Assessment of the microbiological quality of popular food items on sale in secondary school canteens of Mauritius

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Abstract

This study was carried out to assess the microbiological status of three hot meals served in eight selected school canteens of Mauritius, with two schools randomly selected from each of the four school zones of the island. Three individual samples of farata, panini, or fried noodles were collected at each school during two independent visits. The three individual samples of each food type collected during each visit were then pooled before being subjected to microbiological analyses. A total of 48 composite samples were analyzed. The parameters tested were Total Viable Count (TVC), *Escherichia coli*, *Salmonella* spp., *Clostridium perfringens*, *Staphylococcus aureus*, and *Listeria* spp. The microbiological analyses revealed that paninis were deemed as generally acceptable with TVC falling in the range of 3.0-5.7 Log CFU/g and undetectable levels of *S. aureus* and *E. coli*. In contrast, fried noodles and faratas harboured a moderately high level of TVC (4.4-6.7 Log CFU/g) and objectionably high levels *S. aureus* (3.1 to 5.0 Log CFU/g) and *E. coli* (3.1-5.1 Log CFU/g) for seven out of the eight schools.

Introduction

Food is an important basic necessity; it is a critical contributor to the physical well-being and its procurement, preparation, and consumption are vital for sustenance of life. However, infectious diseases that spread through food vehicles are common and can result in appreciable morbidity and occasionally in death (Scharff *et al.*, 2009; Tomohide, 2010) According to the Centers for Disease Control and Prevention (CDC), bacterial agents such as *Salmonella* spp., *Escherichia coli*, *Campylobacter* spp., *Shigella* spp., *Listeria* spp., and *Vibrio* spp. have been implicated in foodborne diseases (CDC, 2009). Ready-to-eat foods (RTE) have been found to be highly contaminated with various pathogens such as *E. coli* and *S. aureus* (Edema and Omemu, 2004). These bacteria can survive on hands and surfaces and eventually become transferred to food (Lues and Van Tonder, 2007). Although foodborne disease is a matter of concern for the general public, it is a particularly high concern for school children for whom foodborne infections can be life threatening (Hayes *et al.,* 2003). Indeed, school children are one of the most susceptible population groups. It is therefore not surprising that foodborne illnesses are more concentrated in schools and institutions rather than in the general community (Meftahuddin, 2002; Soon *et al.,* 2011). From 1990s until today, foodborne disease outbreaks have predominantly occurred in schools (62%) and academic institutions (17%) and a much smaller proportion (8%) in community gatherings in Malaysia (Soon *et al.,* 2011). An in-depth analysis of food poisoning cases in Mauritius revealed that the distribution of food poisoning reported to the Ministry of Health and Quality of Life (MoHQL) was skewed towards individuals in the lower age group of 10-19 (28.2%) and 20-29 (22.4%) (MoHQL, 2014). Many students attending secondary schools regularly purchase RTE hot foods at school canteens. In addition to being nutritious, these RTE hot foods also need to be safe and hygienic. The contamination of RTE foods, even with low levels of *S. aureus*, *Bacillus cereus*, or *Clostridium perfringens*, can compromise the health of the general population due to pre-formed heat-stable enterotoxins in the food. Low levels may be due to natural contamination of raw materials used in the preparation of those foods, but usually their presence suggests faults in the production or subsequent handling of food, which could lead to an unacceptable increase in risk. Enumeration and/or detection of foodborne pathogenic agents at any level is of concern and should thus be investigated with an urgency of response proportionate to the level of contamination and risk to consumers. The objectives of this study were therefore to determine the microbiological and hygienic status of three popular hot meals, namely farata (Indian flatbread), panini, and fried noodles served in secondary school canteens of Mauritius.

Materials and Methods

A total of eight schools were approached during two independent visits for sample collection, with two schools randomly selected from each of the four school zones of Mauritius. Three individual samples of each of farata, panini, and fried noodles were collected during each visit at each school and were aseptically transported to the laboratory in a chilled cooler bag for analysis. The three individual samples of each food type originating from the same batch of preparation were then pooled to form one composite sample. A total of 48 composite samples were analyzed, with 16 composites for each food type. 25g of each pooled sample was aseptically weighed and transferred to a stomacher bag to which 225 mL of sterile 0.1% buffered peptone water was added. The sample was blended for two minutes at 230 RPM in a stomacher to produce a homogeneous sample, which was then diluted in 0.1% sterile Buffered Peptone water to achieve a 10-fold dilution series. Enumerations of TVC, *S. aureus*, *C. perfringens, Listeria monocytogenes*, and *E. coli* were done by plating appropriate dilutions on Plate Count agar (ISO 4833:2003), Baird Parker agar (ISO 6888-1:1999), Iron Sulphite agar (ISO

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15213:2003), PALCAM agar (Pinto et al., 2001) and Eosin Methylene Blue agar (Bello *et al.*, 2011) respectively. Detection of *Salmonella* was carried out by enrichment of samples followed by streaking on Xylose Lysine Deoxycholate agar (ISO 6579:2002). The inoculated plates were then incubated at 35°C for 48 hours. Where appropriate, data were analyzed using Minitab® Release 17. A single factor analysis of variance (ANOVA) and Tukey's one-way multiple comparisons were conducted to determine differences in the population means of the different bacterial species. Significant differences were considered at the 95% confidence level (P<0.05).

Results and Discussion

Table 1 compares the microbiological profile of different RTE food items (farata, panini, and fried noodles) sold in secondary school canteens. Mean population density of mesophilic aerobic bacteria, *E. coli* and *S. aureus* ranged from 4.7-6.7, 3.4-5.1, <2-5.0 Log CFU/g for faratas, 3.0-5.7, <2, <2 Log CFU/g for panini and 4.4-6.7, <2-4.1, <2-4.2 Log CFU/g for noodles respectively, highlighting their variable microbiological quality. No significant difference (P>0.05) was observed in the TVC load of faratas except for faratas from one school canteen (Canteen E), which had a significantly lower TVC carriage of 4.7 Log CFU/g. With regard to panini, the quality of the product sold at school D was inferior to that of the 7 other schools due to a significantly higher TVC carriage (P<0.05) of 6.7 Log CFU/g. No significant difference (P>0.05) was observed among the different schools as far as the general microbiological quality of noodles is concerned. ICMSF (1996) states that RTE foods with TVC falling in the range of 0-10^3 CFU/g (0-3 Log CFU/g), 10^4-10^5 CFU/g (4-5 Log CFU/g) and >10^6 CFU/g (or ≥6 Log CFU/g) are considered acceptable, marginally acceptable (tolerable), or unacceptable respectively. On the other hand, the Mauritius Food Regulations (MoHQL, 1999) and New Zealand Food Regulations (1984) are more stringent stating that RTE foods with TVC exceeding 10^5 CFU/g are of objectionable quality and therefore unfit for consumption. Based on the microbiological standards used, faratas and fried noodles sold at several canteens were deemed unacceptable for sale.

A recent study (Fon *et al.,* 2016) showed that noodles sold in retail outlets of Mauritius harboured relatively high levels of mesophilic aerobes as well as spoilage and pathogenic bacteria making them fairly perishable. It is therefore not surprising that noodles have been recurrently incriminated in food poisoning incidents in Mauritius with an incidence rate of 17.2% (Fon *et al.,* 2016). Furthermore, it was reported that 19% of all food poisoning incidents occurred in educational institutions, implicating foods such as noodles and faratas (Hotee, 2011). Fried noodles are notorious for being prepared in advance, stored uncovered at room temperature for long hours coupled with poor personal hygiene (Ghaffar *et al.*, 2009). Faratas are manually handled extensively with its curry filling cooked in large batches. Factors such as the slow cooling of the curry, subsequent exposure to contaminants via food handlers, utensils, the environment, and the rich medium contribute to the increased microbial loads of the samples (Abdussalam and Käferstein, 1993). The moderate to high TVC counts of the different food items can also be explained by the fact that they comprise of sliced ingredients such as sliced chicken and tomatoes in panini and sliced green beans and carrots in fried noodles. Cross-contamination could likely occur via equipment (i.e. slicer, knives and/or chopping boards) contributing to the high population of mesophilic aerobes. A stringent hygienic practice during manipulation of ingredients is thus necessary during the preparation of these products (Kotzekidou, 2013). Although panini purchased from most schools harboured TVC in the range of 3-4 Log CFU/g, one school had a significantly (P<0.05) higher TVC count of 5.7 Log CFU/g. High aerobic counts alone do not make a food unsafe but do indicate poor handling, storage, or inadequate general hygiene (Gillespie *et al.,* 2000). The occasionally poor microbiological status of panini noted in this study could partly be attributed to poor temperature control. In fact, Kotzekidou (2013) noted a fairly high level of mesophilic aerobes exceeding 8 Log CFU/g in sandwiches stored at ambient temperatures. Similarly, considerably higher aerobic plate counts (10^9 CFU/g) were observed for filled baguettes from retail delicatessens in South Africa sold at room temperature (Christison *et al.,* 2008). For this reason, it is recommended that sandwiches be retailed at 5°C and never higher than 8°C (BSA, 2015). Better temperature control needs to be enforced in retail points at schools since these chicken panini are typically sold at ambient temperatures. Moreover, these are left exposed to air and are not properly covered, thereby encouraging the growth of mesophilic aerobic bacteria to unacceptable levels.

S. aureus counts ranged from <2-5.0, <2, and <2-4.2 Log CFU/g for faratas, panini, and fried noodles respectively. *S. aureus* was recovered from faratas from four schools and fried noodles from two schools at a level falling in the range of 4-5 Log CFU/g. According to the Mauritius Food Regulations (MoHQL, 1999), the maximum tolerable level of *S. aureus* in food is 2 Log CFU/g thus, rendering faratas and fried noodles unfit for consumption on many instances. Soriano *et al.* (2002) recovered *S. aureus* from 11.1% of university cafeteria meals at levels ranging from 2-4.7 Log CFU/g (Soriano *et al.*, 2002). Similarly,

Table 1. Comparative bacterial population density of three main course meals from eight schools.

School code	Farata			Panini			Fried Noodles		
	TVC	*E. coli*	*S. aureus*	TVC	*E. coli*	*S. aureus*	TVC	*E. coli*	*S. aureus*
A	6.5±0.6^{ab}	4.9±0.5^{ab}	3.3±0.5^{ab}	3.8±0.6^{b}	<2.0±0.0^{b}	< 2.0±0.0^{a}	5.2±0.5^{a}	3.5±0.4^{a}	<2.0±0.0^{b}
B	6.7±0.5^{a}	3.4±0.5^{b}	4.1±0.6^{ab}	3.7±0.9^{b}	< 2.0±0.0^{b}	< 2.0±0.0^{a}	6.3±0.7^{a}	3.1±0.3^{a}	4.1±0.7^{a}
C	6.7±0.5^{a}	3.7±0.4^{ab}	< 2.0±0.0^{b}	3.8±0.3^{b}	< 2.0±0.0^{b}	< 2.0±0.0^{a}	6.7±0.4^{a}	< 2.0±0.0^{ab}	3.6±0.3^{a}
D	6.7±0.5^{a}	3.4±0.6^{ab}	3.6±0.8^{ab}	5.7±0.7^{a}	3.9±0.3^{a}	< 2.0±0.0^{a}	5.1±0.4^{a}	3.6±0.8^{a}	<2.0±0.0^{b}
E	4.7±0.9^{b}	3.4±0.5^{b}	3.6±0.8^{ab}	3.0±0.0^{b}	< 2.0±0.0^{b}	< 2.0±0.0^{a}	4.8±2.1^{a}	3.7±0.8^{a}	3.5±0.7^{a}
F	6.7±0.5^{a}	4.5±0.5^{ab}	4.4±0.5^{ab}	4.0±1.2^{ab}	< 2.0±0.0^{b}	< 2.0±0.0^{a}	6.1±0.4^{a}	3.2±0.3^{a}	<2.0±0.0^{b}
G	6.5±0.4^{a}	5.1±1.5^{a}	5.0±1.7^{a}	3.0±0.0^{b}	< 2.0±0.0^{b}	< 2.0±0.0^{a}	5.6±1.0^{a}	4.1±2.0^{a}	4.2±0.5^{a}
H	6.7±0.4^{a}	4.5±0.4^{ab}	4.1±0.6^{ab}	3.7±0.9^{b}	< 2.0±0.0^{b}	< 2.0±0.0^{a}	4.4±1.8^{a}	3.3±0.6^{a}	3.1±0.2^{a}

TVC, Total Viable Count; ^{a,b,ab}values having a common letter are not significantly different at P-level=5%. A lettering system was used to determine if there was any significant school-to-school difference within each product category. <2 Log CFU/g represents the limit of detection of the plating methodology.

Kotzekidou (2013) recovered *S. aureus* from 11% of sandwiches with counts between 2-4 Log CFU/g (Kotzekidou, 2013). The Food and Drug Administration has established that effective doses of staphylococcal enterotoxins are usually elaborated when populations of *S. aureus* attain a population density of >5 Log CFU/g at pH close to neutrality (Cornu and Rosset, 2004). Only faratas purchased at one out of eight schools was found to harbour *S. aureus* at a level enough to cause staphylococcal intoxication. Although this level was not exceeded in the other food items, the presence of *S. aureus* is suggestive of possible cross-contamination between the food handler and the food. The primary reservoir of *S. aureus* is the human nasal cavity with 30% of adults harbouring this organism permanently and 50% intermittently (Wertheim *et al.,* 2005). Indeed, Hatakka *et al.* (2000) and El-Scherbeeny *et al.* (1985) isolated *S. aureus* from the nose, throat, hands and nail samples of food handling personnel and further demonstrated the potential for the pathogen to spread from the nose to the skin, hands and the environment. Bankolé *et al.* (2012) indicated that one sneeze is enough to propel billions of microorganisms in the environment. Under favourable conditions of temperature and relative humidity and considering that 20 minutes is enough for one generation of bacterial cell division (Cornu and Rosset, 2004), bacteria can multiply to potentially hazardous levels within a short timeframe. Hence, it can be inferred that methods of food handling by vendors from preparation to sale can provide multiple routes of bacterial transference as well as potential for pathogen growth in the food sold. The population density of *E. coli* of the different food items ranged from 3.4-5.1, <2-3.9, and <2-4.1 Log CFU/g for faratas, panini, and fried noodles respectively. *E. coli* was undetectable (by plating) in panini in all schools except for one canteen where a mean population of 2.6 Log CFU/g was recorded. According to the New Zealand Food Regulations (1984), the maximum allowable level of *E. coli* in RTE foods is 2 Log CFU/g. This level was clearly exceeded in almost all faratas and fried noodles samples analyzed. The frequency with which *E. coli*, a member of the *Enterobacteriaceae* family, was isolated in this study (67%) is higher than the level of enterobacteria observed by El-Scherbeeny *et al.* (1985) in street-vended foods in Egypt (Bankolé *et al.,* 2012). *E. coli* could have likely originated from hands of workers, which is indicative of poor compliance with the code of hygienic practices (Mirabaud, 2003) and, like other coliforms, may increase due to thermal abuse. Dougnon *et al.* (2012) in fact conducted a survey and confirmed the role of feces as one of the main sources of microorganisms in food (Dougnon *et al.,* 2002).

L. monocytogenes, *Salmonella*, and *C. perfringens* were undetected in all of the food samples during both sampling rounds. *L. monocytogenes* is a ubiquitous geophilic (environmental) pathogen often found on food processing equipment. Cross-contamination of RTE food by *L. monocytogenes* has in the past resulted in outbreaks of listeriosis and major product recalls in other countries (Lin *et al.*, 2006). This is because listeriae can survive on processing equipment, such as meat slicers, which serve as a potential contamination source. Contrary to our findings, other studies have revealed that ingredients of sandwiches such as salad vegetables and sliced meat products harboured *L. monocytogenes* at varying frequencies (5-9%), thus making sandwiches a high-risk food (Guerra *et al.,* 2001). The absence *Listeria* spp. in the food items tested probably suggests that utensils and kitchenware were regularly cleaned and sanitized. *Salmonella* and *C. perfringens* rank among the top five most important foodborne pathogens in many countries (Scallan *et al.*, 2011). *Salmonella* is mostly transmitted from animals to man through consumption of foods of animal origin and is thus classified as a zoonotic pathogen. Non-typhoidal salmonellosis (enteritis) is usually self-limiting but can occasionally engender complications such as bacteraemia. *C. perfringens* occurs naturally in the intestines of animals as well as in environmental niches such as soil and water; making it therefore a "zoonotic" and "geonotic" pathogen. Our findings indicated the absence of *Salmonella* and *C. perfringens* in chicken panini and curry-filled faratas although these pathogens have been previously isolated from chicken sandwiches and gravies respectively (Mason *et al.*, 2001; Moore *et al.*, 2003). This is in contrast with findings of Christison *et al.* (2008) who isolated *Salmonella* at a frequency of 17.5% from filled baguettes sold at retail delicatessens in South Africa and Bankolé *et al.* (2012) who observed the presence of sulphite-reducing clostridia in school canteen meals (Scallan *et al.*, 2011).

It is worthwhile mentioning that these microbiological investigations were carried out in winter during the period of August to September 2014. Since foodborne infections are usually more widespread and frequent in summer (Doyle, 1984), it is anticipated that the microbiological status of these RTE items would be poorer during summer months (November-April) due to the higher prevailing temperatures. This is congruent with the official statistics of the Ministry of Health and Quality of Life (MoHQL, 2013), which have previously highlighted notification of more cases of food poisoning in the months of November and December affecting people of the young age group of 10-19 years old (*i.e.* secondary school students).

Conclusions

Canteen RTE food items, such as faratas, panini, and fried noodles are popular food commodities among Mauritian school children owing to their convenience, affordability, taste, and wholesomeness. Panini sampled from all schools were found to have a satisfactory microbiological and sanitary quality. However, microbiological analyses of faratas sampled from eight random secondary schools indicated the presence of moderately high levels of mesophilic aerobic bacteria, moderate levels of foodborne pathogen *S. aureus* and unacceptably high levels of fecal indicator *E. coli* when compared with published microbiological criteria used for RTE foods. Fried noodles purchased from the eight different canteens also often harboured objectionably high levels of *S. aureus.* This probably reflects the inadequate personal hygiene of canteen workers since the preparation of fried noodles and faratas involves extensive manual manipulation of the ingredients. The poor microbiological quality could also be attributed to the use of contaminated raw materials, cross-contamination during preparation, improper handling and/or conservation. Overall, the findings point out that general principles of good manufacturing practices and food hygiene as well as temperature control should be enforced. Maintenance of correct refrigeration is also fundamental for the safety of these foods and should not be underrated.

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