contamination between raw and processed foods during transportation and storage. Consequently, the unsatisfactory microbiological quality of a considerable number of the school-based street vended foods has indicated public health threat to the school going children. It is important to formulate specific laws, legislations, and guidelines for operating and handling street food vending in developing countries, which should be controlled by relevant national and international authorities.

2.6. **Nutritional aspects of street foods**

Street foods are popular in developing countries where they provide affordable sustenance for a broad spectrum of consumers including the urban poor. A study on nutritional aspects of street foods concluded that although some types of street foods can provide nutritionally balances meals, most cannot provide sufficient nutritional value to replace a complete meal (Ohiokpehai, 2003). Noodles, rice, fried snacks, cakes, pastries, soups, cereals, porridge, drinks, fruits, vegetables, meat, and poultry are prominent foods sold by street vendors. Street foods can be processed by frying, roasting, boiling, baking and steaming as well as being served raw. To date most of the studies on street foods have focused on their safety, the food safety knowledge and attitudes of street food vendors and consumers, and the microbiological quality of street foods. Much less attention has been paid to their nutritional quality.

A study in Gaborone, Botswana, stated that street foods can be considered as a strategy of reducing problems of urban food insecurity a possible vehicle for micronutrient supplementation (Ohiokpehai, 2003). The street foods vended in Gaborone were mostly cereal based and served with meat and salad which enhanced the nutrient content. A study carried out in Nairobi, Kenya, concluded that street foods were mostly bought by the urban poor in areas around their work places as a major meal (Mwangi, 2002). These major meal servings like cereals based can provide enough protein and iron; however, insufficient energy and poor vitamin A source were evaluated. Furthermore, this study also stated that female vendors normally provided foods with higher nutritional value than their male counterparts. According to Mpuchane et al. (2001), attention should be paid during the preparation and processing of street foods in order to retain minimize nutrient losses.

On the other hand, food colours and additives are also important in the production of some street foods. This is of concern as street food vendors can use harmful (or illegal) preservatives and/or abuse legal preservatives in order to extend the shelf-life of their foods (Ohiokpehai, 2003). It has been suggested that the labelling for street foods should be seriously taken into consideration (Ohiokpehai, 2003). As a result, the street foods consumers would know what has been added to the foods allowing them to make informed decisions about what they eat.

2.7. **Summary**

Urbanization and rapid growth in the populations of developing countries is serving as a major driver for the large expansion of the production and popularity street vended foods. This trend can bring a lot of benefits especially for the urban and rural poor and provide a major source of income for people, particularly women. As a result, street food vending has to some extent decreased the burden of governments on food security for low-income urban populations and provided opportunities for a vast number of people for self-employment with low capital investment.

However, governments should take into account the food safety levels of street foods to minimise the risk of food-borne diseases. In addition, they should develop operating guidelines or food safety regulations for this specific food service sector in order to support street vendors. A 'Code of Hygienic Practice' could be an essential tool in this regard. Such a code would have to focus on hygienic handling from preparation to sale of the food and should take into account the principles of the Codex document (WHO, 1996). Preparation and processing should be adequate to eliminate or reduce hazards to an acceptable level, prevent growth of pathogens, production of toxic chemicals and the introduction of physical hazards; and to ensure that foods are not re-contaminated (WHO, 1996).

As biological, chemical and physical hazards may be introduced during the vending operation and may persist through preparation and processing, the quality of the raw materials used is therefore important to the safety of street-vended food (FAO, 1996). Several scientific studies suggest that if good communication strategies are developed, they should take into account not only technical risk assessments such as those reporting microbial content and their level but also consumers and vendors risk perception of food safety and contamination (Altekruse

et al. 1999). Therefore, it is important to educate people on the importance of food safety issues from the general public to stakeholders and regulatory authorities (Wilcock et al. 2004).

3. Materials and methods

This study has the major objective of analysing the safety street foods vended in HoChiMinh city and factors contributing to the safety. The results of this study can contribute to improving the policies and actions of the Vietnam government regarding the safety of street foods. In particular, the study conducted surveys to investigate the food safety knowledge and attitudes of vendors and consumers of street foods in HoChiMinh city, Vietnam's largest industrial city. In addition, the food handling and hygiene practices of the vendors and the microbiological quality of selected popular street food were also evaluated. The studies were performed in the period from July to August 2014. The survey was conducted in four popular districts, namely District Binh Thanh, District Thu Duc, District 3 and District 8 (see Figure 3.1). As can be seen in Figure 3.1, district Binh Thanh and Thu Duc are located at the edge of the city while the latter two are in the center of the city. The procedures followed to perform each study are described below in detail.

Figure 3.1 Map of districts in HoChiMinh city

3.1. Food safety knowledge and attitudes questionnaire

The target of the survey was to assess the food safety knowledge and attitudes of both consumers and street food vendors. The questionnaire which was be used is based in part on those used in previous studies by several researchers including Angelillo, et al. (2001), Bolton et al. (2008), Ansari-Lari et al. (2010), and Soares et. al. (2012). This questionnaire was compiled and applied recently in a similar study performed in Port-au-Prince, Haiti

(Samapundo et al. 2015). In order to apply this questionnaire in Vietnam, it was translated into Vietnamese and tested with 100 people to ensure that all the questions were clear and properly structured before adoption of the final version for the survey. The questionnaire (see Annex 1) was classified into three primary sections including demographic information, food safety knowledge and food safety attitudes. When the participants were not literate enough to fill in the questionnaire themselves, they were aided by the researcher.

In more detail, the demographic information consists of gender, age, location, educational level and food safety training. The knowledge section was designed to evaluate the food safety knowledge of vendors and consumers about food pathogens, food hygiene, high risk groups and proper cleaning. This section contains 18 questions with 3 possible answers 'yes', 'no' and 'do not know'. Each correct answer was awarded one mark (one point) whilst each incorrect and 'do not know' answer was awarded no points (0 points). A maximum of 18 points could be attained in section. The compiled scores were converted to its equivalent on a basis of 18 = 100. A score < 50 was considered as depicting a poor level of food safety knowledge, 50 to 75 was considered as indicating median (adequate) food safety knowledge and > 75 was considered as indicating a good food safety knowledge level. On the other hand, the food safety attitudes questionnaire (see Annex 2) was organized to test how much consumers and vendors understand about food safety. There are a total of 16 questions in this part with the structure and the method of evaluation similar to that used for assessing the food safety knowledge.

During the survey on the street food consumers the researcher situated herself in areas in and around supermarkets, schools, university or parks which are frequented the most by local inhabitants of HoChiMinh city. The researcher identified those pedestrians who were appeared to be ≥ 18 years old and asked them to voluntary participate in the study. This exercise was repeated until 40 consumers had been interviewed in each of the four communes, giving the study a total of 120 consumers.

For selection of the street food vendors, highly frequented streets surrounding supermarkets, schools, universities in each of the four districts were selected for the survey. In order to make each vendor in these streets have an equal chance of being selected as a study subject, the researcher assigned each vendor a unique number. These numbers were written on separate

pieces of papers which were then mixed in a hat. The numbers were picked from the hat and the order was noted. The vendors were then approached in this order and asked to participate voluntarily until 10 had been interviewed from each of the four districts.

3.2. **Food handling practices checklist**

The checklist which was used to assess the food safety practices originated from previous studies (Chukuezi, 2010; Dirks, 2010; Muinde and Kuria, 2005) (Annex 3). The questionnaire was compiled from these studies and applied recently in a similar study performed in Port-au-Prince, Haiti (Samapundo et al. 2015). The first part of the form includes the general demographic information of participants in terms of sex, age, location, educational level and food safety training. The checklist covers five important sections i) information on facilities (source of potable running water *vs*. stored water in containers, availability of toilets, adequate washing facilities) ii) the environment around the stall (presence of flies, animals, and litter) iii) personal hygiene - whether or not head gear and aprons) are worn iv) food storage (cool/refrigeration storage at vending site) and v) utensils (the use of soap and clean water). The researcher randomly approached the food handlers in each district until they had a total of 10 volunteers from each of the four districts.

The vendors who participated in this part of the study were selected using the same random sampling method described above to select the vendors for the food safety knowledge and attitudes study. A consent form based on ethical norms was explained carefully to the vendors before the observation. Those who were willing to participate had to sign the consent (Annex 4). The observations were performed at 10 street food stalls in each commune, which gave the total of 40 stalls observed.

3.3. **Street food samples collection and microbial analysis**

Samples of street vended foods in the four chosen districts were collected to assess their general microbiological quality and safety. 71samples of five popular types of street foods - Saigon baguette, fried spring rolls, stuffed pancakes, Vietnamese pizza and a mixed drink consisting of blended pennywort leaves and green beans - were collected. The samples were gathered over five different days during the course of a week. Upon collection, the samples were initially kept chilled in a cooler box packed with dry ice for a maximum of six hours.

Thereafter, the samples were frozen (-18°C) until they were analysed at the Laboratory of Food microbiology and Food Preservation (Ghent University). Lactic acid bacteria, total mesophilic anaerobic bacteria, total mesophilic aerobic bacteria, coliforms and yeasts and molds counts were determined in order to evaluate the general microbiological quality. In addition, the microbiological safety was assessed through determination of the presence and counts of *Escherichia coli, Bacillus cereus, Listeria monocytogenes* and *Staphylococcus aureus*.

The food samples were collected from vendors selected using the same random sampling method described above to select the vendors for the food safety knowledge and attitudes study. Once purchased, a100 gram composite sample was collected using a disinfected spoon and placed into sterile stomacher bags. The sterile bags were sealed and labelled (place and date of sample collection) and then kept chilled until they were frozen as was described above. At the Laboratory of Food Microbiology and Food Preservation of Ghent University, the samples were stored in the refrigerator at -18 to -22^{0}C until the day of analysis.

Before performing microbial analysis, the samples were thawed by transferring them from the freezer to a refrigerator at 4^{0}C for 24 hours. After thawing, a sterile spoon was used to aseptically collect 25±1g of each sample and transfer it to a sterile stomacher bag. An appropriate amount of physiological peptone saline (PPS = 1g neutralized bacteriological peptone (Oxoid, Hampshire, UK) + 8.5g NaCl per litre) was added to prepare the primary decimal dilution. Thereafter, the diluted samples were homogenized for 1 minute by a stomacher. Serial decimal dilutions were then prepared in tubes with 9ml of PPS starting from the homogenized primary dilutions. In difference to the solid foods, primary dilutions of the blended pennywort and green bean juice samples were prepared by simply collecting 1ml of homogenized juice to 9 ml of PPS.

A summary of the plating technique, media (agar) and incubation conditions used is shown in Table 3.1. In brief, the counts of lactic acid and anaerobic bacteria were determined by pour plating (with an additional over-layer) the decimal dilutions on de Man Rogosa Sharpe agar (MRS agar, Oxoid, Hampshire, UK) and Reinforced Clostridial Agar (RCA, Oxoid, Hampshire, UK), respectively. Before incubation, the RCA plates were placed in an anaerobic jar together with an AnaeroGen sachet (Oxoid, Hampshire, UK) to ensure anaerobic

conditions. Incubation of both MRS and RCA plates was done for 3 days at 30°C, after which enumeration was done. Total aerobic counts and counts of yeasts and moulds were determined by spread plating the decimal dilutions on Plate Count Agar (PCA, Oxoid, Hampshire, UK) and Yeast Glucose Chloramphenicol agar (YGC agar, Oxoid, Hampshire), respectively, followed by enumeration after incubation for up to 3 days at 30°C. Total coliforms were determined by pour plating of the decimal dilutions on Violet Red Bile Agar (VRBA, Oxoid, Hampshire, UK) followed by enumeration after incubation at 37°C for 48 hours. *E. coli, B. cereus, L. monocytogenes* and *S. aureus* were determined by spread plating of the decimal dilutions on RAPID *E. coli* 2 agar (Bio-Rad, France), Mannitol Egg Yolk Polymyxin agar (MEYP agar, Oxoid, Hampshire, UK), Agar *Listeria* according to Ottavani & Agosti (ALOA, Oxoid, Hamphsire, UK) and Baird Parker Agar (BPA, Oxoid, Hampshire, UK), respectively. Typical *E. coli* colonies were enumerated after incubation of the RAPID *E. coli* agar for 48 hours at 44°C. Typical *B. cereus* and *L. monocytogenes* were enumerated after incubation of the MEYP and ALOA plates, respectively, for 72 hours at 30°C. Typical *S. aureus* counts were enumerated after incubation of the BPA plates for 48 hours at 37°C. These counts of typical colonies of a particular pathogen on its selective media gave rise to its 'presumptive' counts. For solid and liquid food samples the counts were reported as CFU/g ($\log_{10}$ CFU/g) and CFU/ml ($\log_{10}$ CFU/ml), respectively. The calculation of the counts was done as follows:

$$X = (A*V)/I$$

Where X = Colony Forming Units (CFU) per g or ml of products,

A = Numbers of colonies,

V = Reciprocal of dilution factor and

I = Inoculum volume (ml)

Pour plates with 30 to 300 CFUs were used for the enumeration whilst plates with 15 to 150 CFUs were used for the spread plates.

Table 3-1. Media and incubation conditions for microbial analysis

Parameters	**Media**	**Incubation conditions**
General microbial quality		
Total aerobic counts	PCA (spread plate)	30°C for 72 hours
Total anaerobic counts	RCA (pour plate + over-layer)	30°C for 72 hours
Lactic acid bacteria	MRS agar (pour plate + over-layer)	30°C for 72 hours
Total yeasts and moulds	YGC agar (spread plate)	30°C for 72 hours
Total coliforms	VRBA (pour plate + over-layer)	37°C for 24-48 hours
Pathogens		
E. coli	Rapid *E. coli* agar (spread plate)	44°C for 48 hours
S. aureus	BPA agar (spread plate)	37°C for 48 hours
B. cereus spp.	MEYP agar (spread plate)	30°C for 72 hours
L. monocytogenes	ALOA agar (spread plate)	30°C for 72 hours

Confirmation tests for pathogens

At first, the plates containing the pathogens on the corresponding selective medium were examined for typical colonies of the target pathogens based on evaluation of the morphological features. Thereafter, the plates with typical colonies were stored in the refrigerator at 2-4°C until confirmation was performed.

Regarding to confirmation of the presumptive *B. cereus* colonies, three individual colonies were picked and transferred from each MEYP plate to a tube with 9ml of sterile tryptone soy broth (TSB, Oxoid, Hampshire, UK) in order to resuscitate them. Resuscitation was done by incubation of the tubes at 30°C for 24-48 hours. Thereafter, sterile inoculation loops were used to streak the resuscitated cultures on tryptone soy agar (TSA, Oxoid, Hampshire, UK) to obtain isolated pure colonies. The haemolytic activity of the pure colonies was determined by streaking pure colonies of the presumptive *B. cereus* onto Sheep Blood Agar (SBA, Oxoid, Hampshire, UK). The SBA plates were then incubated at 30°C for up to 72 hours. Only colonies developing clearing zones, indicating β-haemolysin activity, were retained for

further biochemical confirmation. Biochemical confirmation was done by means of API 50 CHB/E kits (BioMérieux, Durham, US).The API 50 CHB/E kit is a standardized system used to identify *Bacillus* spp. and related genera. The kit contains 50 tests (in micro-tubes) used to study fermentation of substrates belonging to the carbohydrate family and its derivatives like heterosides, polyalcohols, uronic acids etc.. During incubation at 30^0C (the optimum temperature for growth of *B. cereus* spp.) fermentation is revealed by a color change in the tube as a result of the anaerobic production of acid which is detected by the pH indicator present in the chosen medium. The strips are read after the stipulated incubation times of 24 hours and 48 hours.

For confirmation of presumptive *S. aureus*, three typical colonies were picked and transferred from each BPA plate to a tube with 9ml of brain heart infusion broth (BHI broth, Oxoid, Hampshire, UK). These tubes were then incubated at 37°C for 48 hours. The resuscitated culture was then spread plated out on BPA, which were then at 37°C for 48 hours. Isolated colonies on the BPA plates were first subjected to a catalase test using a 3% hydrogen peroxide solution. Only catalase positive colonies were confirmed by means of Staphytect Plus kits (Oxoid, Hampshire, UK). Staphytect Plus kits are latex slide agglutination which can differentiate *S. aureus* from other staphylococci by detection of a clumping factor (Protein A) and certain polysaccharides found in methicillin resistant *S aureus* (MRSA). Most strains of *S. aureus* possess capsular polysaccharides which can mask both protein A and the clumping factor located on the cell surface, thereby preventing agglutination. Staphytect Plus uses blue latex particles coated with porcine fibrinogen and rabbit IgG including specific polyclonal antibodies raised against capsular polysaccharides of *S. aureus*. When the reagent is mixed on a card with colonies of *S. aureus*, rapid agglutination occurs through the reactions between (i) fibrinogen and clumping factor, (ii) Fc portion of IgG and protein A, (iii) specific IgG and capsular polysaccharide. A negative control is needed to ensure the accurate result.

3.4. **Evaluation nutritional value of street foods**

Like other developing countries, Vietnam is famous for its delicious and colourful street foods ranging from quick snacks, take-away foods to entire meals. These have become an important part of the (cultural) eating habits of the local people. Therefore, investigation on how much calories the average portions of street foods contribute to the daily average energy requirement of Vietnamese consumers provides additional important information. The composition of the selected street foods including Saigon baguette, fried spring rolls, stuffed

pancakes and Vietnamese pizza, each of which can constitute an entire meal, and blended pennywort leaf and green bean juice was recorded on site. In addition, the quantity of each serving (portion) was measured so that the average energy intake of each type of those foods could be estimated and compared with the daily average energy requirement.

3.5. **Statistical analysis method**

Spotfire S+ 8_2 was used to analyse data of the survey on the food safety knowledge and attitudes of consumers and vendors and the observations made of the food handling practices of street food vendors. The age and score results of the survey were split into different categories. For descriptive analysis, cut-off points of 25, 35, 45, 55 years were used for division of age groups. Regarding to score range, cut-off points of 50 and 75 were performed. Descriptive analysis was to calculate means, standard deviations, maxima and minima for age, and scores according to age, education, location, sex and training using Spotfire S+ 8_2. In addition, frequency tables were prepared using Spotfire S+ 8_2 for each parameter. Comparison of the scores according to gender, age group, training status and location was performed. Two sample t-Tests were used to compare data sets from two samples in terms of gender, training status. Comparison of more than two groups was conducted by means of fixed effects ANOVA in Spotfire S+ 8_2. First, the normality of the data was tested by means of QQ plots or the Kolmogorov-Smirnov Test. Thereafter the equality of the variances was also checked by means of the modified Levene test. Normality of residuals was also evaluated by using QQ plot or Kolmogorov-Smirnov Test. Non-normally distributed data sets and those with a sample size less than 30, were analysed by means of the non-parametric Wilcoxon rank-sum test for two samples i.e. gender (male of female), food safety training status (trained or not trained) etc. and the Kruskal-Wallis rank sum test when more than two categories i.e. age groups, location and educational levels were analysed. Statistically significant differences between were based on an $\alpha = 0.05$ ($p<0.05$).

For the microbiological analysis of food samples, descriptive analysis was also performed by calculating the means, standard deviation, maxima and minima for each parameter. Comparison of the microbiological qualities of the different types of street foods was also carried out using Spotfire S+ 8_2.

4. Results and discussion

4.1. Food safety knowledge and attitudes results

According to strategies to enhance the safety of street vended foods (WHO, 1996), studies of local street food systems and consideration of education of consumers as well as training of food handlers are important. In addition, most of studies on street vended foods have concentrated on the knowledge of vendors regarding to food safety. However, the understanding and attitudes of consumers about street food safety also have an important role towards this problem through their purchasing decision, in other words, through their decisions of what to consume and from whom to purchase. Therefore, it is obvious that performing this study on food safety knowledge not only for street vendors but also for consumers at the same time in a certain location is necessary.

Table 4.1 and 4.2 below summarize the demographic characteristics of the 120 consumers and 40 vendors, respectively, who voluntarily participated in the study. According to Table 4.1, slightly more female consumers (60%) participated in the survey than male customers (40%). The age of consumers who participated in the study ranged from 18 to 60 years with the average age being 29.7 (±10.9) years. 90% of the surveyed consumers were between 18 and 45 years old, whereas 10% were 45 to 60 years old. It was also noticed that more than a half (55%) of the street food consumers was 18 to 25 years old. Regarding the educational level, 91.7% of the consumers interviewed in this study had attained either high school or university education. The majority of the consumers (91%) did not have any food safety training.

Table 4-1. Demographic characteristics of street food consumers in HoChiMinh city

Characteristics	Number (%)	Mean ± standard deviation	Range
Gender			
Female	72 (60%)		
Male	48 (40%)		
Age (years)			
18-25	66 (55%)	29.7 ± 10.9	18-60
26-35	23 (19.2%)		
36-45	19 (15.8%)		
46-55	6 (5%)		
56-60	6 (5%)		
Education			
Primary school	10 (8.3%)		
High school	38 (31.7%)		
University	72 (60.0%)		

Food safety training	
Yes	29 (24.2%)
No	91 (75.8%)
Location	
District 3	30 (25%)
District 8	30 (25%)
District Thu Duc	30 (25%)
District Binh Thanh	30 (25%)
Total	**120**

Table 4-2. Demographic characteristics of street food vendors in HoChiMinh city

Characteristics	Number (%)	Mean ± standard deviation	Range
Gender			
Female	29 (72.5%)		
Male	11 (27.5%)		
Age (years)			
18-25	6 (15%)	40.7 ± 11.7	21-60
26-35	8 (20%)		
36-45	9 (22.5%)		
46-55	14 (35%)		
56-60	3 (7.5%)		
Education			
Illiterate	6 (15%)		
Primary school	18 (45%)		
Secondary school	7 (17.5%)		
High school	8 (20%)		
University	1 (2.5%)		
Food safety training			
Yes	2 (5%)		
No	38 (95%)		
Location			
District 3	10 (25%)		
District 8	10 (25%)		
District Thu Duc	10 (25%)		
District Binh Thanh	10 (25%)		
Total	**40**		

With regards to the street food vendors, nearly three quarters (72.5%) of the vendors interviewed in this study were women (see Table 4.2). This was in agreement with studies in other developing countries including Guatamela (Freeseet al. 1998); Nigeria (Olufemi and Agboh-Bakkole, 1998); South Africa (Martins and Anelich, 2000); Cameroon (Acho-Chi, 2002); Botswana (Ohiokpehai, 2003); Ghana (Tomlins and Johnson, 2004); Brazil (Hanashiro, 2004); Kenya (Muinde and Kuria, 2005) and Uganda (Muyanja, 2011). Generally, the higher proportion of female vendors can be explained by the fact that women

are responsible for traditional cooking and child care and generally have lower education and skill levels, which result in their greater involvement in informal sector's such as street food vending. Higher proportions of women vendors may actually advantageous as female vendors have been reported to provide street foods with higher nutritional quality than male counterparts Ohiokpehai (2003). In addition, a study in the United States reported that women vendors had safer food preparations (Klontz, Timbo, Fein, and Levy, 1995); however, it has to be pointed out that those female vendors possessed at least a high school education level. In contrast, 60% of the vendors in this study had very low education levels (illiterate or primary school level) while only 20% of had high school education. The mean age of the vendors was 40.7 (± 11.7) years old and the age ranged from 21 to 60. The vast majority of the vendors (95%) did not have any food safety training).

Table 4.3 below illustrates the results of the survey on the food safety knowledge of street food consumers in HoChiMinh City. It is noticeable that the mean score of the consumers was 67, which shows that the consumers surveyed in the four districts had an adequate (satisfactory) food safety knowledge level. This may in part be a result of the participation of Vietnam in WHO's International Food Safety Authorities Network (INFOSAN) since 2011. In particular, since joining INFOSAN, the government has communicated its 'Five Keys to Food Safety' to consumers through a variety of forums such as mass media channels, television, the national radio station "Voice of Vietnam", flyers and broadcast audio messages. Such efforts may contribute positively to the food safety knowledge of Vietnamese consumers. However, it can be seen in Table 4.3 that a significant proportion of the consumers (17.5%) had a poor food safety knowledge level. The survey also indicated that there was no significant difference occurred in food safety knowledge with regards to gender ($p = 0.66$). On the other hand, significant differences occurred in food safety knowledge level on the basis of age ($p = 0$), educational level ($p = 0$), food safety training ($p = 0.0007$) and location (district) ($p = 0$).

In more detail, the youngest age group (18-25 years) had the highest levels of food safety knowledge (76 ± 13) whereas the oldest consumers (55-60 years) had poor levels of knowledge of food safety (35 ± 14). For the age groups in between these two, no significant difference in the food safety knowledge scores were found ($p = 0.06$). With regards to the level of education, it seems that the more educated the consumers were, the better their

knowledge of food safety was. Similarly, those consumers who had received food safety training obtained higher scores (food safety knowledge levels) than untrained consumers. Consumers who had been educated at the university level had good food safety knowledge scores (78 ± 11), whilst those who had received high school and only primary education has adequate (59 ± 11) and poor (32 ± 9) food safety knowledge levels, respectively. This study also shows that the consumers interviewed in the centre of HoChiMinh City (District 3) were more intelligible about food safety than consumers from the other districts. This could have been a result of the fact that Food Administration of Vietnam focuses most of its street food safety communication (campaign) efforts in the central business district.

Table 4-3. Effect of gender, age, education level, food safety training and location on the food safety knowledge of consumers

Characteristics	Number of respondents (%)			Mean score ± SD	Range
	score: <50	score: ≥50 - <75	score: ≥75		
Sex					
Female	11 (9.2)	32 (26.7)	29 (24.2)	68 ± 18	22 - 100
Male	10 (8.3)	21 (17.5)	17 (14.1)	67 ± 17	22 - 94
Age (years)					
18-25	2 (1.2)	26 (21.7)	38 (31.7)	76 ± 13	39 - 100
26-35	3 (2.6)	13 (10.8)	7 (5.8)	68 ± 14	39 - 94
36-45	8 (6.7)	10 (8.3)	1 (0.9)	53 ± 15	22 - 83
46-55	3 (2.6)	3 (2.6)	0 (0)	53 ± 15	33 - 72
56-60	5 (4.2)	1 (0.9)	0 (0)	35 ± 14	22 - 55
Education					
Primary school	10 (8.3)	0 (0)	0 (0)	32 ± 9	22 - 50
High school	11 (9.2)	26 (21.6)	1 (0.9)	59 ± 11	39 - 83
University	0 (0)	27 (22.5)	45 (37.5)	78 ± 11	55 - 100
Food safety training					
Yes	2 (1.7)	8 (6.7)	19 (15.8)	76 ± 16	22 - 94
No	19 (15.8)	45 (37.5)	27 (22.5)	65 ± 17	22 - 100
Location					
District 3	0 (0)	9 (7.5)	21 (17.5)	79 ± 10	50 - 100
District 8	3 (2.6)	18 (15)	9 (7.5)	66 ± 17	22 - 89
District Thu Duc	13 (10.8)	12 (10)	5 (4.2)	57 ± 19	22 - 94
District Binh Thanh	5 (4.2)	14 (11.7)	11 (9.2)	68 ± 17	33 - 94
TOTAL	**21 (17.5)**	**53 (44.2)**	**46 (38.3)**	**67 ± 16**	**22 - 100**

Table 4.4 below shows the food safety knowledge scores of the vendors as a function of their demographic characteristics. The mean score of the vendors (38 ± 11) was significantly ($p = 0.01$) lower than the mean score of the consumers (67 ± 16). In particular, the majority of the vendors (90%) had an insufficient food safety knowledge level as they obtained scores less than 50. Moreover, only 7.5% had adequate food safety knowledge levels as they obtained scores between 50 and 75 and 2.5% had good food safety knowledge levels as they had scores greater than 75. In addition, the range of scores varied considerably between 17 and 83. Compared to previous studies in Haiti (Samapundo et al. 2015) and in Malaysia (Rosnani, 2014), the vendors in Vietnam had much poorer food safety knowledge levels. Nevertheless, the average score of the food handlers in Vietnam was higher than those surveyed reported in second study performed in Malaysia (Toh, 2000) and was similar to that of vendors surveyed in Turkey (Bas, 2004). There were no significant differences in the food safety knowledge levels of the street food vendors with regards to gender ($p = 0.4$) and age ($p = 0.2$). These findings are supported by some previous studies in Malaysia (Muyanja et al. 2011; Siow & Norrakiah, 2011), and in Haiti (Samapundo et al. 2015). However, the results contradicted the findings of Lorraine et al. (2013) carried out in Canada, who reported that age had a significant bearing on the food safety knowledge of food handlers ($p = 0.001$). The educational levels of the vendors were determined to have a significant influence on their food safety knowledge ($p = 0.001$). Those who were illiterate or only studied up to primary school level had poor food safety knowledge level (≤32). Only one vendor was educated at the university level and they obtained the highest food safety knowledge score (83). In addition, significant differences occurred between the food safety knowledge levels of vendors who had received food safety training and those who had not ($p = 0.04$), with the untrained vendors attaining lower scores (36 ± 12) compared to trained vendors (67 ± 23). Similar findings were also found in several other studies including in Vienna, Austria (Pichler et al. 2014); in Malaysia (Rosnani, 2014; Toh, 2000); in Uganda (Muyanja et al. 2011). Consequently, lower education levels are associated with poor hygiene practices during handling and storage of foods which can increase the risk of street food contamination (Kitagwa et al. 2006). Regarding the location, the results show that the food handlers in district Thu Duc had the poorest levels of food safety knowledge (25 ± 7) which were significantly lower to those of the vendors in the other communes ($p = 0.005$). People with lower incomes and/or lower educational levels frequent this district which may explain this observation.

Table 4-4. Effect of gender, age, education level, food safety training and location on the food safety knowledge of food vendors

Characteristics	Number of respondents (%)			Mean score ± SD	Range
	score: <50	score: ≤50 - <75	score: ≥75		
Sex					
Female	27 (67.5)	2 (5)	0 (0)	36 ± 11	17 - 55
Male	9 (22.5)	1 (2.5)	1 (2.5)	41 ± 20	17 - 83
Age (years)					
18-25	4 (10)	2 (5)	0 (0)	46 ± 12	33 - 67
26-35	7 (17.5)	0 (0)	1 (2.5)	44 ± 20	17 - 83
36-45	9 (22.5)	0 (0)	0 (0)	34 ± 7	22 - 44
46-55	13 (32.5)	1 (2.5)	0 (0)	33 ± 13	17 - 55
56-60	3 (7.5)	0 (0)	0 (0)	39 ± 10	28 - 44
Education					
Illiterate	6 (15)	0 (0)	0 (0)	26 ± 6	16 - 33
Primary school	18 (45)	0 (0)	0 (0)	32 ± 10	17 - 50
Secondary school	5 (12.5)	2 (5)	0 (0)	47 ± 8	33 - 55
High school	7 (17.5)	1 (2.5)	0 (0)	45 ± 11	27 - 66
University	0 (0)	0 (0)	1 (2.5)	83 ± 0	
Food safety training					
Yes	1 (2.5)	0 (0)	1 (2.5)	67 ± 23	50 - 83
No	35 (87.5)	3 (7.5)	0 (0)	36 ± 12	17 - 67
Location					
District 3	8 (20)	1 (2.5)	1 (2.5)	44 ± 19	17 - 83
District 8	8 (20)	2 (5)	0 (0)	42 ± 10	28 - 55
District Thu Duc	10 (25)	0 (0)	0 (0)	25 ± 7	17 - 39
District Binh Thanh	10 (25)	0 (0)	0 (0)	40 ± 8	28 - 50
TOTAL	**36 (90)**	**3 (7.5)**	**1 (2.5)**	**38 ± 11**	**17 - 83**

Table 4.5 shows the scores of food safety attitudes of the consumers in HoChiMinh city as a function of their demographic characteristics. The mean food safety attitude score (68 ± 13) of the consumers was similar to that of their food safety knowledge (67 ± 16). This indicates that the consumers have adequate food safety attitudes or an adequate understanding of food safety. This result is in agreement with a study performed in Haiti (Samapundo et al. 2015), which indicated that the consumers in Port-au-Prince had adequate food safety attitudes. This positive result can be explained by the same reason as the survey on food safety knowledge of consumers, which implied that the satisfactory food safety knowledge and attitudes of consumers have been achieved due to the participation of Vietnam in WHO's INFOSAN since 2011. 74.2% of the consumers had food safety attitude scores >50 (= at least an adequate understanding of food safety), whilst nearly a quarter (25.8%) had poor food safety attitudes or a poor understanding of food safety (scores <50). No significant differences occurred between the food safety attitude scores on the basis of gender ($p = 0.85$); however, the significant differences were found on the basis of age ($p = 0$), education ($p = 0$), food safety training status ($p = 0.007$) and location ($p = 0.004$).

With respect to age, the youngest consumers (between 18 and 35 years) had food safety attitude scores which were significantly greater than those of the older consumers. Among them, the consumers aged 18 to 25 years had the best attitude towards food safety (78 ± 12). In general, the younger consumers in Vietnam have better and higher educational backgrounds compared to older consumers. In addition, they have more chances to encounter the food safety communications from the government which are channeled through mass media and schools. As expected, the consumers with higher educational levels had better food safety attitudes. The consumers who had studied at university had good food safety attitudes (79 ± 11), while those who had studied up to high school level had average food safety attitudes (54 ± 9) and whilst those who had only studied up to primary school level had poor attitudes towards food safety (32 ± 7). This result contrasted with the findings in Haiti by Samapundo et al. (2014) and other studies (Annor and Baiden, 2011; Rheinländer et al. 2008) which indicated that no significant differences occur in the food safety attitudes of consumers with regards to their level of education.

Table 4-5. Effect of gender, age, education level, food safety training and location on the food safety attitudes of consumers

Characteristics	Number of respondents (%)			Mean score ± SD	Range
	score: <50	score: ≥50 - <75	score: ≥75		
Sex					
Female	21 (17.5)	25 (20.8)	26 (21.7)	67 ± 19	25 - 100
Male	10 (8.3)	22 (18.3)	16 (13.3)	67 ± 18	25 - 100
Age (years)					
18-25	4 (3.3)	24 (20)	38 (31.7)	78 ± 12	50 - 100
26-35	6 (5)	14 (11.7)	3 (2.5)	61 ± 14	37 - 94
36-45	10 (8.3)	8 (6.7)	1 (0.9)	54 ± 15	25 - 87
46-55	5 (4.2)	1 (0.9)	0 (0)	43 ± 13	25 - 62
56-60	6 (5)	0 (0)	0 (0)	34 ± 9	25 - 50
Education					
Primary school	10 (8.3)	0 (0)	0 (0)	32 ± 7	25 - 44
High school	18 (15)	20 (16.7)	0 (0)	54 ± 9	31 - 68
University	3 (2.5)	27 (22.5)	42 (35)	79 ± 11	50 - 100
Food safety training					
Yes	4 (3.3)	8 (6.7)	17 (14.2)	75 ± 17	31 - 100
No	27 (22.5)	38 (31.7)	25 (20.8)	64 ± 18	25 - 100
Location					
District 3	1 (0.9)	12 (10)	17 (14.2)	77 ± 11	50 - 93
District 8	12 (10)	10 (8.3)	8 (6.7)	63 ± 19	25 - 93
District Thu Duc	12 (10)	10 (8.3)	8 (6.7)	60 ± 21	25 - 100
District Binh Thanh	6 (5)	15 (12.5)	9 (7.5)	67 ± 16	25 - 100
TOTAL	**31 (25.8)**	**47 (39.2)**	**42 (35)**	**68 ± 13**	**25 - 100**

According to the WHO (WHO, 2015), Vietnam's Food Administration should make greater efforts to educate consumers on food safety and subsequently instill positive attitudes towards food safety problems so that they can positively identify good quality street food stalls and thereby reduce food-borne diseases related to street food consumption in Vietnam. In addition, a multi-state survey performed in the United State advised that development of consumer educational efforts to promote safe food-handling and food-consumption practices should be a priority (Altekruse, 1999). In agreement with this, the results of this study showed that the consumers who had received some food safety training had higher scores indicating they had more positive attitudes (understanding) towards food safety. In the context of this study, the location (district) also influenced he food safety attitudes of the consumers. In particular, the consumers in district 3 (located in the center of HoChiMinh city) had the highest mean food safety attitude score (77 ± 11 = good food safety attitudes), while those were district Thu Duc (located at the edge of the city) had the lowest mean score (60 ± 21 = adequate food safety attitudes).

The results of the survey on the food safety attitudes of the food handlers are shown in Table 4.6. The mean score of food safety attitudes of the vendors (40 ± 16) was low (indicating poor levels of understanding food safety) and not significantly different to their food safety knowledge scores (38 ± 11) ($p = 0.2$). The food safety attitudes of the vendors were significantly poorer than those of the consumers (68 ± 13) ($p = 0.01$). 80% of the vendors had food safety attitude scores <50, whilst 15% had an adequate food safety attitude (scores between 50 and 75) and only 5% had a good attitude towards food safety (scores >75). The mean food safety attitude scores of the vendors surveyed in this study was slightly higher than that of those surveyed in Malaysia (mean score = 18.5) (Toh, 2000); however, it was lower than those reported in Turkey (mean score = 44.2) (Bas, 2004) and in Haiti (mean score = 73) (Samapundo et al. 2015). No significant differences occurred in the food safety attitude scores with respect to gender ($p = 0.28$), age ($p = 0.16$) and food safety training status ($p = 0.08$). This finding agreed with those of a study performed in Turkey (Bas, 2004) where no differences were found in the food safety attitudes of trained and untrained food handlers. However, it contradicts the findings of McIntyre et al. (2013) and Samapundo et al. (2015) who both reported that trained food handlers in Brazil and Haiti, respectively, have higher food safety attitudes compared to untrained food handlers.

Table 4-6. Effect of gender, age, education level, food safety training and location on the food safety attitudes of food vendors

Characteristics	Number of respondents (%)			Mean score ± SD	Range
	score: <50	score: ≥50 - <75	score: ≥75		
Sex					
Female	25 (62.5)	4 (10)	0 (0)	38 ± 16	12 - 75
Male	7 (17.5)	2 (5)	2 (5)	46 ± 20	25 - 81
Age (years)					
18-25	6 (15)	0 (0)	0 (0)	43 ± 9	25 - 50
26-35	5 (12.5)	1 (2.5)	2 (5)	54 ± 21	31 - 81
36-45	7 (17.5)	2 (5)	0 (0)	37 ± 20	13 - 75
46-55	12 (30)	2 (5)	0 (0)	35 ± 15	16 - 69
56-60	2 (5)	1 (2.5)	0 (0)	35 ± 18	25 - 56
Education					
Illiterate	6 (15)	0 (0)	0 (0)	22 ± 6	12 - 31
Primary school	17 (42.5)	1 (2.5)	0 (0)	35 ± 12	19 - 69
Secondary school	5 (12.5)	2 (5)	0 (0)	45 ± 12	25 - 56
High school	4 (10)	3 (7.5)	1 (2.5)	58 ± 15	37 - 81
University	0 (0)	0 (0)	1 (2.5)	81 ± 0	
Food safety training					
Yes	1 (2.5)	0 (0)	1 (2.5)	66 ± 22	50 - 81
No	31 (77.5)	6 (15)	1 (2.5)	39 ± 17	12 - 81
Location					
District 3	7 (2.5)	1 (11.3)	2 (11.3)	50 ± 20	25 - 81
District 8	8 (2.5)	2 (16.3)	0 (6.3)	42 ± 16	25 - 75
District Thu Duc	9 (0)	1 (12.5)	0 (12.5)	27 ± 12	12 - 56
District Binh Thanh	8 (0)	2 (12.5)	0 (12.5)	42 ± 16	16 - 69
TOTAL	**32 (80)**	**6 (15)**	**2 (5)**	**40 ± 16**	**12 - 81**

In addition, this study found that significant differences occurred in the food safety attitude score according to the educational levels of the vendors ($p = 0.006$) and their location ($p = 0.03$). Toh (2000) also highlighted a positive correlation between the level of education and food safety attitudes of food handlers. Education has also been reported to play a key role in increasing the food safety knowledge of food handlers, and hence improving their attitudes towards food safety and hygiene, and food-borne illnesses (WHO, 1996; FAO, 1995; Bryan, 1993). With regards to the location, the findings were similar to those with regards to the food safety knowledge. Vendors in district Thu Duc had significantly poorer food safety attitudes (27 ± 12) compared to those of the vendors surveyed in the other communes. The highest food safety attitude belonged to the vendors in district 3 (50 ± 20). It has to be stressed that the food safety attitudes of the vendors were in most cases poor.

4.2. **Food safety practices of the street food vendors**

The profiles of the vendors who participated in this part of the study are summarized in Table 4.2 above including socio-economic and demographic data such as gender, age, training status and educational level. The majority of the vendors (72.5%) was female with 57.5% in the 36–55 years age group and only 15% was belong to the young age group from 18 to 25 years. The level of education among the vendors was quite low with 15% having no formal education and 45% attending primary school education level. Only 1 participant (2.5%) had been educated at university level. 95% of respondents had no food safety training. Generally, this profile of vendors had similar trend with various previous studies performed in Nigeria (Chukuezi, 2010), Uganda (Muyanja, 2011), Burkina Faso (Barro et al. 2006), Trinidad (Olivierra & Badrie, 2006) and Kenya (Muinde & Kuria, 2005). The low education levels are presumably associated with poor hygiene practices during handling and storage of foods which can increase the risk of street food contamination (Kitagwa et al. 2006). On the other hand, Choudhury, (2010) conducted a study in India which concluded that most of the food vendors were educated up to primary to high school level. Table 4.7 summarizes the observed food handling practices of the vendors and the structural and environmental characteristics of the vending sites.

Table 4-7. Food safety observation checklist

Observation checklist item	Observation			
Facilities	**No**		**Yes**	
*Kind of material the stall structure where the food was prepared***:**	**N#**	**%**	**N#**	**%**
Zinc/iron	0	(0%)	1	(2.5%)
Canopies	0	((0%)	16	(40%)
Small containers	0	(0%)	4	(10%)
Wooden tables	0	(0%)	2	(5%)
Vans	0	(0%)	1	(2.5%)
Wheelbarrows	0	(0%)	16	(40%)
The food is prepared				
At home	0	(0%)	16	(40%)
On site	0	(0%)	24	(60%)
Environment around the stall				
Is vending stall protected from sun, wind and dust	21	(52.5%)	19	(47.5%)
Animals or pests flies etc. evident around the vending stall	25	(62.5%)	15	(37.5%)
The vending stall maintained in a clean condition	13	(32.5%)	27	(67.5%)
There is access to potable water at the site or close to the site	21	(52.5%)	19	(47.5%)
There are adequate hand washing facilities available	19	(47.5%)	21	(52.5%)
There are adequate waste water or food disposal facilities available	12	(30%)	28	(70%)
The environment around the stall is clean: far from rubbish, waste water, toilet facilities, open drains and animals	35	(87.5%)	5	(12.5%)
Personal hygiene				
The operator washes their hands in clean water each time before the handling, preparation and serving of food	21	(52.5%)	19	(47.5%)
The operator washes their hands each time after visiting the toilet	0	(0%)	40	(100%)
The operators clothes are clean and presentable	6	(15%)	34	(85%)
The operator uses an apron when handling, preparing and serving of food	30	(75%)	10	(25%)
The operator handles food with bare hands	8	(20%)	32	(80%)
If no, do they use disposable gloves	34	(85%)	6	(15%)
The operator has clean and short nails	10	(25%)	30	(75%)
The hair of the operator is covered when handling preparing and serving of food	39	(97.5%)	1	(2.5%)

The operator handles money while serving food	12	(30%)	28	(70%)
If yes. Are hands washed after handling money before handling food again	39	(97.5%)	1	(2.5%)
Dirt or dust is removed by:				
Apron	0	(0%)	7	(17.5%)
Bare hands	0	(0%)	8	(20%)
Dirty cloth	0	(0%)	23	(57.5%)
Clean cloth	0	(0%)	2	(5%)
Does the operator wear jewellery	19	(47.5%)	21	(52.5%)
If yes. Is the jewellery adequately covered	21	(100%)	0	(0%)
Does vendor smoke during the handling preparation of food	40	(100%)	0	(0%)
Does the operator use the same utensil knives and boards to prepare raw and cooked food	30	(75%)	10	(25%)
Food storage				
Food is stored/displayed:				
Openly in the stalls	0	(0%)	13	(32.5%)
In a wheelbarrow	0	(0%)	20	(50%)
In sealed (transparent or opaque) container	0	(0%)	7	(17.5%)
Are raw partially cooked and cooked food products kept separate	21	(52.5%)	19	(47.5%)
Are previously cooked foods kept cool i.e. ice box or refrigerated	12	(30%)	28	(70%)
Utensils				
Are utensils covered	27	(67.5%)	13	(32.5%)
Are utensils cleaned adequately every time after use	2	(5%)	38	(95%)
Utensils are cleaned with:				
Cold and soapy water	0	(0%)	31	(77.5%)
Clean water with no soap	0	(0%)	9	(22.5%)

Most of the stalls were under canopies (40%) and in wheel barrows (40%). Only 10% of the stalls were housed in small containers whilst the remainder operated from wooden tables and vans. Other studies have also reported that simple canopies were used the most by street vendors (Chukuezi, 2010; Samapundo et al. 2015). 60% of the food was prepared on site. This finding agreed with that of Samapundo et al. (2015) in Haiti but was in contrast to studies performed in South Africa (Lues et al. 2006) and Mauritius (Subratty et al. 2004) where the majority of the food, 90% and 76%, respectively, was prepared at home. Regarding the sanitary conditions of the environment surrounding the vending sites, half (52.5%) of the vending sites were not protected from the sun, wind and dust. Dust potentially carries pathogens and therefore may become a vector for their transmission to prepared foods. Similar observations were reported by Muinde and Kuria (2005) and Mensah et al. (2002) in studies conducted on street foods in Nairobi (Kenya) and Accra (Ghana), respectively. Evidence of the presence of animal and/or pests and flies was observed at 62.5% of the stalls. The same situation has been reported in Uganda (Muyanja, 2011), India (Choudhury, 2010) and Kenya (Muinde, 2005). 52.5% the vending stalls had no direct access to potable water at the site, whilst 47.5% did not have adequate hand washing facilities and 30% lacked waste water and food disposal facilities. This study is in agreement with those that have been performed in Accra, Ghana (Mensa et al. 2002), Uganda (Muyanja, 2011) and Kenya (Muinde, 2005), which found that running water was not readily available at street vending sites. However, a study performed in Nigeria (Chukuezi, 2010) reported that only 9.5% of the vendors complained of water shortages. Without enough water, hygiene and sanitary practices cannot be exercised correctly; moreover, safe water is an essential pillar for health (World Bank, 1995). In addition, personal hygiene can only be achieved if adequate potable water is available (Latham, 1997). Therefore, it is very important for the vendors to have sufficient potable water for drinking, preparation of all kinds of foods and washing operations.

The hygienic conditions surrounding the stalls were observed to be unsatisfactory in 87.5% of the stalls investigated. Similarly, studies performed in Kenya and Mauritius concluded that 93% and 78% of the stalls did not have garbage receptacles, respectively; hence they disposed their garbage just near the stalls (Subratty, 2004). 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, waste water, dust and animals (FAO, 1995). In addition to this, the vendors disposed of their waste food and water next to their stalls. As a consequence,

this dirty environment attracted flies, which are not only an indication of poor hygiene and sanitary conditions, but they are also vectors of fecal pathogens. Proper garbage collection and disposal facilities were also found to be lacking in a study performed in Nairobi, Kenya (Muinde, 2005). In order to decrease the risk of contamination of prepared food and potable water, sufficient drainage and waste disposal facilities should be installed properly in the street food stalls (FAO, 1999).

In addition, the vendors were observed to predominately have poor levels of personal hygiene. Slightly more than half (52.5%, 21/40) of the vendors did not wash their hands before handling, preparing and serving foods, while 75% (30/40) worked without aprons and 80% (32/40) used their bare hands during the handling, preparation and serving of foods. Only 15% (6/40) of the observed vendors used disposable gloves during the handling foods. These findings were in agreement with those of studies performed in India (Rane, 2011), Uganda (Muyanja, 2011), Kenya (Muinde, 2005), China (Liu, 2014) and Nigeria (Idowu, 2006). Failure to wash hands during food preparation, serving and handling may contribute to the occurrence of food-borne illness outbreaks (Humphrey, 2002). According to the FAO, the hands are a crucial factor in the contamination and spreading of fecal-oral transmitted bacteria; therefore, this risk greatly enhances when food is handled with bare hands (FAO, 1997). According to the FAO's guidelines for handling street foods in Africa, clean tongs, forks, spoons or disposable gloves should be used regularly when handling, serving or selling food (FAO/WHO, 1999).

Almost all of the vendors (97.5%, 39/40) did not cover their hair and 70% (28/40) exchanged money during the handling and serving foods. Money is dirty and may cause contamination of food (FAO, 1997). It was noticed that 57.5% (23/40) of the operators used dirty cloth's to clean the stalls (repeatedly) and 52.5% (21/40) wore uncovered jewelry. In comparison to these results, Chukuezi (2010) reported better food safety practices in Nigeria as 52% of the food handlers in that study did not cover their hair while 19% wore uncovered jewelry while serving food. No smoking was observed at the stalls investigated during the handling of foods. Half of the vendors stored their foods in a wheelbarrow while 32.5% displayed foods openly in the stalls and only 17.5% stored them in sealed containers. 52.5% of the vendors did not separate raw, partial and cooked food products whilst 70% kept previously cooked foods in refrigerators for vending in the following days. Street foods which cannot be served

immediately to customers should be kept hot or cooled down rapidly and reheated completely to a minimum core temperature of 70^{o}C before serving in order to prevent the growth of microbes on the food (AJFAND, 2005).

A large proportion (67.5%) of the stalls observed did not to cover their utensils. Utensils in which the food is displayed for sale must be kept clean, covered and protected as they easily become contaminated (FAO, 1995). Kinton and Ceserani (1992) also recommended that foodstuffs of all kinds should be kept properly covered to prevent contamination from dust and flies. 77.5% of the vendors washed their utensils using cold and soapy water while 22.5% washed their utensils with clean water soap-less water. These results agreed with the practices observed in other studies carried out in Nigeria (Omemu, 2008) and Uganda (Muyanja, 2011). Most of the vendors used the same water to rinse their utensils several times during the day. The repeated use of the same water may lead to cross contamination from the water to cooked food *via* the rinsed utensils (Mahon et al. 1999; FAO, 2005).

In summary, it can be generally concluded that street foods are vended in HoChiMinh City under largely unsafe (unhygienic) conditions consisting of the dirty open air environments in which the foods compounded by poor food handling practices and often inadequate storage conditions.

4.3. **Evaluation of the energy value of the street foods**

The energy values of all ingredients of the collected street foods were calculated based on the Vietnamese Food Composition Table (Nutritional Institute, Ministry of Health, 2007). According to National Institute, the average daily energy requirement for men and women who aged from 19 to 60 was suggested 2634 Kcal/day and 2183 Kcal/day, respectively. As can be seen in the table, the total energy of a serving of stuffed pancakes was highest (587 Kcal/portion), which accounts for 22.2% and 26.8% of the average daily energy requirement for men and women in Vietnam, respectively. One serving of Vietnamese sandwiches (which are also considered as a major dish by the local people) accounts for 16.4% and 19.7% of the average daily energy requirement for men and women, respectively. Spring rolls and Vietnamese pizza are considered as snacks, with three and one pieces being consumed, respectively, at a single sitting. The energy contribution from three fried spring rolls and one piece of Vietnamese pizza accounts for *ca*. 8.8% and 10.6% of the daily energy requirements for Vietnamese men and women, respectively. On the other hand, the popular blended juice of pennywort leaves and green beans accounts for only 2.8% and 3.5% of the daily energy requirements for Vietnamese men and women, respectively.

Table 4-8. Energy contribution of the selected street foods

Type of street food	Portion (g)	N# of portions typically consumed	Energy value (Kcal)	Percentage of average daily energy requirement for men	Percentage of average daily energy requirement for women
Stuffed pancakes (major dish)	105 ± 5	3	587 ± 11	22.2%	26.8%
Vietnamese sandwiches (major dish)	184 ± 5	1	431 ± 12.2	16.4%	19.7%
Fried spring rolls (snack)	53 ± 3	3	231 ± 7.8	8.8%	10.6%
Vietnamese pizza (snack)	97 ± 3	1	230 ± 6.5	8.7%	10.5%
Blended juice	70 ± 3.5	1	76 ± 0.6	2.8%	3.5%

4.4. Evaluation of microbiological quality of the street foods

4.4.1. Description of street foods evaluated in this study

A total of 71 street food samples were collected and analysed in this study. These consisted of stuffed pancakes (n = 15, 21%) and Vietnamese sandwiches (n = 15, 21%) which can be consumed as a major dish, fried spring rolls (n = 10, 14%) and Vietnamese pizza (n = 16, 23%) which are considered as snacks and a traditional fresh blended juice (of Pennywort leaves and green beans) (n = 15, 21%) which is very popular in Vietnam during the summer.

As can be seen in Table 4.9, among the collected street foods, the Vietnamese sandwiches and the juice did not require heating (cooking), while the stuffed pancakes, fried spring rolls and the traditional pizza need be cooked well by frying, deep frying or grilling before serving, respectively. However, apart from the juice, it was observed that most of the consumers were served with bare hands, which is potential source of contamination. In addition, various factors including the use of contaminated water during food processing, serving foods without wearing gloves and head coverings, use of unclean towels, dirty water for washing utensils, unhygienic equipment for processing are possible causes of bacterial contamination in street vended foods (Faruque et al. 2010). Moreover, it was observed that polyethylene bags or paper bags were usually used to carry the cooked food. Therefore, unclean bags or contaminated bags may also be an important source of contamination.

In general, coliforms can be used traditionally as indicator organisms to assess the overall quality of foods and the hygienic conditions present during food processing (Kornacki and Johnson, 2001). However, coliforms are limited as good or effective sanitary indicators to certain foods such as meat or poultry products, and raw vegetables (ICMSF, 2011; Jay et al. 2005; Kornacki and Johnson, 2001). On the other hand, raw meat, poultry and vegetables are commonly contaminated with bacteria including possible food-borne pathogens such as *Staphylococcus aureus, Bacillus cereus, Listeria monocytogenes, Escherichia coli* (ICMSF, 1998). Besides that, bacteria can be transferred *via* cross-contamination during cutting or chopping different types of foods with the same knives. *Bacillus* spp., and *Staphylococcus* spp. can also be detected on people's hand or in surrounding open environments (ICMSF, 1996). According to the ICMSF, *E. coli* can also be found (transferred) when vendors use the water for thawing raw chicken to rinse other raw materials ICMSF (1998). Furthermore, *S.*

aureus should be considered as a risk of contamination when foods include ingredients such as meat, poultry and eggs. Similarly, contamination by *B. cereus* should be taken into account in the case of rice or rice based products (EU, 2005). Therefore, the street foods which have high water activity (a_w), relatively high pH values as well containing a large number of ingredients including meat, poultry, eggs or other high protein ingredients are highly risky for contamination (PAHO, 1992).

Table 4-9. Overview of cooking methods, handling and possible sources of contamination of collected food

Type of food	Description	Preparation method	Handling after cooking	Potential sources of contamination
Stuffed pancakes	Consists of a dough made of rice flour, water, turmeric powder, stuffed with pork, shrimp, diced green onion and bean sprouts, served with fresh vegetables	Frying	Served with bare hands in foam or normal plates	Hands, utensils, water, vegetables
Vietnamese sandwiches	Baguette filled with various cold cuts such as sliced pork or pork bellies, pork sausage together with liver paté and vegetables like carrots or cucumbers	Manual assembly (no cooking)	Served with bare hands in a polyethylene bag or paper bag.	Hands, utensils, vegetables and bags
Fried spring rolls	Usually composed of seasoned ground meat, mushrooms, and diced vegetables (e.g. carrots, kohlrabi and jicama), rolled up in a sheet of moist rice paper	Deep frying of the rolls until the rice paper coat turns crispy and golden brown	Served with a fork or chop sticks in foam or normal plates	Hands, equipment, utensils
Vietnamese pizza	Thin layer of rice cake with a topping consisting of eggs, dried shrimp, sausage, cheese, chilli sauce	Grilling until the whole cake turns crispy	Served with a fork or bare hands in foam plates covered by a polyethylene bag or paper bag (takeaway)	Hands, equipment, utensils and bags
Blended juice	Fresh pennywort leaves and steamed green beans	Homogenization in a blender (no cooking)	Served with a straw in foam or glass cups	Hands, equipment, water, ice

4.4.2. pH and water activity (a_w) of the street foods

Table 4.10 shows the range of pH and water activity valued of the street foods evaluated in this study. The pH values were generally low acid to near neutral. The Vietnamese sandwiches had the lowest pH values (5.3 ± 0.5) among those collected street foods, which can be explained as they contain pickled vegetables. Of the foods evaluated stuffed pancakes had the highest pH values (6.4 ± 0.3). All the street foods evaluated had a_w values ≥0.89. The street foods with the highest a_w values were stuffed pancakes (0.993 ± .001) and the blended juice (0.981 ± 0.010). Fried spring rolls and Vietnamese pizzas had the lowest a_w values. This was attributed to the cooking methods used for these products, frying and grilling, respectively, where moisture is lost.

The pH values of those street foods are suitable for the growth of most microorganisms including most pathogens, for example *S. aureus* which grows at between pH 4.5 and 9.3 (Uyttendaele, 2012). Similarly, the high a_w values of some of the street foods evaluated in the study (especially stuffed pancakes and blended juice) can support the growth of most spoilage and pathogenic microorganisms.

Table 4-10. pH and water activity (a_w) of the street foods evaluated in this thesis

Type of food	pH	water activity
Stuffed pancakes	6.4 ± 0.3* (6.1 – 6.5)**	0.993 ± 0.001 (0.991 - 0.994)
Vietnamese sandwiches	5.3 ± 0.5 (4.9 – 5.6)	0.951 ± 0.002(0.950 - 0.954)
Fried spring rolls	6.1 ± 0.1 (5.9 – 6.1)	0.950 ± 0.003 (0.947 - 0.952)
Vietnamese pizza	6.2 ± 0.7 (5.6 – 6.7)	0.938 ± 0.040 (0.892 - 0.964)
Blended juice	5.6 ± 0.3 (5.4 – 5.8)	0.981 ± 0.010 (0.971- 0.991)

*mean ± standard deviation, **range

4.4.3. The result of general microbiological quality

Table 4.11 summarizes the results of the microbiological analysis of the street foods evaluated in this study. At a first glance, it can be seen that the Vietnamese sandwiches generally had the highest mean counts for most of the microbial parameters used to assess the general microbiological quality and the hygienic conditions. The mean counts of total aerobic bacteria (7.2 ± 0.7 log CFU/g) and lactic acid bacteria (7.1 ± 0.6 log CFU/g) both just exceeded end of shelf-life criteria for aerobic and lactic acid bacteria of 10^7CFU/g, recommended by Uyttendaele et al.(2010), indicating that the samples of the this street food were generally of an unacceptable microbiological quality. Furthermore, some of the samples had total aerobic and lactic acid counts as high as 8.5 and 8.3 log CFU/g, which is far above the end of shelf-life criteria recommended by Uyttendaele et al.(2010). The mean counts of the other parameters for the general microbiological quality were acceptable according the end of shelf-life criteria recommended by Uyttendaele et al. (2010). Mean yeast and mould counts (3 ± 1.6 log CFU/g) and total anaerobic counts (6.5 ± 0.4 log CFU/g) were less than recommended end of shelf-life criteria of 5 and 7 log CFU/g, respectively. However, one pizza sample had an unacceptable total anaerobic count of 7.1 log CFU/g. Vietnamese sandwiches were one of two street foods evaluated in this study which were not heat treated, which could explain the higher microbial counts on this product.

After the Vietnamese sandwiches, the blended juice of pennywort leaves and green beans generally had the second highest counts for most of the parameters used to evaluate the general microbiological quality. As for the Vietnamese sandwiches, the blended juice is not heat treated. Although none of the mean counts of the general microbiological quality parameters exceeded the end of the shelf-life criteria recommended by Uyttendaele et al. (2010), one sample had unacceptable total aerobic and lactic acid bacteria counts of 7.9 and 7.6 log CFU/g, respectively. After the blended juice, the stuffed pancakes appeared to third highest counts for most of the parameters used to evaluate the general microbiological quality. However, none of the mean counts of the general microbiological quality parameters exceeded the end of the shelf-life criteria recommended by Uyttendaele et al. (2010). Stuffed pancakes are fried which may help to reduce the microbial contamination levels. The fried spring rolls and Vietnamese pizza had the best microbiological quality; with very similar counts for most of the parameters evaluated. This

was expected from the more severe heat processing they undergo of deep frying and grilling, respectively. In conclusion, 14.1%, 2.8% and 11.3% of the samples did not satisfy the end of shelf-life criteria for ready-to-eat foods recommended by Uyttendaele et al. (2010) on the basis of their total aerobic bacteria, total anaerobic bacteria and lactic acid bacteria counts, respectively.

76.1% of the street food samples were determined to have coliform counts $>10^2$ CFU/g or ml, which implies that they were unsatisfactory according to the criteria recommended by the International Commission on Microbiological Specifications for Foods (ICMSF, 2011). Generally, coliforms are used as indicator microorganisms for the hygienic conditions during the processing of foods (Kornacki and Johnson, 2001). The results therefore indicate that the majority of the street foods sampled were potentially produced or vended under unhygienic conditions. This confirms in part the conclusions from the food handling practices study. However, the results for the coliforms have to be treated with caution as coliforms can increase during storage before sale and the counts may therefore not reflect the true counts at the time of preparation. No significant differences ($p > 0.05$) were determined between the coliforms counts on the different types of street foods evaluated in this study.

Table 4-11. Indicators of general microbiological quality and hygienic conditions

Type of food	log CFU/ g or ml				
	Total aerobes	Yeasts and moulds	Lactic acid bacteria	Total anaerobes	Total coliforms
Stuffed pancakes	5.1 ± 0.4*	3.0 ± 1.3	3.5 ± 0.6	3.6 ± 0.7	3.2 ± 0.7
	4.5 - 6.0**	<2 - 4.4***	2.7 - 4.4	2.3 - 4.6	1.9 - 4.2
Vietnamese sandwiches	7.2 ± 0.7	3.0 ± 1.6	7.1 ± 0.6	6.5 ± 0.4	3.7 ± 0.7
	6.0 - 8.5	<2 - 4.9	6.0 - 8.3	5.6 - 7.1	2.5 - 5.1
Fried spring rolls	3.2 ± 0.1	0.5 ± 1.9	2.6 ± 0.3	1.0 ± 1.4	0.2 ± 0.6
	3.0 - 3.5	<2 - 5.3	1.9 - 3.0	<1 - 3.5	<1 - 2.1
Vietnamese pizza	3.8 ± 0.9	0.6 ± 1.3	3.3 ± 0.9	2.4 ± 1.7	1.1 ± 1.1
	2.9 - 4.5	<2 - 4.2	2.3 - 6.3	<1 - 6.3	<1 - 2.7
Blended juice	6.4 ± 0.7	3.8 ± 0.5	6.1 ± 0.6	6.1 ± 0.5	3.6 ± 0.7
	5.6 - 7.9	3.1 - 5.0	4.9 - 7.6	5.0 - 6.8	2.4 - 4.9

*mean counts (log CFU/g or ml); **range of counts (log CFU/g or ml); ***<2 or <1indicates that the counts were below the detection limit of the method

4.4.4. The result of pathogenic microbiological quality

Table 4.12 shows the number (and %) of samples of each street food with typical colonies of a particular pathogen. None of the samples had typical *Listeria* spp. colonies on the ALOA agar plates. 4/15 (26.7%), 3/15 (20%) and 2/15 (13.3%) samples of Vietnamese sandwiches, blended juice and stuffed pancakes, respectively, were determined to have typical *E. coli* colonies of *E. coli* on the RAPID *E. coli* 2 agar plates. 6/15 (40%), 3/10(30%) and 10/16 (62.5%) samples of products stuffed pancakes, fried spring rolls and Vietnamese pizza, respectively, were determined to have typical *B. cereus* colonies on the MEYP agar plates whilst 7/15 (46.7%), 14, 2/15 (13.3%) and 5/15 (33.3%) samples of products stuffed pancakes, Vietnamese sandwiches, Vietnamese pizza and blended juice, respectively, were determined to have typical *S. aureus* colonies on the BPA plates. These typical (presumed) pathogen colonies were then subjected to some confirmatory tests.

Table 4-12. Number of samples of each street food with typical colonies of the targeted pathogens

Street food	*Listeria* spp.	*E. coli*	*S. aureus*	*Bacillus* spp.
Stuffed pancakes	0	2	7	6
Vietnamese sandwiches	0	4	14	0
Fried spring rolls	0	0	0	3
Vietnamese pizza	0	0	2	10
Blended juice	0	3	5	0

A summary of the results of the confirmation tests is shown in Table 4.13. 62.5% the presumptive *B. cereus* spp. colonies evaluated were confirmed to be *B. cereus* spp. In more detail, *B. cereus* spp. were found in 20 and 12.5% of the stuffed pancakes and pizza samples, respectively. The mean counts (log CFU/g) of presumed *B. cereus* spp. in these two products were 2.93 (± 1.13) with the value ranging between 0 and 5.91 log CFU/g. *B. cereus* spp. are widespread in the environment which leads to a high likely-hood of their presence in foods.

Being spore formers, they can potentially survive mild cooking and heating processes. Meat and vegetables as well as rice cake (papers) are possible sources of *B. cereus* spp. in the stuffed pancakes and pizza. Apart from *B. cereus* spp., *Bacillus subtilis* and *Bacillus licheniformis* were found in 6.7% of the stuffed pancakes samples, while 43.8 and 30% of the pizza and fried spring roll samples were contaminated with *B. subtilis*. In addition, *B. mycoides* was identified in 6.3% of the pizza samples. In similarity to *B. cereus* spp., farinaceous ingredients such as rice papers or food prepared from poultry, meat, and vegetables are likely sources of these other *Bacillus* spp.. Spices such as pepper, which are added before or after the main cooking process, are also often contaminated by *Bacillus* spp., especially in the spore form (Guidelines for Assessing the Microbiological Safety of Ready-to-Eat Foods Placed on the Market, 2009).

With regards to *S. aureus*, the mean counts of presumptive colonies on BPA were 4.45 (±1.21) log CFU/g with the counts ranging from <2 to 6.14 (log CFU/g). According to the confirmation tests performed, 85% of the presumptive *S. aureus* colonies evaluated were confirmed as being *S. aureus*. 4/15 (26.7%) and 2/16 (12.5%) of the Vietnamese sandwiches and pizza samples, respectively, were confirmed to be contaminated by *S. aureus*. The counts of presumptive *E. coli* (which in addition to being a pathogen is also considered as an indicator to assess the hygiene status of the food products) were 2 (±1.10) log CFU/g or ml with the counts value ranging from <2 to 4.14 log CFU/g. 2/15 (13.3%), 4/15 (26.7%) and 3/15 (20%) of the samples of stuffed pancakes, Vietnamese sandwiches and blended juice, respectively, were confirmed to be contaminated by *E. coli*.

Whilst the counts of the presumptive pathogens do raise some concerns in some cases, they have to be interpreted with caution. The reason for this being that in most cases not all three colonies picked for confirmation from a particular sample were actually confirmed to be a particular pathogen, the number confirmed varied from sample to sample. This implies that using the presumptive counts would overestimate the actual numbers present. Therefore, it was decided not to make definitive conclusions from these results but to report that there is reason for concern about the microbial safety of street foods vended in HoChiMinh city.

Table 4-13. Summary of the confirmation tests

Street food	Confirmed pathogens	Contaminated samples (%)
Stuffed pancakes	*E. coli*	13.3
	B. cereus	20
	B. subtilis	6.7
	B. licheniformis	6.7
Vietnamese sandwiches	*E. coli*	26.7
	S. aureus	26.7
Fried spring rolls	*B. subtilis*	30
Vietnamese pizza	*S. aureus*	12.5
	B. cereus	12.5
	B. subtilis	43.8
	B. mycoides	6.3
Blended juice	*E. coli*	20

The results obtained in this study agreed mostly with those from other studies which have evaluated the microbiological quality of street foods in other countries. A few examples are discussed below. Fecal coliforms were present in 30% of street food samples from Sao Paolo, Brazil (Hanashiro, 2005). Furthermore, *E. coli* was found in 22.5% of the same samples, probably originating from raw vegetables and a lack of good hygienic practices. In Nigeria, coliform counts ranged from 10^3 CFU/g in vegetable samples to 10^6 CFU/g in clam meat; counts which was above the maximum level of 10^2 CFU/g (Ekanem, 1998). A study performed on street foods in Johannesburg, South Africa, showed that *B. cereus* was present in 12.5% of samples at counts > 10^3 CFU/g. In a study carried out in Latin America cities, *S. aureus* occurred in 1.9 to 25.2% of the street food samples at counts > 10^3 CFU/g (Almeida et al. 1996).

As a result of differences in the types of street foods samples, environment as well as the method of preparation, differences occur between the results obtained in different countries. However, the majority of the studies including this study have indicated that street foods consumers are potentially at risk as a result of the unhygienic conditions under which these foods are mostly prepared and vended. In particular, this study showed that the presence of *E.*

coli, *S. aureus*, *B. cereus* and other pathogenic *Bacillus* spp. indicates that the safety of street foods vended in HoChiMinh city is questionable or suspect.

5. Conclusions and recommendations

5.1. Limitation of the thesis and recommendations

i. Due to the limitation of time and resources, the study was only carried out in four districts in HoChiMinh city including three areas near the centre and the other on the edge of the city. This selection may lead to the bias of the study because only one low income area was chosen which may lead to unfair representation among the participants,

ii. The sample size of the surveyed vendors was selected randomly and not calculated carefully, which may also lead to bias in the results of this study since the characteristics of 'representative participants' were unknown,

iii. Due to the difficulties in delivery of the samples from HoChiMinh city to Belgium for microbiological analysis, the number of samples as well as the types of the collected street foods was limited. Therefore, many other popular street foods were not included in this study, which may lead to arbitrary conclusions about microbiological quality and safety of street foods in HoChiMinh city,

iv. Although the survey of food safety knowledge and attitudes of consumers was carried out at various locations including near schools, universities, markets, supermarkets, parks or crowded areas, ultimately a large percentage of the voluntary participants were from people near schools or universities. This selection may lead to the high proportion of high educational level which may have biased the food safety knowledge and attitudes estimated for the consumers.

If this study could be extended, some critical points following are highly recommended to take into account:

i. Other common pathogens which can occur in ready to eat foods should be analysed in order to entirely evaluate the risk of food-borne pathogenic bacteria caused by street food consumption, i.e. *Salmonella, Campylobacter, Clostridium perfringens*,

ii. The microbiological quality of potable water used by street food vendors should be assessed because water is a potential source of contamination during the preparation, processing and vending of street foods.

iii. Street food consumption plays is of cultural importance to the inhabitants of HoChiMinh city and a big variety of street foods is available all the time. However, the quality and sources of raw materials and other ingredients used by vendors are unclear. Therefore, it is necessary to also evaluate the quality of raw materials.

5.2. **Conclusion**

This study achieved the main objectives of assessment of food safety knowledge and attitudes of both street food consumers and vendors as well as food handling practices of food vendors in the certain districts in HoChiMinh city, Vietnam. Although the surveyed consumers had adequate knowledge and attitudes on food safety, the street food vendors had a poor understanding of food safety which was reflected in their unhygienic practices during the preparation and vending of the foods. The results also showed that most of street vendors had a low educational level and did not have any formal food safety training which contributed to the unsafe (unhygienic) conditions under which the foods are vended. In addition, the study highlighted the presence of some pathogenic bacteria in the samples collected in those areas. Regarding the nutritional aspects, the average energy value of the selected street foods was evaluated and it was determined that those street foods considered as major dishes contribute a significant amount of the average energy requirement of Vietnamese men and women.

Although Vietnam has legislation on street food safety in general, the official regulations as well as food safety standards for the street foods sector have not been published yet. On the other hand, street food consumption has become more widespread especially among working class population with lower and middle incomes. Therefore, apart from formal food safety training, Vietnam's Food Administration (VFA) and local government should pay more attention on build standardized infrastructures for street food sectors such as potable water, toilets and waste disposal facilities at the vending sites so that the risks of cross contamination can be minimized.

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Appendices

Appendix A1a Food safety knowledge questionnaire

Sex: Male / Female Age: Food safety training: Yes / No

Education: Illiterate Elementary school High school Higher education

FOOD SAFETY KNOWLEDGE	YES	NO	DO NOT KNOW
Washing hands before work reduces the risk of food contamination			
Using gloves while handling food reduces the risk of food contamination.			
Proper cleaning and sanitization of utensils increase the risk of food contamination.			
Eating and drinking in the work place increase the risk of food contamination.			
Food prepared in advance reduces the risk of food contamination.			
Reheating cooked foods can contribute to food contamination.			
Washing utensils with detergent leaves them free of contamination.			
Children, healthy adults, pregnant women and older individuals are at equal risk for food poisoning.			
Typhoid fever can be transmitted by food.			
AIDS can be transmitted by food.			
Bloody diarrhea can be transmitted by food.			
Abortion in pregnant women can be induced by food-borne disease.			
Salmonella is among the food-borne pathogens.			
Hepatitis A virus is among the food-borne pathogens.			
Staphylococcus is among the food-borne pathogens.			
Can swollen cans contain microorganisms			
Microbes are in the skin, nose and mouth of healthy handlers.			
During infectious disease of the skin, it is necessary to take leave from work.			

Appendix A1b Food safety attitude questionnaire

FOOD SAFETY ATTITUDES	YES	NO	DO NOT KNOW
Well-cooked foods are free of contamination.			
Proper hand hygiene can prevent food-borne diseases.			
Can a closed can/jar of cleaning product be stored together with closed cans and jars of food products			
Raw and cooked foods should be stored separately to reduce the risk of food contamination.			
It is necessary to check the temperature of refrigerators/freezers periodically to reduce the risk of food contamination.			
Defrosted foods can be refrozen.			
The health status of workers should be evaluated before employment.			
The best way to thaw a chicken is in a bowl of cold water.			
Wearing masks is an important practice to reduce the risk of food contamination.			
Wearing gloves is an important practice to reduce the risk of food contamination.			
Wearing caps is an important practice to reduce the risk of food contamination.			
The ideal place to store raw meat in the refrigerator is on the bottom shelf.			
Eggs must be washed after purchase			
Dish towels can be a source of food contamination.			
Knives and cutting boards should be properly sanitized to prevent cross contamination.			
Food handlers who have abrasions or cuts on their hands should not touch foods without gloves.			

Appendix A2 Food safety observation checklist

Food safety observation checklist

Name vendor: …….

Location: …….

Age: ……

Sex: ……

Education level: ……..

Food safety training: ……..……

1. Facilities

- Indicate what kind of material the stall/structure were the food is prepared and sold is made

Wooden	Canopy	Van	Wheelbarrow	Zinc/ iron	Container

- Is food prepared on-site or at home?
- Is vending stall protected from sun, dust and wind? Yes/No
- Are animals or pests (flies etc.) evident around the vending stall? Yes/No
- Is the vending stall maintained in a clean condition? Yes/No
- Is there access to potable water at the site or close to the site? Yes/No
- Are adequate hand washing facilities available? Yes/No
- Are adequate waste (water or food) disposal facilities available? Yes/No
    - this is usually a closed (foot operated) bin
    - access to community operated waste water and general waste disposal sites

2. Environment around the stall

- Is environment around the stall clean: far from rubbish, waste water, toilet facilities, open drains and animals? Yes/No

3. Personal hygiene

- Does the operator wash their hands in clean water each time before the handling, preparation and serving of food? Yes/No

- Does the operator wash their hands each time after visiting the toilet? Yes/No
- Are the operators clothes clean and presentable? Yes/No
- Does the operator use an apron when handling, preparation and serving of food? Yes/No
- Does the operator handle food with bare hands? Yes/No
    - If answer was NO, do they use disposable or reusable gloves?
    - Are the gloves cleaned properly i.e.. in clean water (with or with soap) before the handling, preparation and serving of food?
- Does the operator have clean short nails? Yes/No
- Is the hair of the operator covered when handling, preparation and serving of food? Yes/No
- Does the operator handle money while serving food? Yes/No
    - Are hands washed after handling money before handling food again? Yes/No
- Does the operator wear jewelry? Yes/No
    - Is the jewelry adequately covered? Yes/No
- Does the operator blow air into polythene bag before use? Yes/No
- Is dirt or dust removed by means of an apron, dirty cloth or bare hands ?
- Is dirt or dust removed by blowing?
- Does vendor smoke during the handling/ preparation of food? Yes/No
- Does the operator use the same utensil (knives and boards) to prepare raw and cooked food products or to cut raw vegetables and fresh meat and poultry? Yes/No
- Please note down any unhygienic behavior you may notice by the operator while vending food i.e.
    - Blowing of nose into hands continuing to work without washing the hands
    - Coughing into hands and continuing to work without washing the hands

4. Food storage

- Is food stored/displayed
    - Openly in the stalls
    - In a wheelbarrow
    - In sealed (transparent or opaque) containers
- Are raw, partially cooked and cooked food products kept separate? Yes/No
- Are previously cooked foods kept cool (i.e. ice box) or refrigerated?

5. Utensils

- Are utensils cleaned with
    - Warm soapy water
    - Cold soapy water
    - Clean water with no soap
    - Dirty water with no soap
- Are utensils covered? Yes/No
- Are utensils cleaned adequately every time after use? Yes/No

Appendix A3 Consent form

VOLUNTEER AGREEMENT FORM

Title: **Food safety behavior, attitudes and practices of street food vendors and consumers in Vietnam**

General Information about Research

This study will investigate the food safety knowledge, attitudes and practices of street food vendors and consumers of street food.

Possible Benefits, Risks and Discomforts

There are no direct benefits to be gained from this study immediately, neither are there any risks associated with it. The only inconvenience might come from the time you will spend completing the questionnaire. The data from this study will be used only for the purpose of the study. (Master Thesis)

Confidentiality

Your identity and your participation in this study will be treated strictly confidential. The information that we obtain from you will not be shared with anybody, except the study investigators. Your identity remains secret since your personal information will only be designated by a unique participant number. Your name will not appear in any reports or publications resulting from this study. After the study is completed, you may request information about the study results.

Voluntary Participation and Right to Leave the Research

You participate entirely voluntarily in this study. You have the right to refuse to participate in the study**.** You also have the right to stop your participation in the study at any time, even after you have signed this informed consent form. The withdrawal of your consent will not cause any disadvantage or loss of advantages/privileges.

Contacts for Additional Information

Any questions or any further clarifications concerning the study can be directed to:

Contact of the promoter:

Prof. Frank Devlieghere/ Dr. Simba Samapundo

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VOLUNTEER AGREEMENT

The above document describing the benefits, risks and procedures for the research title ***(name of research)*** has been read and explained to me. I have been given an opportunity to have any questions about the research answered to my satisfaction. I agree to participate as a volunteer.

Date Name of volunteer

If volunteers cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

Date Name of Witness

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

Date Signature of Person Who Obtained Consent