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Exploring safety of food truck products in a developed country

Bendegul Okumus[a,*], Sevil Sönmez[b], Sean Moore[c], Daniel P. Auvil[c], Griffith D. Parks[d]

[a] Rosen College of Hospitality Management, University of Central Florida, 9907 Universal Boulevard, Orlando, FL, 32819, USA
[b] College of Business, University of Central Florida, 12744 Pegasus Dr., Orlando, FL, 32816-1991, USA
[c] Burnett School of Biomedical Sciences, UCF College of Medicine, 4110 Libra Dr., Orlando, FL, 32816, USA
[d] Burnett School of Biomedical Sciences, UCF College of Medicine, 6850 Lake Nona Blvd, Orlando, FL, 32827, USA

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ABSTRACT

There is limited research on food safety practices of street foods, particularly food trucks in developed countries. Given this gap, this study explores the safety and sanitation status of food trucks in the highly developed tourist destination of Orlando, Florida, in the United States. A sample of 30 raw and cooked ready-to-eat foods was collected from 24 food trucks located in residential and touristic sites located in Orlando and then held for microbiological analyses (*E. coli* and *Salmonella enterica* spp.) to determine pathogen populations of the final products. In addition to lab analyses for coliform bacteria, food safety practices of vendors were evaluated. Although developed countries are believed to have strict safety and quality measures in place, our study results reveal that food prepared in and sold from food trucks can be potential vehicles of clinically relevant *E. coli* and *Salmonella* carrying intestinal pathogenic virulence factors or antibiotic resistance genes, which might create a public health hazard or more specifically foodborne illnesses and outbreak. To minimize foodborne illnesses and infection risks, food inspections and monitoring processes should be carefully revised by municipal, county, and state health departments. This is one of the first studies to explore safety of food truck products in the context of a developed country.

1. Introduction

Street foods are often integral components of local culture and offer diverse opportunities to tourists and locals alike, for unique cultural experiences. Since food and travel are inextricably linked in memorable tourist experiences, travelers often try local cuisine at various types of restaurants or try indigenous foods at street food stalls. The sensual experience of eating and engaging in adventures involving various types of food and cuisines have led to the creation of the term "*food porn*" by travelers and bloggers (Scott, 2018). According to the Food and Agriculture Organization, 2.5 billion people around the world regularly consume street food and it is considered to be the most common form of public dining (Food and Agriculture Organization, 2007; Kraig and Sen, 2013). Street food also represents one of the most significant sources of employment for low-income families (Bhowmik, 2012; Freese et al., 1998).

From time to time, the food service industry has been associated with news related to foodborne illnesses resulting from improper food handling, lack of sanitation, and other problems. Mobile and street food vendors (e.g., food trucks) in particular have been associated with environmental and public health risks. These types of events are attributed to improper food preparation and service, absence of food safety regulations, and improper waste management practices (Alimi, 2016; Food and Agriculture Organization, 2011; Kothe et al., 2016; Liu et al., 2014; Qureshi and Azim, 2016; World Health Organization, 1996).

Previous studies on street food and street food vendors have revealed numerous safety, quality, and environmental problems in developing countries (Alimi, 2016; Al Mamun et al., 2013; Campos et al., 2009). However, there is limited data on street food and especially food trucks—which are the most common form of street food in United States—sold in developed countries. Although developed countries are known to have and to enforce specific safety and/or quality measures and have monitoring systems in place, food service businesses continue to be linked with some measures of risk to the public for food borne illnesses and outbreaks (Muyanja et al., 2011). Several recent cases in the U.S. have revealed a number of foodborne illnesses and related hazards in the context of food manufacturing and food service industries (Centers for Disease Control and Prevention, 2018c). While the U.S. food supply is considered to be among the safest in the world,

* Corresponding author.
E-mail addresses: bendegul.okumus@ucf.edu (B. Okumus), Sevil.Sonmez@ucf.edu (S. Sönmez), Sean.Moore@ucf.edu (S. Moore), dauvil36@stmatthews.edu (D.P. Auvil), griffith.parks@ucf.edu (G.D. Parks).

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according to the Food and Drug Administration (FDA) (2016), there are 48 million cases of foodborne illnesses, or the equivalent of one in six Americans falling sick from consumed food, 128,000 hospitalizations, and 3000 deaths each year.

Contaminated food and beverage items can cause foodborne illnesses and infections, such as traveler's diarrhea, the most common travel related illness. Although it may be rarely serious or life threatening for healthy adults, it can disrupt a vacation experience in an unpleasant manner (Centers for Disease Control and Prevention, 2018a). Despite these facts, there is limited research and information about food safety practices of street food and food truck vendors to clearly highlight risk factors. The studies from developing nations revealed that primary problems that emerge revolve around the inability of vendors to follow safety practices (Kothe et al., 2016; Liu et al., 2014). These are due to the absence of running water and functioning toilets nearby; inability to protect food ingredients, utensils, and serving dishes from insects and dirt; absence of proper refrigeration; the lack of strict implementation of sanitation codes and licensing, training and monitoring of vendors by local or national organizations; as well as the lack of consumer pressure demanding improvements (Cortese et al., 2016). Therefore, regardless of the training level that vendors might receive, required food safety practices are difficult to practice without fundamental infrastructure (Campos et al., 2009).

There is a clear gap and lack of data in research on the public health risks of street food consumed in developed nations, which this study intends to address. The main purpose of this study is to investigate the food handling and safety practices of food trucks in Orlando, Florida, which is a well-established tourist destination to explore safety management measures in place for both the local and traveling public. In particular, this study aims to:

1 analyze samples of food collected from food trucks in Orlando for microbiological contamination (*E. coli* and *Salmonella enterica* spp.),
2 observe food handling practices and sanitary conditions of food truck personnel,
3 propose recommendations to minimize potential health/safety risks as appropriate, following analyses.

Following a critical review of relevant literature, the research design and methodology of the study are described below. Following a discussion of the findings, theoretical and practical implications are highlighted and suggestions are made for future research. This is the first study that empirically explored safety of food truck products in a developed country and also at a leading destination.

2. Literature review

2.1. Existence of infectious agents

Infectious agents such as viruses, bacteria and parasites represent some of the earliest living organisms. Bacteria, for example, are regularly found in the human body; the normal flora consists of over 200 species and provide many benefits including preventing colonization by pathogens (harmful bacteria) that compete for attachment and nutrients (Boston University School of Public Health, 2017). Some of these agents, however, can cause infectious diseases such as Hepatitis and can increase the risk of some types of cancer that can form through in/direct contact with a person, animal, food, water, soil, or vegetation (MedlinePlus, 2018; National Cancer Institute, 2017). Some viruses can disrupt cell growth and proliferation. Moreover, some infection agents can weaken the immune system, which in return results make the human body unable to defend cancer-causing infections (American Cancer Society, 2018; National Cancer Institute, 2017). Foodborne pathogens or bacteria often cause foodborne illness (food poisoning) outbreaks and they can be found in food along with viruses, parasites, and the other bacteria (The United States Food and Drug Administration, 2018). While every outbreak of foodborne illness is different, some significant foodborne pathogens are described below.

Escherichia coli (abbreviated as *E. coli*) are bacteria found in human and animal intestines and some foods. Although most strains of *E. coli* are harmless, some of them can cause diarrhea, urinary tract infections, respiratory illnesses and pneumonia, and other illnesses (Centers for Disease Control and Prevention, 2018b). *E. coli O157:H7* known as the worst type of *E. coli* making a toxin called Shiga toxin-producing *E. coli* (STEC). This toxin causes bloody diarrhea, hemolytic uremic syndrome (HUS) – red blood cells destroy by the toxin and cause kidney injury-even death. HUS patients need intensive care, kidney dialysis, and transfusions (Foodsafety.gov, 2018). Infections start when STEC is ingested in the form of undercooked ground beef, juice, unpasteurized milk, soft cheeses made from raw milk, and raw fruits and vegetables, drinking untreated water, swimming in contaminated water, or around animals and their environment particularly cows, sheep, and goats and feces of infected people (Centers for Disease Control and Prevention, 2018c; Food and Drug Administration, 2016; Foodsafety.gov, 2018) and lack of hand washing (DeForge et al., 2018).

Salmonella are group of bacteria that can cause food-borne infections called *Salmonellosis* and it is a common causes of food poisoning. Fever, headache, nausea, diarrhea, stomach cramps, and vomiting are common symptoms (Ontario Ministry of Health and Long Term Care, 2018). Symptoms can arise within 6–72 h after being infected and can last between 4 and 7 days. People with a strong immune system can get through without treatment. However, *Salmonella*, which can be destroyed by cooking and pasteurization, can cause more serious illness in older adults, infants, and persons with chronic diseases (Foodsafety.gov, 2018; Ontario Ministry of Health and Long Term Care, 2018; United States Department of Agriculture, 2018). Main food sources of *Salmonella* are eggs, poultry, meat and meat products, raw fruits, vegetables cheese, unpasteurized milk or juice, spices and nuts. Most foodborne illnesses are caused by nontyphoidal *Salmonella* spp. (11%) and 28% of leading causes result in death.

Despite advances in food regulations, over nine million people have a foodborne illness each year (Scallan et al., 2011) due to bacterial transmission. Preventing this public health issue is challenging since resources are limited and transmission occurs through a variety of foods (Painter et al., 2013). Animals including reptiles, amphibians, birds and pet food also spread the bacteria and cause foodborne illnesses (Foodsafety.gov, 2018). Recent studies on microbiologic quality of street food revealed that developing countries in Asia, South America, and Africa showed inadequate safety and sanitary conditions, hygiene practices and heavy microbiologic contamination. For example, *Escherichia coli* and *Salmonella* were isolated from many raw and cooked food samples including salads, macaroni, rice, water, raw or uncooked food and animal food in these regions (Kothe et al., 2016; Liu et al., 2014; Shagufta et al., 2017). Although the microbiological quality of ready-to-eat street vending commerce in industrialized countries are scarcely evaluated, one European study revealed *E. coli* in food samples including hamburgers, hotdogs, and food trays (Campos et al., 2015). Fruit and vegetable juices (Tambekar et al., 2009), bean sprouts (Liu et al., 2014) and low quality of raw food (Rath and Patra, 2012) transmit pathogens frequently. According to Food Safety News (2018) raw chicken or turkey (79%), shellfish (55%), reheated take-away food (46%), eggs (37%), unwashed vegetables or salad (29%), cooked sliced meats (19%), pre-prepared salads (18%) and cereal (2%) transmitted bacteria and caused foodborne illness in restaurants, pubs, cafes and takeaways. To the authors' best knowledge, this study is one of the first studies sharing empirical evidence on degree of contamination of food sold in food trucks in touristic and residential sites of an urban area. Based on the above discussions, it can be proposed that the degree of contamination may vary by type of location of food trucks (tourist areas versus residential areas) and type of food (cooked food versus raw vegetables and fruits).

2.2. Current food safety practices in county health departments in the U.S

Each state or city may have its own set of specific requirements that must be met depending on the mode of operation (Entrepreneur, 2018). In the case of Florida, Department of Business and Professional Regulation (Florida DBPR) regulates food service businesses including mobile food vehicles, the Florida Department of Health (DOH) works with food service establishments and food service operations to ensure their foodservice process are safe for the public (Florida Health, 2018). For food inspections, risky food service facilities are inspected annually – more often than those that are considered to pose lesser risk. Accordingly, using the FDA Model Food Code high-risk facilities are inspected two to four times annually, moderate risk facilities are inspected about twice and low risk facilities are inspected once annually (Florida Health, 2018).

Although food inspections are completed without any predetermined time frame by some health departments, many food service facilities including food trucks are inspected during scheduled time frames that coincide with regular business hours in many states. Therefore, certain numerous risk factors such as food temperatures, poor sanitation of utensils, personal sanitation and the internal environment of the food truck may not be easily or consistently observed by health inspectors (Okumus and Sonmez, 2018; Zuraw, 2015). Unlicensed food trucks present a particular challenge to food inspectors because they can easily move to a different location. Considering the foregoing, it is essential for street food consumers to be cognizant of the potential health risks linked with food trucks (Vanschaik and Tuttle, 2014).

The regulation of food service facilities requires various Federal licenses or permits across all U.S. cities (e.g., food service business license, food safety permit, general business license) (U.S. Small Business Administration, 2018). Some states also require general liability insurance or commercial car insurance, and gas and electrical safety certificates for food truck vendors. Health and safety regulations and location and parking regulations are applied to food truck businesses by city and state health departments (Mccarthy, 2017). Food truck operators are required to obtain a permit from the local health departments, which require detailed plans to minimize the risk of foodborne illnesses. Since health departments generally have countywide jurisdiction, food truck owners are required to obtain approvals when they wish to operate in a new county (Rey, 2018).

3. Materials and methods

3.1. Field survey

Food truck vendors were unwilling to let the researchers observe and record all the processes they noticed during the food preparation and service. Therefore, a field survey was conducted from the perspective of a customer, using the Florida Department of Health (DOH) observation checklist, which is available at http://www.floridahealth.gov. Food handling practices and food service environment and utensils were observed along with as much of the preparation, storage and service risks that could be observed from the customer service window area and evaluated. The following items are available in the observation checklist.

1 Personal hygiene (using apron, gloves, hat and mask, washing hands before handling foods).
2 Food handling and sanitation practices (using and cleaning the utensils, basic temperature check- hot food hot, cold food cold).
3 Availability of facilities for food trucks and basic infrastructure for sanitation practices (portable water access, electricity, propane tank, drainage system, waste containers, serving station, sanitation grade and license).

3.2. Data collection

3.2.1. Study site

The study's primary objective was to investigate food handling/safety practices of food trucks in Orlando to explore safety management measures for both tourist and resident consumers. Orlando was chosen for this study for several reasons: (1) it is the 4th (of 917) most populated city in Florida (USA Population, 2018), (2) it is the tourism capital of the world with over 72 million visitors in 2017 (Russon, 2018), and (3) it has an economic impact of more than $50 billion (Orlando Economic Partnership, 2017). Despite the presence of over 5000 restaurants in Orlando, food trucks are a source of quick and low-cost meals for many resident and tourists alike and offer a rich array of food (e.g., hamburger, hot dog, sandwiches, seafood, desserts, American/Latin and Middle Eastern/Asian foods). They represent a ready-to-eat food source that is increasing in popularity, with nearly 200 food trucks in different locations around Orlando, including six food trucks at the commercial parking lot and taxi staging area of Orlando's International Airport (Brown, 2013; Orlando Street Food, 2016; Yelp, 2016).

3.2.2. Study sample/sampling strategy

Purposive sampling was used to collect food samples from food trucks located in two types of locations: one that has high tourist traffic in Kissimmee, Orlando that is situated across from Old Town, a visitor draw and one with both commercial and residential areas where locals who live and work in the area purchase food, on a major artery road (Orange Blossom Trail (OBT). Thirty samples of both cooked and raw foods were purchased and immediately prepared for delivery to the university lab for analysis.

3.2.3. Data collection

Data were completed in five phases over the course of two months: (1) a list of food trucks in Orlando was compiled through relevant websites (e.g., Yelp.com; orlandostreetfood.com; thefoodtruckbazaar.com; roaminghunger.com; foodtrucksin.com) and categorized by location and food type; (2) a sample of 30 ready-to-eat foods was collected from 24 food trucks located in the two study sites (touristic location: 15 food samples and commercial/residential location: 15 food samples). Purchased food samples (weighing approximately 100 g) were immediately enclosed in marked sterile plastic bags and transported in cold containers (4–7 °C; 39–44 °F) to the laboratory for microbiological analysis; (3) food safety practices of street food vendors were evaluated based on an observation checklist, which was prepared in accordance with the Florida Department of Business and Professional Regulations (FDBPR, 2013).

3.3. Laboratory testing for presence of bacteria in food samples

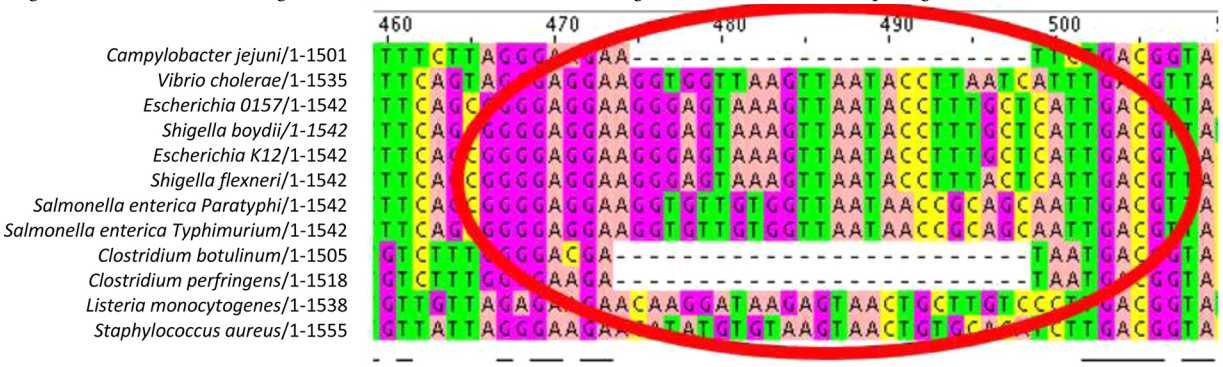
3.3.1. DNA purification

Food samples were aseptically processed with razor blades to partially homogenize and reduce solid sizes to ˜0.5 cm. Five grams of this material was transferred to a 15 mL conical tube and submerged in 5 mL of 50 mM Tris-Cl, 10 mM ethylenediaminetetraacetic acid. Ten 1/4 in. banded zirconium-ceramic beads were added to each sample (MPBio, Santa Ana, CA) and each was processed in a FastPrep 24 5G homogenizer using a TeenPrep adapter (MPBio) until an even homogenate formed. Of these homogenates, 500 uL was subsequently processed for total DNA using a FastDNA(tm) Spin Kit for Soil according to the manufacturer's instructions (MPBio).

3.3.2. Pathogen screening

Bacterial DNA was detected using custom primers that annealed to highly conserved regions flanking the V3/V4 region of the 16S rRNA genes all pathogens of interest (Table 3; primers Path_F and Path_R). These primers were similar to conventional 16S taxonomic primers, but have no degeneracy, have matched and higher Tm values, and the

Table 1
Alignment of the V3 variable region of the small ribosomal subunit RNA gene (16S) for several food pathogens.



reverse primer lacks a 3′ CC, which we computationally discovered would exclude a notable subset of bacterial 16S genes. These PCR products served as templates to secondarily screen for different bacteria using custom primers that annealed within the V3 and V4 variable regions and specifically recognized the target genus (Tables 1 and 3). These presence/absence screening PCRs were performed with GoTaq 2X PCR mix according to the manufacturer's instructions (Promega, Madison, WI).

3.3.3. The V3 region of target bacteria

The variable-3 and variable-4 regions of bacterial 16S rRNA genes were used to screen for specific bacteria. In this example for the V3 region, the *Coli_F* and *Salm_F* primers have unique sequences that identify their genus and/or species. Similarly, the reverse primers that bind in the V4 region were designed to be specific. For *E. coli*, this sequence is the same for *Shigella*, so Sanger sequencing of the entire amplicon was used to confirm *E. coli*.

3.3.4. Virulence gene screening

An engineered target PCR template was generated by amplifying a 461 bp segment of the *E. coli lacZ* gene while adding the primer binding sites for established diagnostic primers for the *cdtB* and *agfA* virulence genes (Figueiredo et al., 2015). The amplicon was gel purified, quantified using the Quant-iT™ PicoGreen™ dsDNA Assay Kit (ThermoFisher), and serially diluted to generate standard curve to establish a limit of detection for the real-time qPCR assay.

4. Study results

DNA of *Escherichia* and *Salmonella* were detected in first 14 out of 30 cooked and raw samples from residential/commercial (OBT) and touristic (Kissimmee) areas, but that virulence genes associated with diseases from these organisms were mostly absent. Sequencing of the Path_F/Path_R amplicon pools revealed the presence of the several opportunistic pathogen listed in Table 2, such as *Cronobacter sakazakii* in two residential/commercial (OBT) samples, commensal enteric *Citrobacter freundii* and *Panteo conspicua* in two residential/commercial (OBT) samples. *E. coli* was less prevalent, detected in one touristic (Kissimmee) and three residential/commercial (OBT) samples. *Salmonella* was detected in seven touristic (Kissimmee) and four residential (OBT) samples (Table 2).

PCR Amplicons from positive samples were sequenced and compared to bacterial databases at the National Center for Biotechnology Information at the National Library of Medicine using their online BLASTn interface. Table 2 presented the closest reported matches.

4.1. General pathogen detection

An improved pathogen screening PCR was developed for this study using a two-stage PCR. The primary PCR used custom primers derived from a commonly employed primer pair that amplifies a conserved region of most prokaryotic 16S rRNA genes (Pro341F and Pro805R, flanking V3 and V4) (Takahashi et al., 2014). It was noted that these primers are calculated to have a substantially different annealing Tm and that the heterogeneous positions in the primers are unnecessary for our target pathogen group; both of which are expected to reduce PCR efficiency that would lower detection sensitivity.

To improve the screening primers, 16S sequences from *Escherichia coli*, *Salmonella enterica*, *Vibrio cholerae*, *Clostridium botulinum*, *Campylobacter jejuni*, *Staphylococcus aureus*, and *Listeria monocytogenes* were aligned using MUSCLE (Edgar, 2004) and viewed in JalView (Waterhouse et al., 2009) to evaluate the V3/V4 regions. This analysis revealed that the 5′ ends of the Pro341 F and Pro805R could be extended such that the Tm for each was higher and matched. The 3′ C of Pro805R was removed as well. This new primer pair was designated "Path_F" and "Path_R" and are calculated to amplify a ˜470 bp region from a majority of prokaryotic 16S targets (Table 3). The second stage screening PCR used nested primers that annealed to distinguishing sites in the V3 and V4 region of the path PCR products. These primer pairs were designed to bind to unique sequences in the pathogen alignment described above and produced ˜200 bp products (Table 3).

4.2. Salmonella virulence gene detection

A large collection of *Salmonella* virulence genes was previously characterized for abundance in pathogenic strains (Figueiredo et al., 2015; Suez et al., 2013). From these, a subset of targets was selected that were present in most of those pathogenic strains (*agfA*, *cdtB*, *envF*, *pagC*, *pagD*, *pltA*, *pltB*, and *taiA*). For PCR controls and also to quantify gene abundance in the extracted DNA samples, a set of artificial PCR templates was generated that contained primer binding sites for the target gene-screening primers flanking spacer segments of the *E. coli lacZ* gene (Table 3). These amplified templates were gel purified, quantified, and serially diluted to establish standard curves and detection limits using quantitative PCR (qPCR) reactions with the SsoFast EvaGreen Supermix (Bio-Rad, Hercules, CA). After optimization of the annealing temperature and extension time by monitoring the quality of the amplified products by agarose electrophoresis and melt-curve analysis (Bio-Rad CFX96 real-time system), a limit of detection for the *agfA* target gene was established at 1.1×10^5 templates per microliter in the extracted DNA, which corresponded to ˜2.2×10^7 genes per mL in the food sample homogenates. None of the analyzed samples generated a qPCR signal above our limit of detection.

A.) Ethidium Bromide agarose gels showing the results of standard PCR reactions performed with primers specific for pathogenic *E. coli*. (K = Kissimmee camp location; OBT = Orange Blossom Trail camp location).

Table 2
Identified Bacterial Pathogens in first 14 food samples.

Sample	Bacterial Strain
Chicken (K)	*Salmonella enterica* subsp. enterica serovar Wandsworth
Chicken Taco (K)	*Escherichia coli* / *Salmonella enterica* subsp. enterica serovar Minnesota
Chicken (OBT)	*Escherichia coli*
Chicken kabob (meat only) (OBT)	*Escherichia coli* / *Citrobacter freundii*
Kabob Veggies (OBT)	*Escherichia coli* / *Panteo conspicua*
Tripe Taco (K)	*Salmonella enterica* subsp. enterica serovar Wandsworth
Shrimp Taco (K)	*Salmonella enterica* subsp. enterica serovar Typhi / *Salmonella enterica* subsp. enterica serovar Minnesota
Hamburger only with bun (K)	*Salmonella enterica* subsp. enterica serovar Wandsworth
Bacon/Sausage (K)	*Salmonella enterica* subsp. enterica serovar Typhi / *Salmonella enterica* subsp. enterica serovar Minnesota
Tongue Taco (K)	*Salmonella enterica* subsp. enterica serovar Typhi / *Salmonella enterica* subsp. enterica serovar Minnesota
Chicken Sandwich (OBT)	*Salmonella enterica* subsp. enterica serovar Typhi / *Salmonella enterica* subsp. enterica serovar Minnesota
Sandwich Veggies (OBT)	*Salmonella enterica* subsp. enterica serovar Wandsworth
Shrimp (OBT)	*Salmonella enterica* subsp. enterica serovar Typhi / *Cronobacter sakazakii*
Chicken (OBT)	*Salmonella enterica* subsp. enterica serovar Typhi / *Cronobacter sakazakii*

K: Kissimmee (touristic area); OBT: Orange Blossom Trail (residential/commercial area).

B.) Ethidium Bromide agarose gels showing the results of standard PCR reactions performed with primers specific for pathogenic *Salmonella*. (K = Kissimmee camp location; OBT = Orange Blossom Trail camp location). Control reactions used DNA from *E. coli* strain MG1655 (K-12).

As Fig. 2 presents, the second group of samples from both touristic and residential/commercial sites did not show any *E. coli* or *Salmonella* in food samples. In the picture, all the way to the left, a column of bright bands illustrates the ladder to help determine the size of our DNA product. All the way to the right represents one individual band and this band signifies our positive control. Positive control was used to ensure that our PCR reaction worked and that our gel was run properly. Since a band did show up for our positive control, the PCR reaction and gel were performed correctly. No other bands showed up for any of the food samples, which means that the amount of pathogenic *Salmonella* in our food samples was not high enough to be at that threshold level that we can detect the bacteria.

4.3. Food truck observation and safety assessment of food handlers

Food service employees can transmit bacteria on their body parts such as skin, hair, eyes, nose, mouth, and hands which might be main contamination sources. Based on the observation, most vendors were middle-aged men and women. The data on observation of the vendors' food service practices are presented in Table 4. Regarding personal hygiene, hats, hair/beard nets, and aprons were rarely worn, but most vendors wore gloves at first glance but the same glove is used to serve numerous customers, prepare food, handle money, and clean the food preparation areas. The vendors had their hair either short or tied, nearly half of them were non-native English speakers. It was observed that the use of face masks and the display of inspection grades were scarce. Vendors in both touristic and residential/commercial sites tended less to demonstrate basic food safety and sanitation practices and mostly declined communication with researchers regarding their raw materials, food preparation methods, food handling and sanitation practices, and food supply chains.

Infrastructure facilities for food truck vendors in both study sites were considered proper with regard to access to potable water and waste disposal. At the residential/commercial site, most of the food trucks were open until 12:00 a.m. to serve clubbers and motorcycle groups out late at night. During data collection late in the evening, researchers observed that some of the food trucks consistently located on streets with poor hygiene and heavy traffic. Food items were exposed to dirt (i.e., dust, wind, vehicle/motorcycle exhaust fumes) posed chemical and microbiological risks. Furthermore, during sample collection at night around 11:00 p.m., few food truck vendors were found unlicensed and had limited basic sanitation facilities and drainage infrastructure, which may cause serious public health risks. Although all preparation surfaces, cooking and serving utensils should be clean and litter-free, due to the heavy night time demand, vendors appeared to be rushed to serve all customers and distracted from properly cleaning their utensils and service areas; however, disposable items such as containers, paper towels, cups, plates, and other service items appeared to be adequate for proper foodservice.

5. Discussion and conclusions

This exploratory study demonstrates that food prepared and served from food trucks can be a potential vehicle for clinically relevant *E. coli*

Table 3
Primers used in this study.

Primer name	Sequence (5' – 3')	Product length (bp)	Reference
Path_F	ACTCCTACGGGAGGCAGCAG		This study
Path_R	GCGTGGACTACCAGGGTATCTAATC	~470	This study
Coli_F	GGGGAGGAAGGGAGTAAAGTTAATACC		This study
Coli_R	GAGACTCAAGCTTGCCAGTATCAG	217	This study
Salm_F	GGAGGAAGGTGTTGTGGTTAATAACC		This study
Salm_R	GACTCAAGCCTGCCAGTTTCG	213	This study
cdtB_agfA_temp_F	CAACATCAATAGCCGAGTGGTAAAAGTGGCAGCATTCGGTGCCTTCTTCCGCGTGC		This study
cdtB_agfA_temp_R	GACCATGATCATCTGCAGCTTATCGGAGTTTTTAGCGTTCACACTTGCTGATGCGGTGC	539	This study
agfA_F	TAAAAGTGGCAGCATTCG		Figueiredo, et al.
agfA_R	TATCGGAGTTTTTAGCGTTC	327[a]	Figueiredo, et al.

[NOTE: In the study by Figueido et al., the fimbrial gene, *agfA*, was detected in all tested strains, so this target was used to screen for pathogenic *Salmonella*. If there was a positive hit, we would have subsequently screened for other virulence genes.].

[a] The product length listed for the *agfA* primers is the expected size for the *Salmonella* gene. The product size generated from the artificial template control is 499 base pairs.

Table 4
Food truck observation and sample collecting list.

T-Vendor (using glove, mask, hat, apron and inspection grade)	Food Type	Food Name	**R**-Vendor (using glove, mask, hat, apron and inspection grade)	Food Type	Food Name
V1-glove	American	Chicken	V1-none	American	Chicken
V2-glove, cap	Hispanic	Coleslaw	V2-glove	Hispanic	Chicken kabob
V3-glove	Hispanic	Chicken taco	V3-glove	Hispanic	Chicken sandwich
V4-glove	American	Hamburger	V4-glove,hat	Hispanic	Sandwich veggies
V5-glove	Hispanic	Tribe taco	V5-glove	Hispanic	Shrimp
V6-glove, cap	Hispanic	Shrimp taco	V6-none	Hispanic	Chicken
V7-glove	American	Burger w/bun	V7-none	Hispanic	Chicken
V8-glove	Hispanic	Tongue taco	V8-none	Hispanic	Chicken kabob
V9-glove, cap	Hispanic	Meat taco	V9-glove	Hispanic	Kebob veggies
V10glove,hat	American	Bacon /sausage	V10-glove	Hispanic	Chicken sandwich
V11glove,hat	Hispanic	Burger veggie	V11-glove	American	Shrimp
V12-none	Hispanic	Corn with mayo	V12-hat	American	Chicken

T: Touristic site, R: Residential/commercial site, V: Vendor.

and Salmonella carrying intestinal pathogenic virulence factors or antibiotic resistance genes, which might in turn represent a public health hazard or more specifically cause foodborne illnesses and even outbreak. In addition, the study further demonstrates the food-handlers' hygiene practices and infrastructure facilities of the vendors. The basic food truck observation checklist highlighted food safety risks and ineffectiveness of routine food safety inspections of food trucks. Neither of the sites (residential nor touristic) under study reached 100% adequacy for hygiene or sanitary conditions; however, except for a few food trucks, they were not all considered extremely poor establishments. The main problems found were equipment and utensils in poor hygienic condition, utensils left uncovered, some of the ingredients stored in unsuitable containers, some of the trash cans left open and the presence of insects and some animals (e.g., birds, bugs), chemicals from dust, soot and dirt carried by the wind, all primarily because food trucks are located and operate outdoors. Another important problem was the misuse of gloves; when vendors handle food and money or clean service areas, changing gloves before other activities (switching from handling cash to handling food) was not frequent. This is of particular importance, since hands are important agents when it comes to transmitting microorganisms and intestinal parasites to food (DeForge et al., 2018).

The observation checklist findings that build on earlier studies conducted in developing countries or regions identified the most critical step for potential contamination of street food in other studies (Cortese et al., 2016; Liu et al., 2014; Lucca and da Silva Torres, 2006; Samapundo et al., 2015). Because Orlando is a well-established destination and food truck inspections are guided by strict food regulations by the Orange County Health Department, it can be assumed to a degree that food truck vendors practice more regular personal hygiene (Florida Health, 2018). This being the case, the low adequacy levels observed are chiefly due to the lack of food hygiene knowledge rather than to negligence in taking appropriate precautions. Most vendors or staff working with vendors might never have had required training on the subject of hygiene and sanitation, which is why their food handling practices are insufficient and do not meet the U.S. Food and Drug Administration (FDA) and Florida Health Departments' good food handling standards (Florida Health, 2018; The United States Food and Drug

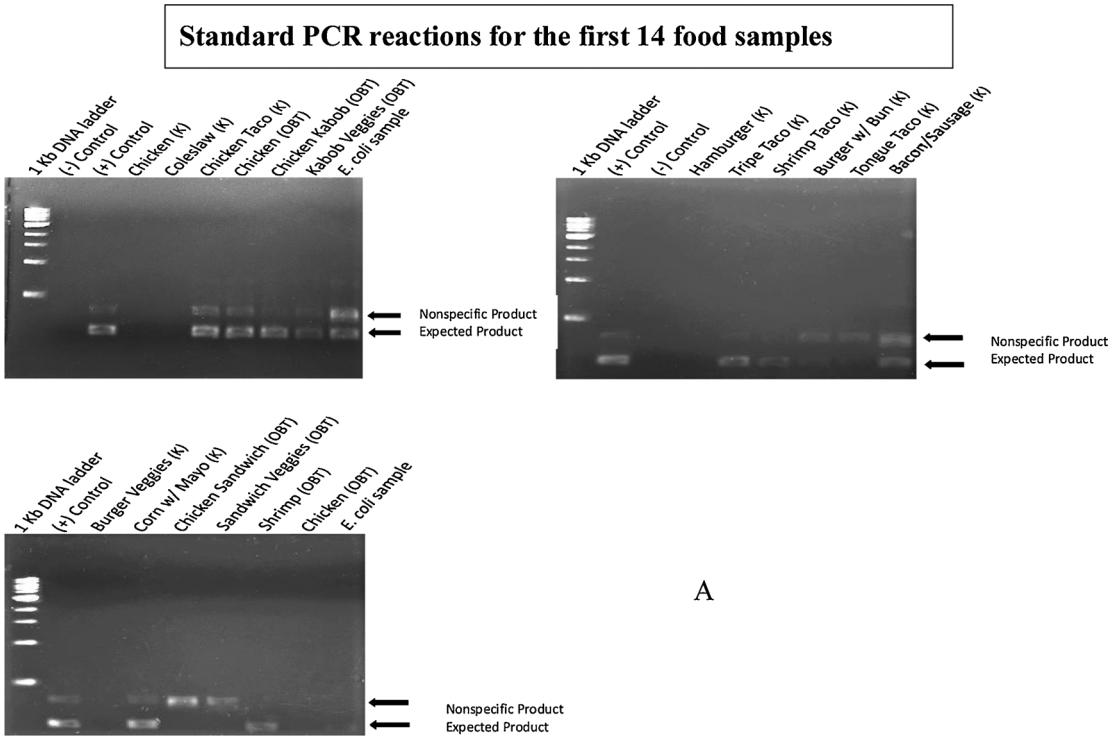


Fig. 1. Screening using standard PCR with primers specific for *E. coli* and *Salmonella*.

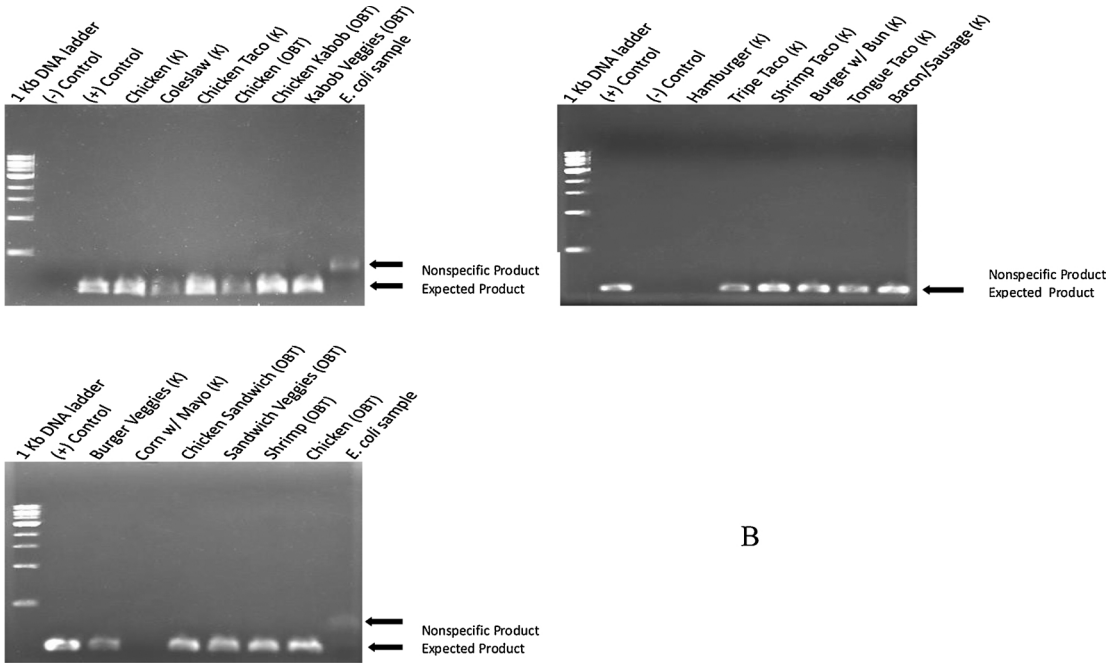


Fig. 1. (*continued*)

Administration, 2018).

Incidence of bacterial pathogens: The study results presented that DNA of some pathogens especially DNA of *E. coli* and *Salmonella enterica* spp. were detected in first 14 out of 30 food samples (Fig. 1, Tables 2 and 3). The DNA of *Salmonella* prevalence was greater in touristic (7 samples out of 14) sites compared with residential/commercial (4 samples out of 14) sites. *E coli*, on the other hand, was detected in only one touristic (Chicken Taco) and 3 residential/commercial (Chicken, Chicken Kabob and Kebob Veggie) samples (total 4 samples out of 30). Although virulence genes associated with diseases from these organisms were mostly absent, DNA prevalence of *E. coli and Salmonella enterica* spp., was identified both in raw and cooked samples. The closest reports from the National Center for Biotechnology Information at the National Library of Medicine were also matches with Table 2.

Standard PCR reactions on samples collected from residential (OBT) and touristic (Kissimmee) sites showed that the amount of pathogenic *Salmonella* and *E. coli* in both raw and cooked food samples was not high enough to be at the detection threshold in the second 16 food samples (Fig. 2). The current study findings are similar to the findings from some developed countries such as Portugal and Korea (Bezerra et al., 2010; Campos et al., 2015; Cho et al., 2011). However, the study results are different from data from developing countries where most of street foods had a poor safety and sanitation standards with the high presence of different pathogens (Manguiat and Fang, 2013; Ramesh et al., 2018; Tabashsum et al., 2013).

Sanitation and food handling practices of food trucks observed by the researchers were not fully satisfactory in both residential/commercial and touristic sites. However, on the other hand, based on the general pathogen detection and pathogen (*Salmonella* and *E. coli*) virulence gene detection, the incidences of foodborne pathogens were found comparatively low and the quality and safety of foods analyzed in this study was considered to be acceptable. In other words, the observed environmental and personal hygiene as well as food preparation practices were inadequate, but pathogen (*Salmonella* and *E. coli*) levels of food analyzed were considered to be acceptable. This finding suggests that the observed food handling risks were reduced with adequate cooking and/or short holding times due to the numbers of customers in both touristic and residential/commercial sites. However, the DNA of bacterial pathogens especially *E. coli* and *Salmonella* were present in both cooked and raw samples and possible foodborne illness and outbreak risks do still exist. This implies that even the minimal errors on food handling practices in both touristic and residential/commercial sites may increase the amount of the pathogens and create food borne illness and outbreak anytime. Although food hygiene practices in developed countries are more advanced than in developing countries (Okumus and Sonmez, 2018), the current study justifies that there is

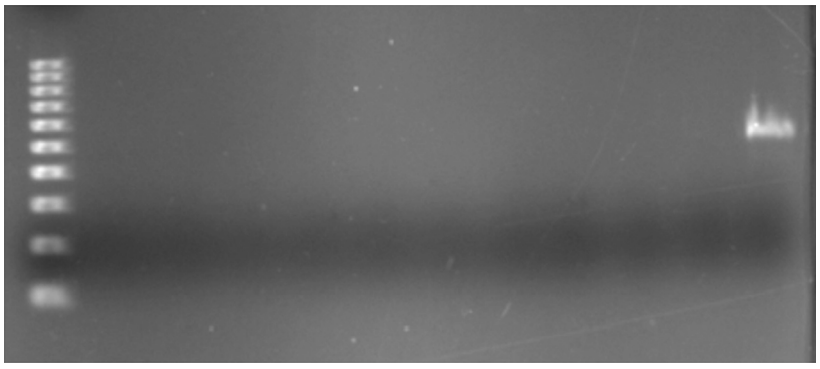


Fig. 2. Standard PCR reactions for the second 15 food samples from touristic (Kissimmee) and residential (OBT) site.

still safety risks and gaps and these risks primarily occur due to lack of sanitation and awareness among food truck vendors. For that reason, county health departments and food inspectors can improve current practices by providing bilingual food truck vendor training, mystery shopping programs, reward programs to vendors, vendor education and/or certification programs, random day and night time food inspections and ongoing monitoring.

Consumers' viewpoints and acts are also important to minimize the safety risks. Their social and geographical origins largely determine their acceptance and reaction to foods, whether clean or not, and this point is generally neglected in the literature (Marras, 2014). Although, consumers' complaints and comments are usually considered as a negative reflection of the business, the comments may provide useful information for authorities and food truck owners that they can use such comments to their advantage. However, many consumers consider that the authorities do not care their comments and will not take any action, if they provide the issues and the concerns. Therefore, consumers should be encouraged to report such cases directly to health departments and to share their experiences and concerns on their social media platforms. If consumers realize that the link of the communication are actually open, they will not ignore reporting the issues so such cases can be effectively addressed by county health departments. Finally, reviewing food truck-related online social media websites can assist county health departments to improve their action plans and inspections.

6. Limitations and future research

The study highlighted the need for additional studies of food trucks and their possible risk for foodborne illnesses in this sector. Although this study provides several implications for street food and food safety literature, it is subject to several limitations. For instance, the sample of the study consisted of licensed food trucks located in well-established parts of the city of Orlando, Florida. Future research may include unlicensed food trucks since these trucks can easily escape food inspections due to their mobility. In addition, future research can examine additional factors such as chemical loads of the samples and cooking utensils and it can be analyzed in both licensed and unlicensed food trucks to show possible health risks.

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