MICROBIOLOGICAL ASSESSMENT OF NOODLES SOLD AT RAMADAN BAZAAR IN KUCHING, SARAWAK, MALAYSIA

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ABSTRACT. *The Ramadan bazaar offers a diverse array of food for numerous customers during the month of Ramadan; however, the rising incidence of food poisoning raises concerns about the microbiological safety of these foods. This study aims to evaluate the microbial quality of various noodle types sold at the Ramadan bazaar in Kuching, Sarawak. A total of thirty-three (33) samples were collected from different sites and analyzed for Aerobic Plate Count, coliform bacteria, Escherichia coli, Staphylococcus aureus, Bacillus cereus, and Salmonella spp. Among the samples tested, 88%, 3%, 21%, 6%, and 16% exceeded acceptable limits for APC, coliforms, E. coli, S. aureus, and B. cereus, respectively, while all samples tested negative for Salmonella spp. Additionally, local specialties such as laksa Sarawak, kolo mee, and mee Jawa showed the highest levels of contamination with E. coli, S. aureus, and B. cereus. The presence of these microorganisms indicates cross-contamination likely due to insufficient hygiene practices before and after the cooking process.*

KEYWORDS: Food safety, noodles, microbiological quality, Ramadan bazaar, street food.

INTRODUCTION

The Ramadan bazaar in Malaysia is an annual event that takes place throughout the month of Ramadan. It features a diverse selection of food, ranging from drinks to main courses. Each state in Malaysia showcases unique dishes at their Ramadan bazaars that reflect the local culture, all at affordable prices accessible to all age groups and socioeconomic classes. For instance, Sarawak is renowned for its delicious noodle dishes such as *laksa Sarawak*, *kolo mee*, and *mee jawa*, which can be found at every Ramadan bazaar.

While the food at the Ramadan bazaar is a popular choice, it has often been associated with foodborne illnesses. The food offered is typically ready-to-eat and sold as takeout, intended for immediate consumption or for breaking the fast. Several factors can contribute to the contamination of food at these bazaars, leading to potential foodborne illnesses. Key issues include poor hygiene practices among food handlers, cross-contamination, and improper time and temperature management during food storage. In 2023, the Malaysian Ministry of Health issued 2,188 notices during inspections of 51,849 Ramadan bazaar locations across 640 areas nationwide. Violations included failure to complete food handler training, lack of anti-typhoid vaccinations, and non-compliance with food handler attire requirements. There were also 17 complaints related to food safety at the Ramadan bazaars, but only two reports of food poisoning were associated with food purchased at these events (The Sun, 2023).

Additionally, food samples from the Ramadan bazaar were examined for microbial contamination. The Kelantan State Health Department reported that one sample contained *S. aureus* in duck egg curry, while chicken-based dishes were found to have *Salmonella spp*. (Berita Harian, 2022). Furthermore, Mat Zin *et al*. (2017) conducted a microbiological analysis of meat samples at the Ramadan bazaar in Kelantan, Malaysia, which yielded unsatisfactory results for coliforms, *Staphylococcus spp*., *E. coli*, and *Salmonella spp*. Moreover, in October 2023, a food handler at a Ramadan bazaar in Limbang, Sarawak, was fined RM1,000 for selling food contaminated with pathogenic bacteria during last Ramadan (Utusan Borneo, 2023). Although there have been no reported cases of food poisoning associated with food and drinks sold at Ramadan bazaar stalls across Sarawak, there remains a risk of contamination with pathogenic bacteria, as evidenced by the situation in Limbang. Abdul-Mutalib *et al*. (2015) noted that foodborne diseases are prevalent in Malaysia, yet not all cases are reported, particularly less severe ones. Thus, this study aims to assess the microbial quality of noodle delicacies sold at the Ramadan bazaar in Kuching, Sarawak. Given the popularity of noodles among consumers in Sarawak and their potential for contamination, this research focuses specifically on noodles. The findings of this study may provide valuable insights for regulatory agencies to take appropriate action in the future.

MATERIALS AND METHOD

2.1 Sample Collection and Preparation

The sampling activities took place at six Ramadan bazaars across three locations in Kuching, Sarawak, Malaysia: Kuching North (18 samples), Kuching South (5 samples), and Padawan (10 samples). During the month of Ramadan, a total of 33 samples, representing eight types of noodles (see Figure 1), were collected aseptically for laboratory analysis. Each sample was assigned a serial number, transported in a cool box, and maintained at a temperature of 4 °C. The samples were either examined immediately or stored in a refrigerator to be tested within 24 hours of collection. All analyses were conducted in accordance with standard methods, assessing the samples for APC, coliforms, *E. coli*, *S. aureus*, *B. cereus*, and *Salmonella spp*

Figure 1: Types of noodles collected from the Ramadan bazaar in Kuching, Sarawak.

2.2 Microbiological analysis

A 10-fold serial dilution was carried out on the homogenized samples. Following this, 1 mL of each appropriate dilution was plated in triplicate on the selected media. This study utilized five standard methods for microbiological analysis: (1) AOAC International Official Method 990.12:2002 for Aerobic Count Plate (AOAC, 2002a), (2) AOAC International Official Method 991.14:2002 for Coliform and *E. coli* Plate (AOAC, 2002b), (3) AOAC International Official Method 2003.07 for Staph Express Count Plate (AOAC, 2003), (4) ISO 7932:2004 (E), which describes the horizontal method for the enumeration of presumptive *B. cereus* using the colony-count technique at 30°C, and (5) ISO 6579:2002 (E), detailing the horizontal method for detecting *Salmonella spp*. The contamination levels of APC, coliforms, *E. coli*, *S. aureus, B. cereus*, and *Salmonella spp*. were assessed against the standards set by the Food Standards Australia New Zealand (FSANZ) Compendium of Microbiological Criteria for Food (2022).

2.3 Statistical Analysis

All statistical analyses were conducted using IBM's Statistical Package for Social Sciences (SPSS), Version 26. Descriptive statistics were employed to assess the quantities of aerobic plate count (APC), coliforms, *E. coli, S. aureus, B. cereus, and Salmonella spp.* present in the food items sold at the Ramadan bazaar in Kuching, Sarawak, Malaysia. This analysis aimed to provide a comprehensive overview of the microbial contamination levels in the food products, contributing valuable insights into food safety and public health at the bazaar.

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RESULTS AND DISCUSSION

3.1 Microbiological Count

The bacterial counts, including aerobic plate count (APC), coliforms, *E. coli, S. aureus*, and B. *cereus* in the noodles sold at the Ramadan bazaar in Kuching, are detailed in Table 1. Samples collected from the Ramadan bazaar in Kuching North exhibited the highest levels of APC, coliforms, *E. coli*, and *S. aureus* contamination, with mean values of 5.188 ± 0.445 log CFU/g, 4.246 ± 0.695 log CFU/g, 2.343 ± 0.910 log CFU/g, and 2.205 ± 0.489 log CFU/g, respectively. In contrast, samples from the Ramadan bazaar in Padawan recorded the highest contamination of B. cereus, with a mean value of 3.156 ± 0.848 log CFU/g. Notably, Salmonella spp. was absent in all noodle samples analyzed during this study.

Bacterial loads can vary significantly from one location to another due to a range of factors, including environmental conditions and hygiene practices (Amare *et al*., 2019; Nguendo, 2018). In this instance, the Ramadan bazaar in Kuching South is equipped with adequate handwashing facilities, whereas both Kuching North and Padawan only have a single water source available at each bazaar. This limitation often forces food handlers to retrieve water in buckets or large bottles for handwashing and utensil cleaning, hindering proper hygiene practices. Additionally, it is noteworthy that most food handlers were observed using bare hands when preparing food, which could contribute to cross-contamination.

The presence of APC in all samples, with an overall mean value of 5.035 ± 0.622 log CFU/g, indicates that the noodles sold at the Ramadan bazaar in Kuching, Sarawak, were contaminated with various pathogens. APC is utilized to assess the overall bacterial contamination levels in food and beverage samples, reflecting hygiene and sanitation conditions at the point of sale, as documented by Mohd Nawawee *et al*. (2019) and Salamandane *et al*. (2021). It serves as a valuable tool for monitoring food handling processes, and its results can reveal the cleanliness of food preparation and storage practices (Upadhyaya *et al*., 2017). Furthermore, food items with elevated APC levels are deemed potentially harmful, even in the absence of identified pathogens (Reda *et al*., 2017). Hence, these findings clearly indicate that the noodles sold at the Ramadan bazaar in Kuching, Sarawak, are prepared under inadequate hygiene practices by food handlers.

In this study, coliform bacteria were detected in all samples, yielding a total mean value of 3.974 ± 0.763 log CFU/g. While coliforms are generally harmless to humans, they can occasionally be associated with serious waterborne diseases (Thi *et al*., 2021). The water used for food preparation and utensil cleaning can be a potential contamination source, as food handlers often recycle water for washing and cleaning purposes. As a subgroup of fecal coliform, *E. coli* serves as an indicator of sanitary conditions (Reda *et al*., 2017) and was present across all locations in this study. The mean *E. co*li count observed is consistent with previous research conducted by Mumu et al. (2021), which reported *E. coli* levels in noodles from street food carts ranging between 102 CFU/g to 103 CFU/g. Additionally, *E. coli* was isolated in noodles by Tamilnila *et al*. (2018) and Siddabathuni (2019). The presence of *E. coli* in food suggests either inadequate heat processing or fecal contamination resulting from poor hygiene practices among food handlers (Amare *et al*., 2019).

S. aureus, the most found pathogen on hands (Amare *et al*., 2019; Woh *et al*., 2017), was also detected in this study, indicating cross-contamination likely due to insufficient hand washing practices by food handlers. The washing of hands and utensils was identified as a significant risk factor, especially as food handlers often store water for cleaning in buckets due to the distance from the vending site to the water source. The repeated use of this water can elevate the risk of cross-contamination, resulting in pathogen transfer to food products (Birgen *et al*., 2020). Similarly, S. aureus has been found in noodles by Tamilnila *et al*. (2018) and Siddabathuni (2019), although Mumu *et al*. (2021) reported no S. aureus contamination in noodles, instead isolating other bacteria such as Klebsiella spp. and Pseudomonas spp. Other studies have documented the presence of S. aureus in cooked foods, including meat, rice, and fried snacks (Birgen *et al*., 2020; Vadesh & Neel, 2017; Abd Rahim *et al*., 2019).

Previous research has shown that *B. cereus* is also present in various food items, such as cooked rice and fried snacks (Saba *et al*., 2019; Fahani et al., 2019; Khasnabis *et al*., 2017). In the current study, *B. cereus* was detected in 21% of the samples, with a total mean value of 3.276 ± 0.837 log CFU/g; however, it was absent from samples taken at the Ramadan bazaar in Kuching South. *B. cereus* is a gram-positive, endospore-forming, motile rod-shaped bacterium commonly found in food and soil, and it produces two types of toxins (Yeo *et al*., 2018). According to Fahani *et al*. (2019), leftover food stored in refrigeration for sale the following day can promote toxin formation, leading to food poisoning.

Importantly, no *Salmonella spp*. was detected in any of the noodle samples from the Ramadan bazaar in Kuching, Sarawak. This finding aligns with Mumu *et al*. (2021), which similarly found no *Salmonella spp*. in noodles sampled in Dhaka City, India. Additionally, it corroborates Salamandane *et al*. (2021), who noted that *Salmonella spp*. is rarely found in cooked foods but is often present in street foods due to post-contamination. However, Tamilnila *et al*. (2018) reported potential *Salmonella spp*. contamination in street food noodles in Thanjavur City, India, attributed to poor environmental conditions.

Table 1: Microbiological counts of APC, coliform, *E. coli, S. aureus, B. cereus* and *Salmonella* spp. in noodles at Ramadan bazaar in Kuching, Sarawak.

Parameter	District	N[1](%)	Mean[2]	SD
APC	Kuching North	18 (100)	5.188	0.445
	Kuching South	5 (100)	4.798	0.944
	Padawan	10 (100)	4.880	0.709
	Total	33 (100)	5.035	0.622
Coliform	Kuching North	18 (100)	4.246	0.695
	Kuching South	5 (100)	3.193	0.478
	Padawan	10 (100)	3.877	0.750
	Total	33 (100)	3.974	0.763

E. coli	Kuching North	7 (39)	2.343	0.910
	Kuching South	1 (20)	2.491	.
	Padawan	1 (10)	2.204	.
	Total	9 (27)	2.344	0.791
S. aureus	Kuching North	13 (72)	2.205	0.489
	Kuching South	4 (80)	2.251	0.169
	Padawan	4 (40)	3.147	0.584
	Total	21 (64)	2.393	0.583
B. cereus	Kuching North	1 (6)	4.000	.
	Kuching South	0(0)	.	.
	Padawan	6 (60)	3.156	0.848
	Total	7 (21)	3.276	0.837
Salmonella spp.	Kuching North	0(0)	.	.
	Kuching South	0(0)	.	.
	Padawan	0(0)	.	.
	Total	0(0)	.	.

[1]Number of positive samples

[2]Mean bacterial counts expressed in Log (CFU/g), SD: standard deviation

3.2 Comparison of Bacterial Count with Microbiology Standard

Table 2 illustrates the contamination levels of APC, coliforms, *E. coli, S. aureus*, *B. cereus*, and *Salmonella spp*. in noodles, in comparison with the Food Standards Australia New Zealand (FSANZ) Compendium of Microbiological Criteria for Food (2022). Based on the results, 12% of the total samples were classified as marginal, while 88% were rated as unsatisfactory for APC contamination. The elevated bacterial counts in the noodles may be attributed to the addition of gravy and condiments, such as chopped spring onions and chilies, after the cooking process. Previous studies have also reported high levels of APC contamination exceeding 5.0 Log CFU/g in various food types, including cooked meats, fried snacks, vegetables, and beverages (Mehboob & Abbas, 2019; Mohd Nawawee *et al*., 2019; Alem *et al*., 2020; Thi *et al*., 2021).

In terms of coliform contamination, 97% of the samples were found to fall within the marginal range, while only 3% were deemed unsatisfactory. This finding contradicts several studies that have indicated a high prevalence of unsatisfactory coliform levels in various foods, such as sandwiches, beverages, cooked rice, and fried snacks (Mohd Nawawee *et al*., 2019; Abd Rahim *et al*., 2019; Salamandane *et al*., 2021). As noted by Mohd Nawawee *et al*. (2019), the presence of these bacteria may result from direct contact with the hands or bodies of food handlers or from the

use of unboiled water during food preparation. Furthermore, a significant presence of coliforms in food is indicative of unsanitary conditions during processing, handling, distribution, and post-handling contamination (Abd Rahim *et al.*, 2019).

Regarding *E. coli* contamination, 73% of the samples were considered satisfactory, with 6% at a marginal level and 21% classified as unsatisfactory. Abd Rahim *et al.* (2019) reported that only two samples in their research were contaminated with *E. coli*, and both exceeded acceptable standards. The main factors contributing to *E. coli* contamination in their samples were identified as food handlers failing to adhere to proper hygiene practices, such as washing their hands after using the restroom and before handling food. Mumu *et al.* (2021) indicated that *E. coli* counts exceeding permitted food safety standards suggest that many food handlers do not practice appropriate food handling measures, including smoking while working and serving food without gloves or protective coverings for hair and masks. Additionally, a lack of consistent supervision by relevant food safety authorities contributes to the non-compliance of food safety practices among food handlers.

For *S. aureus* contamination, nearly half of the samples achieved satisfactory levels (46%), while 48% were at a marginal level, and only 6% were rated as unsatisfactory. A study by Abd Rahim *et al.* (2019) found that 33% of samples sold in Chow Kit, Kuala Lumpur, were contaminated with *S. aureus*, with mean values surpassing 4 Log CFU/g. Moreover, Afreen et al. (2019) reported that 100% of street drinks tested were classified as unsatisfactory for S. aureus contamination, identifying several risk factors associated with *S. aureus*, including the type of juice, vending location, water source, food covering, serving food with bare hands, and the cleaning of utensils. In this study, 79% of the total samples for *B. cereus* contamination were satisfactory, followed by 6% at a marginal level and 16% that were unsatisfactory. A study conducted in Ghana by Saba *et al.* (2019) reported a higher prevalence of unsatisfactory food samples from enclosed vendors, with fried rice having the highest incidence of unsatisfactory results.

Table 2: Level of contamination level for APC, coliform, *E. coli, S. aureus, B. cereus* and *Salmonella* spp. in noodles at Ramadan bazaar in Kuching, Sarawak.

Parameter	No. of Satisfactory Samples (%)	No. of Marginal Samples (%)	No. of Unsatisfactory Samples (%)
APC	0 (0%)	4 (12%)	29 (88%)
Coliform	0 (0%)	32 (97%)	1 (3%)
E. coli	24 (73%)	2 (6%)	7 (21%)
S. aureus	15 (46%)	16 (48%)	2 (6%)
B. cereus	26 (79%)	2 (6%)	5 (15%)
Salmonella spp.	33 (100%)	0 (0%)	0 (0%)

3.3 Distribution of *E. coli*, *S. aureus* and *B. cereus* in Different Types of Noodles

Figure 2 illustrates the distribution of *E. coli* (9 isolates), *S. aureus* (21 isolates), and *B. cereus* (7 isolates) across eight different types of noodles. The popular local noodle, *mee jawa*, showed the highest level of contamination, closely followed by *kolo mee* and *laksa Sarawak*. This pattern indicates that these foods are susceptible to contamination due to the various ingredients used in their preparation. These types of noodles are typically served with gravy and an array of condiments, including meat, sliced spring onions, chilies, bean sprouts, and fried onions. The addition of these condiments increases the likelihood of contamination, particularly from insufficient personal hygiene and poor food handling practices. Food handlers often use their bare hands to add these toppings, raising concerns about their hand hygiene, especially given the limited hand washing facilities available at the Ramadan bazaar. Previous studies have demonstrated that bacterial loads on food handlers' hands can exceed safe limits (Lee *et al*., 2017), and a lack of hand-washing habits is a recognized risk factor for microbial contamination (Afreen *et al*., 2019). While disposable gloves can be effective in preventing cross-contamination if used correctly, they should not replace hand washing (Trafialek *et al*., 2018; Afreen *et al*., 2019). It is also advisable to utilize clean tongs, forks, or spoons when handling food (Birgen *et al*., 2020). Therefore, it is crucial to emphasize proper hand hygiene and effective hand-washing techniques, particularly to new, young, and inexperienced food handlers (Anowai *et al.*, 2019).

Despite the presence of good hand washing facilities at the Ramadan bazaar in Kuching South, other risk factors for microbial contamination were identified, as contamination by *S. aureus* still occurred in nearly all samples. The noodle gravy can also act as a contamination source if not stored and handled correctly by food handlers. Noodle gravy is typically prepared with coconut milk or chili paste and made in advance at home. Improper handling and storage practices of coconut milk may lead to cross-contamination. Previous studies by Nurul *et al*. (2017) and Sari *et al.* (2019) have highlighted the presence of *E. coli* and *S. aureus* in coconut milk due to inadequate personal protective equipment and improper storage practices.

Additionally, fried noodles, such as fried *mee hoon*, fried *kolo mee*, and fried *kuetiau*, were found to contain *E. coli*, *S. aureus*, and *B. cereus*. These fried noodles are often left uncovered during sales, exposing them to flies and dust, which can contribute to contamination. Moreover, cooked foods that remain out for extended periods can create favorable conditions for pathogenic microorganisms to grow and multiply, resulting in potential infections and foodborne illnesses when consumed (Amare *et al*., 2019; Mwove *et al*., 2019).

Previous research by Tamilnila *et al*. (2018) reported the presence of *E. coli*, *S. aureus*, *Salmonella spp*., and *Clostridium* in street food noodles sold in India. They noted a significant increase in contamination risk due to the extremely unsanitary environment in which these foods are prepared and served. Additionally, a lack of adequate garbage disposal facilities and clean water sources for drinking and cleaning further exacerbates the situation. Similarly, Siddabathuni (2019) found 21 bacterial pathogens, including *S. aureus, Proteus spp*., and *E. coli*, in 79% of contaminated noodle samples, linking these findings to poor hand hygiene among vendors, the use of contaminated water in food preparation, and the contamination of utensils by pathogens carried by flies from nearby sewage and garbage. The findings from both Tamilnila *et al*. (2018) and

Siddabathuni (2019) emphasize that extremely poor environmental conditions and inadequate facilities at food premises are significant contributing factors to food contamination.
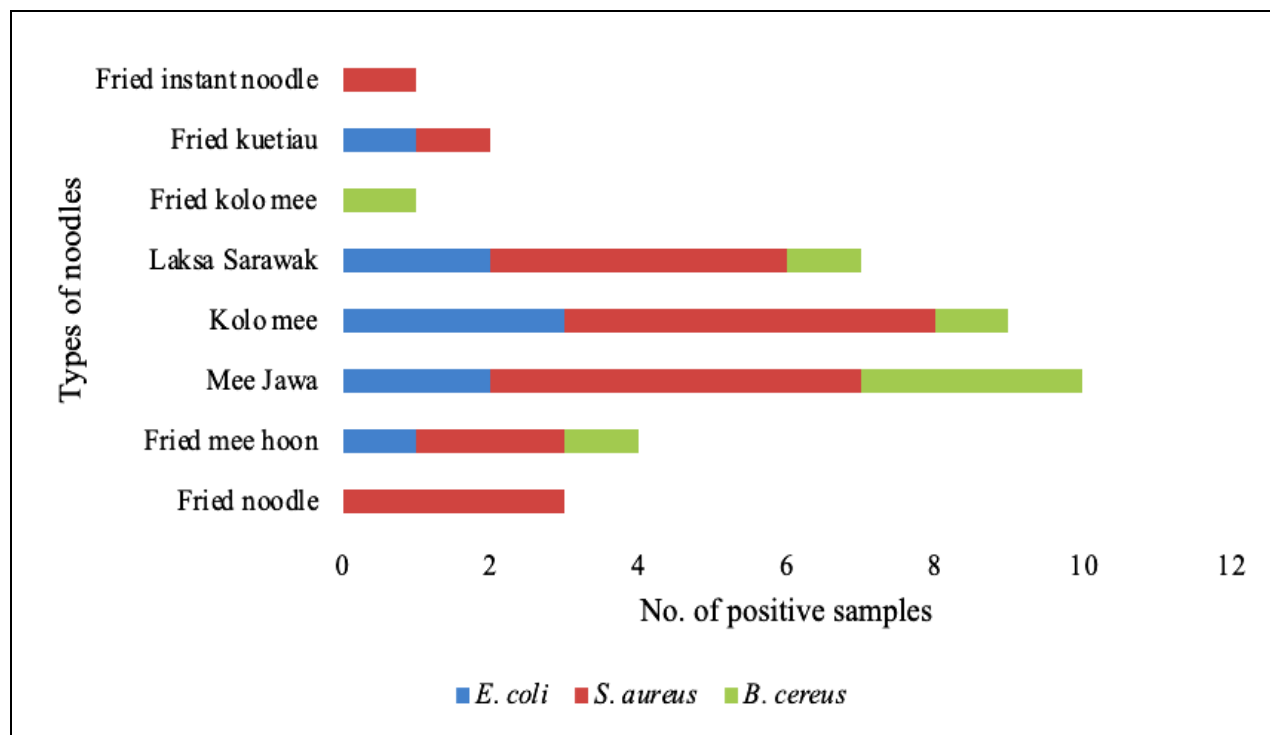

Figure 2: Type of noodles contaminated with *E. coli*, *S. aureus* and *B. cereus*

CONCLUSION

The findings of this study indicate that noodles sold at Ramadan bazaars in Kuching, Sarawak, may have been contaminated with harmful microorganisms, including *S. aureus* and *B. cereus*. The presence of these bacteria in food poses potential health risks for consumers. Furthermore, the microbial analysis showed that some noodle samples had contamination levels that exceeded the acceptable standards. Consequently, this study recommends the implementation of more effective health education and food handling training for food vendors at Ramadan bazaars in Kuching, Sarawak, Malaysia. Additionally, it is essential to establish information and training programs for consumers to raise awareness about food safety, thereby protecting them from potential foodborne illnesses.

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