

HEALTH RISKS ASSOCIATED WITH MICROBIAL CONTAMINATION OF STREET-VENDED FRUIT JUICES IN SOUTHEAST ASIA: A SYSTEMATIC REVIEW

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ABSTRACT

Street-vended fruit juices and beverages are widely consumed across Southeast Asia due to their accessibility, affordability, and cultural acceptability; however, inadequate regulatory oversight and poor compliance with food safety standards may contribute to microbial contamination and associated public health risks. This systematic review, conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework, aimed to synthesize available evidence on the microbiological quality, contributing factors, and health risks of street-vended fruit juices and beverages in Southeast Asia. A systematic search of relevant databases was performed for studies published from 2019 to 2025, focusing on selected Southeast Asian countries, and ten (10) studies meeting the eligibility criteria were included in the narrative synthesis. The reviewed studies employed various microbiological methods, including Total Plate Count (TPC), Total Aerobic Plate Count (TAPC), Total Coliform Count (TCC), and specific detection and enumeration of *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus*. Findings revealed substantial microbial contamination in multiple samples, predominantly involving coliforms, *E. coli*, *Salmonella* spp., and *S. aureus*, which was attributed to poor vendor hygiene, inadequate handwashing, use of contaminated water and utensils, unsanitary preparation areas, improper handling, and inappropriate storage conditions. Several studies reported microbial loads exceeding permissible limits, indicating a heightened risk of foodborne and gastrointestinal illnesses among consumers. Overall, the findings underscore the need to strengthen hygiene and sanitation practices, ensure access to potable water, promote proper food handling and storage, and implement regular microbiological monitoring to improve the safety of street-vended fruit juices and beverages in Southeast Asia.

Keywords:

street-vended beverages; fruit juices; microbial contamination; food safety; *Escherichia coli*; *Salmonella* spp.; *Staphylococcus aureus*; vendor hygiene; Southeast Asia

INTRODUCTION

In tropical countries where warm temperatures persisted year-round, street juices were in high demand due to their convenience and refreshing qualities for consumers. They came in a wide variety of flavors; some countries used freshly squeezed fruits, while others used artificial fruit powders for flavoring. However, their preparation and selling conditions exposed them to potential microbiological contamination. Factors such as the quality of water and ice used, handling practices, utensils, storage conditions, environmental exposure, and personal hygiene of vendors contributed to the presence and growth of microorganisms in freshly prepared beverages. Therefore, assessing the microbiological quality of street-vended juices was important in determining their safety for consumers.

Studies conducted in Southeast Asia reported microbial contamination in street-vended beverages. In Kuala Lumpur, Malaysia, a study of 31 street-vended beverages found contamination with total coliforms and *Staphylococcus aureus*, with fruit juices showing the highest average *S. aureus* count among the beverage groups examined. The researchers associated the contamination with improper handling, inadequate hygienic practices, and environmental conditions (Alimi et al., 2019). Similarly, research on street-vended fresh-cut fruits in Bangkok, Thailand, detected *Escherichia coli* and *S. aureus* in some samples, demonstrating that foods handled and sold in street environments were exposed to microbial hazards (Sapoo et al., 2013).

The concern was also relevant in the Philippines, where street-vended fruit juices were commonly available. A study conducted in Caloocan City examined four types of street-vended fruit juices and drinks from five locations and identified microorganisms using serial dilution, pour-plate techniques, and selective media (Dhakal & Acharya, 2015). More recently, a 2026 study in Sagay City, Philippines, assessed street-vended fruit juices for coliforms, fecal coliforms, and *E. coli* using the Most Probable Number method. The study reported elevated coliform contamination in samples from several barangays, highlighting the importance of regular microbiological monitoring and improved sanitary practices.

These findings demonstrated the importance of examining the microbiological quality of street-vended juices in Southeast Asia. Assessing microorganisms such as total viable bacteria, coliforms, *E. coli*, *Staphylococcus aureus*, *Salmonella*, yeasts, and molds, depending on the scope and available laboratory methods, provided information about possible contamination and the sanitary quality of the beverages. Such assessment contributed to food-safety awareness and provided evidence that could help improve hygiene and handling practices among street-vended juice sellers.

METHODOLOGY

This systematic review was undertaken to critically synthesize the literature on the microbial contamination and associated health risks of street-vended fruit juices and beverages in Southeast Asia. The review considered studies that investigated the microbiological quality of street-vended beverages, factors contributing to contamination, microorganisms detected, and potential health risks associated with consumption. The systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 criteria in the identification, screening, eligibility assessment, selection, and synthesis of relevant studies (Page et al. 2021).

Search Strategy

The systematic review conducted a literature search to identify and analyze relevant studies concerning microbial contamination and health risks associated with street-vended fruit juices and beverages. The literature search involved studies conducted in Southeast Asian settings and included publications from 2019 to 2025, based on the studies identified for this review. To make the literature search relevant to the objectives of the review, keywords included "street-vended fruit juice," "street-vended beverages," "microbial contamination," "microbiological safety," "food safety," "foodborne illness," "*Escherichia coli*," "*Salmonella*," "coliform bacteria," and "*Staphylococcus aureus*."

Boolean operators were used to improve the precision of the search, including ("street-vended fruit juice" AND "microbial contamination"), ("street-vended beverages" AND "food safety"), ("fruit juice" AND "*E. coli*"), and ("street-vended beverages" AND "*Salmonella*"). The search focused on studies conducted in Southeast Asia, particularly those involving street-vended fruit juices and beverages from the Philippines, Indonesia, Malaysia, and Cambodia. Studies were considered when they provided sufficient information regarding microbiological analysis, contamination factors, microorganisms detected, or potential health risks.

Inclusion and Exclusion Criteria

The final body of literature was obtained through the selection and evaluation of studies using predefined eligibility criteria following the PRISMA 2020 framework to promote consistency and methodological rigor (Page et al. 2021). Studies were included when they examined street-vended fruit juices or beverages and provided evidence concerning microbial contamination, microbiological quality, contamination-related factors, identified microorganisms, or potential health risks. Studies employing laboratory microbiological analysis, vendor surveys or interviews, sanitation observations, or statistical analyses related to beverage contamination were eligible for inclusion.

Studies were excluded when: (1) they did not investigate street-vended fruit juices or beverages; (2) microbial contamination or microbiological quality was not examined; (3) the study did not provide findings related to contamination factors, microorganisms, or potential health risks; (4) the publication was a duplicate; or (5) insufficient information was available for meaningful synthesis. Different publication types were retained when they contained relevant research findings applicable to the objectives of the review.

Screening and Selection Process

The identified studies were evaluated through a stepwise selection process based on their titles, study focus, and available full-text information, following the PRISMA 2020 framework (Page et al. 2021). During the initial screening stage, studies that were clearly unrelated to microbial contamination of street-vended fruit juices or beverages were excluded. The remaining studies were assessed according to the established inclusion and exclusion criteria.

The potentially eligible studies were further evaluated based on their study design, study location, type of beverage examined, microbiological methods, contamination results, contributing factors, microorganisms identified, and reported potential health risks. Studies that met the eligibility requirements were retained for the final synthesis.

Following the screening and eligibility assessment, ten (10) studies were included in the systematic review. The selected studies consisted of cross-sectional, descriptive laboratory-based, experimental, and observational research designs. Their methodologies included microbiological laboratory analysis, vendor surveys and interviews, sanitation observations, serial dilution, spread plate techniques, microbial identification, and statistical analysis.

Data Analysis and Classification

The data obtained from the included studies were synthesized through a systematic narrative synthesis, allowing the integration and comparison of findings on microbial contamination and associated health risks of street-vended fruit juices and beverages in Southeast Asia. The included studies were categorized based on the following main areas: (1) contributing factors related to contamination, including vendor hygiene, environmental sanitation, water quality, food handling, preparation practices, and storage conditions; (2) microbial contamination among different types of street-vended juices and beverages, including TPC, TAPC, TCC, and other microbiological measurements; and (3) identified microorganisms and associated health risks, including coliform bacteria, *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, yeast, and molds. The results were also classified according

to beverage type, study location, contamination levels, and reported risk factors to allow comparative analysis across the studies. This systematic approach helped identify common patterns and trends in microbial contamination and the potential health risks associated with street-vended beverages.

RESULTS AND DISCUSSION

This section presents the synthesized findings from the ten (10) studies included in this systematic review regarding microbial contamination and associated health risks of street-vended fruit juices and beverages in Southeast Asia. The reviewed studies utilized different microbiological assessment methods, including Total Plate Count (TPC), Total Aerobic Plate Count (TAPC), Total Coliform Count (TCC), *Escherichia coli* detection, *Salmonella* identification, yeast and mold enumeration, and other laboratory-based analyses. The findings were categorized based on contributing factors related to contamination, comparison of microbial contamination levels among different street-vended juices, and microorganisms identified with their associated health risks.

Table 1. Summary of Reviewed Studies on Microbiological Contamination of Street-Vended Fruit Juices and Beverages

No.	Title	Sources	Location	Effects	Risk Factor	Symptoms	Key Findings	References
1	Association of Food Safety Knowledge and Practice with Microbiological Contamination in Street Vended Fruit Juice: A Cross-Sectional Study in Chattogram Metropolitan City	Street-vended lemon and sugarcane juices	Chattogram Metropolitan City, Bangladesh	Foodborne illness, diarrhea, and gastrointestinal infections	Poor food-safety knowledge, dirty hands, inadequate handwashing, insanitary surroundings, reluctance to use gloves, and poor waste-management facilities	Diarrhea, gastrointestinal infections, and foodborne illness	Samples showed substantial microbial loads. TPC ranged from 8.58×10^2 – 4.38×10^4 CFU/mL for lemon juice and 1.24×10^4 – 8.34×10^4 CFU/mL for sugarcane juice. Several hygiene and knowledge factors were significantly associated with microbial contamination.	Mazumder, D., Saha, S., Chowdhury, A. M., Chakma, P., Roy, S. R., & Dutta, P. (2022). <i>Association of food safety knowledge and practice with microbiological contamination in street vended fruit juice: A cross-sectional study in Chattogram metropolitan city</i> . Bangladesh Journal of Veterinary and Animal Sciences, 10(2), 34–42.
2	Identification of Coliform Bacteria in Various Modern Beverages Sold by	Street-vended modern beverages	Salatiga City, Indonesia	Foodborne illness and gastrointestinal infections	Poor sanitation and possible contamination during beverage preparation and handling	Diarrhea, gastrointestinal infections, nausea, vomiting, and abdominal	The study investigated the presence of coliform bacteria in various beverages sold by street	Yustika, A., Wijayanti, A. W., & Kushartanti, R. (2022). <i>Identification of coliform bacteria in</i>

N o.	Title	Sources	Location	Effects	Risk Factor	Symptoms	Key Findings	References
	Street Vendors in Salatiga City					discomfort	vendors in Salatiga City, Indonesia. The presence of coliform bacteria indicated potential microbiological contamination and possible sanitation problems.	<i>various modern beverages sold by street vendors in Salatiga City.</i> Jurnal Kesehatan Lingkungan, 41(3).
3	Presence of Microorganisms in Street Beverages That Are Sold by Street Vendors at Puncak Alam	Street-vended beverages and environmental samples from street-vending areas	Puncak Alam, Malaysia	Foodborne illness and gastrointestinal infections	Poor beverage preparation hygiene, contaminated utensils/preparation areas, and possible cross-contamination	Diarrhea, gastrointestinal infections, nausea, vomiting, and abdominal discomfort	A low positive correlation was observed between environmental and beverage contamination ($r = .291$), but the association was not statistically significant ($p > .05$).	Mohd Nor Husaini, N. D. (2023). <i>Presence of microorganisms in street beverages that are sold by street vendors at Puncak Alam.</i> Student Project, Universiti Teknologi MARA.
4	Microbiological Safety and Nutritional Quality of Street-Vended Fruit Juices in Urban Centers	Street-vended fruit juices	Urban centers, Indonesia	Foodborne illness, diarrhea, gastrointestinal infections, and nutritional degradation / Vitamin C loss	Poor sanitation, microbial growth during ambient storage, and prolonged holding time before consumption	Gastroenteritis, diarrhea, nausea, vomiting, and abdominal discomfort	68.3% of samples exceeded the Indonesian TPC limit, 74.2% exceeded the coliform limit, 41.7% were positive for <i>E. coli</i> , and 8.3% were	Kusuma, I., Purwanto, D., & Purwanto, T. (2025). <i>Microbiological safety and nutritional quality of street-vended fruit juices in</i>

No.	Title	Sources	Location	Effects	Risk Factor	Symptoms	Key Findings	References
5	Enumeration of Bacteria in Unpasteurized Juices from Different Fruit Juice Vendors in Ozamiz City, Misamis Occidental	Unpasteurized fruit juices from different street-vendors	Ozamiz City, Misamis Occidental, Philippines	Foodborne illness, diarrhea, and gastrointestinal infections	Infrequent handwashing, bare-hand handling, handling money and juice simultaneously, open drainage/dustbins, and inadequate storage	Diarrhea, gastrointestinal infections, nausea, vomiting, and abdominal pain	positive for <i>Salmonella</i> . Coconut juice showed particularly high contamination, with <i>E. coli</i> at $6.5 \pm 2.5 \log_{10}$ CFU/mL and total coliforms at $6.35 \log_{10}$ CFU/mL. 65% of vendors reported infrequent handwashing, while 100% handled juice and money with bare hands.	urban centers. International Journal of Agriculture and Nutrition, 7(1), 146–149. Lagbunan, A. I. C., Espiga, J. R. G., Sobere, J. R., & Canini, N. D. (2025). <i>Enumeration of bacteria in unpasteurized juices from different fruit juice vendors in Ozamiz City, Misamis Occidental</i> . Proceedings of the 4th International Conference on Biodiversity and Climate Change (IConBaCC 2025).
6	Assessing Microbiological Quality of the Ready-To-Eat Food Vended along the Street Around Local Markets in Phnom Penh	Street-vended sugarcane juice and soy juice	Phnom Penh, Cambodia	Foodborne diseases and gastrointestinal infections	Poor personal hygiene, cross-contamination, unsanitary storage and display, contaminated ingredients, and post-processing contamination	Severe gastrointestinal and systemic symptoms, diarrhea, vomiting, abdominal pain, and foodborne illness	Sugarcane juice showed higher microbial contamination, with 100% <i>E. coli</i> and 44% <i>Salmonella</i> spp. prevalence, compared with soy juice, which had 60% <i>E. coli</i> and 16% <i>Salmonella</i>	Chong, A., Chhim, P., Huoy, L., & Phan, K. (2025). <i>Assessing Microbiological Quality of the Ready-To-Eat Food Vended along the Street Around Local Markets in</i>

No.	Title	Sources	Location	Effects	Risk Factor	Symptoms	Key Findings	References
7	Estimation of Microbial Contamination in Fresh and Commercial Fruit Juices: A Comparative Study	Fresh street-vended fruit juices and commercial fruit juices	Ahmedabad, Gujarat, India	Foodborne illness and potential gastrointestinal infections	Poor sanitation and handling practices associated with fresh street-vended juices	Gastrointestinal symptoms, diarrhea, nausea, vomiting, and foodborne illness	spp. Street-vended fresh fruit juices exceeded FSSAI limits for Total Plate Count, yeast and mold count, and coliform count. <i>E. coli</i> , <i>Salmonella</i> , and <i>Staphylococcus aureus</i> were detected in 75% (6/8) of the street-vended fresh juice samples. All 12 juice samples (100%) were contaminated with <i>E. coli</i> and deemed unsafe.	<i>Phnom Penh</i> . The Cambodia Journal of Basic and Applied Research, 7(2), 51–57. James, V., & Panchal, H. (2021). <i>Estimation of Microbial Contamination in Fresh and Commercial Fruit Juices: A Comparative Study</i> . Journal of Pharmaceutical Research International, 33(50A), 145–153.
8	Microbiological Analysis of Street-Vended Juices	Street-vended buko and lemon juices	Cogon Market and Divisoria, Philippines	Foodborne and gastrointestinal infections	Poor raw material quality, unsanitary vending areas, unhygienic vendor practices, improper fruit washing, contaminated water, and poor juice preparation methods	Diarrhea, nausea, vomiting, kidney failure, and severe gastrointestinal infections	Cogon Market had higher contamination than Divisoria, while buko juice had higher counts than lemon juice due to lemon's acidity. The highest count was 45	Balino, K. P., & Badar, E. G. B. (n.d.). <i>Microbiological Analysis of Street-Vended Juices</i> . Advancing Biology Research, 8(1), 32–38.

No.	Title	Sources	Location	Effects	Risk Factor	Symptoms	Key Findings	References
9	Microbiological Analysis of Water Used to Prepare "Palamig" Juices Sold along Higher Education Institutions in Region 2, Philippines	Water used for the preparation of street-vended "Palamig" juices	Region 2, Philippines	Transmission of waterborne and foodborne pathogens to vulnerable students	Septic tank seepage contaminating groundwater within 15 meters of deep wells; refilling stations relying on physical filtration without active disinfection	Diarrhea, gastrointestinal infections, nausea, vomiting, and abdominal discomfort	CFU/25 mL in Cogon Buko Juice 2. All water samples (100%) failed drinking water standards. MTFT: 7/8 exceeded 8.0 MPN/100 mL; TFCT: 6/8 exceeded 8.0 MPN/100 mL; HPC: 7/8 exceeded 6,500 CFU/mL, with only one sample passing at 90 CFU/mL.	Juan, K. G. P., Mequin, E. J., Tan, M. S., & Ramos, B. A. (2021). <i>Microbiological Analysis of Water Used to Prepare "Palamig" Juices Sold along Higher Education Institutions in a City of Region 2, Philippines</i> . Salettinian Open Academic Review, 3, 45–52.
10	Microbiological Safety of Street-Vended Beverages in Chow Kit, Kuala Lumpur	Street-vended beverages from vending stalls	Chow Kit, Kuala Lumpur, Malaysia	Foodborne diseases, bloody diarrhea, hemolytic uremic syndrome, and staphylococcal food poisoning	Stalls near heavy traffic roads and uncovered garbage bins; handling paper currency and drinks simultaneously; contaminated commercial block ice	Bloody diarrhea, gastrointestinal symptoms, vomiting, abdominal pain, and symptoms associated with staphylococcal food poisoning	Only 9.7% of drinks were contamination-free, while 90.3% contained viable bacteria. The mean TVC was 5.03 log CFU/mL, exceeding the acceptable limit. 71% tested positive for total coliforms, and 58.1% contained <i>S. aureus</i> .	Nawawee, N. S. M., Bakar, N. F. A., & Zulfakar, S. S. (2019). <i>Microbiological Safety of Street-Vended Beverages in Chow Kit, Kuala Lumpur</i> . International Journal of Environmental Research and Public Health, 16(22), 4463.

As presented in **Table 1**, the reviewed studies consistently demonstrated microbiological contamination in street-vended fruit

juices and beverages across the included study locations. Commonly identified microorganisms included coliform bacteria, *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus*, indicating concerns regarding the microbiological quality and safety of these beverages. Several studies reported microbial counts or contamination rates that exceeded established microbiological standards. For instance, high prevalence rates of *E. coli*, coliforms, and *Salmonella* spp. were documented in fruit juices, sugarcane juice, coconut juice, and water used for beverage preparation. These findings suggest that microbiological contamination is a recurring concern among street-vended beverages rather than an isolated occurrence associated with a single beverage type or study location.

Across the reviewed studies, contamination was associated with several recurring hygiene and sanitation factors. These included inadequate handwashing, bare-hand contact with beverages, simultaneous handling of money and food products, contaminated water and ice, improperly cleaned utensils, unsanitary preparation environments, inadequate waste management, and inappropriate storage conditions. Water quality emerged as an important concern because water is frequently used for beverage preparation, dilution, washing of ingredients and utensils, and ice production. The detection of coliforms and *E. coli* in beverage and water samples further suggests possible deficiencies in sanitation and hygienic handling throughout the preparation process. In addition, prolonged storage at ambient temperature and exposure to contaminated surroundings may facilitate microbial survival, growth, and cross-contamination.

Variations in contamination levels were also observed among beverage types and study locations. Some studies reported greater microbial contamination in sugarcane, coconut, and other unpasteurized fruit juices, while beverages with greater acidity, such as lemon juice, showed comparatively lower bacterial counts in certain samples. Such variations may be influenced by differences in beverage composition, preparation methods, ingredient quality, environmental conditions, storage practices, and vendor hygiene. Despite these differences, the overall pattern across the reviewed studies indicates that inadequate sanitary practices and uncontrolled preparation and storage conditions are important factors associated with microbial contamination.

Overall, the evidence summarized in Table 1 indicates that street-vended fruit juices and beverages may pose potential food-safety concerns when appropriate hygiene and sanitation measures are not consistently practiced. The repeated detection of microbial indicators and foodborne pathogens highlights the importance of proper hand hygiene, safe water and ice, sanitary utensils and preparation areas, prevention of cross-contamination, and appropriate storage conditions. Strengthening vendor food-safety practices and conducting regular microbiological monitoring may therefore contribute to reducing contamination and minimizing potential foodborne and gastrointestinal health risks among consumers.

Table 2. Comparison of Microbial Contamination and Associated Health Risks in Street-Vended Fruit Juices and Beverages

Author /Year	Type of Juice/Beverage	Microbial Findings	Results	Health Risk Level (Low <50%; Moderate 50–74%; Moderate-High 75–89%; High ≥90%)
Mazumder et al. (2022)	Lemon juice and sugarcane juice	Total Plate Count (TPC) and Total Coliform Count (TCC)	Lemon juice showed TPC ranging from 8.58×10^2 – 4.38×10^4 CFU/mL, while sugarcane juice ranged from 1.24×10^4 – 8.34×10^4 CFU/mL, indicating considerable microbial contamination.	Moderate–High
Yustika et al. (2022)	Various modern beverages	Coliform bacteria	Coliform bacteria were detected, indicating possible contamination associated with sanitation and handling practices.	Moderate
Mohd Nor Husaini (2023)	Street beverages	Microorganisms from beverage and environmental samples	Microorganisms were detected, suggesting possible contamination from preparation areas and utensils.	Moderate
Kusum a et al. (2025)	Street-vended fruit juices	TPC, coliform, <i>E. coli</i> , and <i>Salmonella</i>	68.3% of samples exceeded TPC limits, 74.2% exceeded coliform limits, 41.7% were positive for <i>E. coli</i> , and 8.3% were positive for <i>Salmonella</i> .	High
Lagbun an et al. (2025)	Unpasteurized fruit juices, particularly coconut juice	TAPC, <i>E. coli</i> , total coliform, and <i>S. aureus</i>	Coconut juice showed high bacterial contamination, including high levels of <i>E. coli</i> and coliforms.	High
Arechkung et al. (2025)	Sugarcane juice and soy juice	<i>E. coli</i> and <i>Salmonella</i>	Sugarcane juice showed higher contamination, with 100% <i>E. coli</i> and 44% <i>Salmonella</i> prevalence.	High

Author /Year	Type of Juice/Beverage	Microbial Findings	Results	Health Risk Level (Low <50%; Moderate 50–74%; Moderate-High 75-89%; High ≥90%)
Balino and Badar (n.d.)	Buko and lemon juices	<i>E. coli</i>	All 12 juice samples tested positive for <i>E. coli</i> contamination.	High
Nawaw ee et al. (2019)	Street-vended beverages	Total bacteria, coliform, and <i>Staphylococcus aureus</i>	90.3% of beverages contained viable bacteria, while 71% tested positive for total coliforms.	High

As presented in **Table 2**, the reviewed studies demonstrated varying degrees of microbial contamination in street-vended fruit juices and beverages, with relative health-risk classifications ranging from moderate to high based on the criteria applied in this review. Coliform bacteria and other microbial indicators were frequently detected, while potentially pathogenic microorganisms, including *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus*, were identified in several beverage samples. Elevated microbial counts and contamination rates were particularly evident in unpasteurized and street-prepared beverages, indicating concerns regarding their microbiological quality and safety.

Several studies classified as having a high relative health risk reported substantial levels of contamination. These included the detection of *E. coli* in all examined buko and lemon juice samples in one study, 100% *E. coli* prevalence in sugarcane juice in another, and viable bacteria in 90.3% of street-vended beverages examined in Kuala Lumpur. Other studies reported samples exceeding recommended microbiological limits for Total Plate Count and coliforms, as well as the presence of *Salmonella* spp. and *S. aureus*. In contrast, studies classified within the moderate to moderate–high categories generally reported microbial indicators or elevated bacterial counts but provided comparatively lower or less extensive evidence of pathogenic contamination. These differences suggest that the microbiological quality of street-vended beverages varies according to beverage type, preparation conditions, and the extent of hygienic control.

The observed contamination patterns may be associated with multiple factors occurring throughout beverage preparation and vending, including inadequate sanitation, poor personal hygiene, contaminated water or ice, improper handling of ingredients and utensils, cross-contamination, and inappropriate storage conditions. Beverages such as sugarcane juice, coconut juice, buko juice, lemon juice, and other unpasteurized products may be particularly susceptible when prepared and sold under conditions that allow microbial introduction or growth. The detection of indicator organisms and foodborne pathogens therefore highlights the importance of maintaining hygienic practices at each stage of beverage preparation, storage, and distribution.

Overall, the findings indicate that microbial contamination represents a potential food-safety concern in street-vended fruit juices and beverages. The higher relative risk classifications observed in several studies reflect substantial microbial contamination or frequent detection of potentially pathogenic microorganisms. These results emphasize the need for improved sanitation, safe water and ice, proper food-handling practices, appropriate storage conditions, and routine microbiological monitoring to minimize contamination and reduce potential foodborne health risks among consumers.

Table 3. Identified Microorganisms and Associated Health Risks in Street-Vended Fruit Juices

Microorganism Identified	Studies Reporting Detection	Associated Health Risks
Coliform bacteria	Yustika et al. (2022), Kusuma et al. (2025), Nawawee et al. (2019)	Indicates poor sanitation and possible contamination; associated with foodborne illness and gastrointestinal infections.
<i>Escherichia coli</i>	Kusuma et al. (2025), Lagbunan et al. (2025), Arechkung et al. (2025), Balino and Badar (n.d.)	May cause diarrhea, gastrointestinal illness, and foodborne diseases.
<i>Salmonella</i> spp.	Kusuma et al. (2025), Arechkung et al. (2025)	Associated with salmonellosis and gastrointestinal infections.
<i>Staphylococcus aureus</i>	Lagbunan et al. (2025), Nawawee et al. (2019)	May cause staphylococcal food poisoning due to contamination from human handling.
Yeast and molds	Kusuma et al. (2025), Iwan Kusuma et al. (2025)	Indicates reduced microbiological quality and possible beverage spoilage.

As presented in **Table 3**, the reviewed studies identified several microorganisms in street-vended fruit juices and beverages, including coliform bacteria, *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, and yeasts and molds. The occurrence of

these microorganisms indicates concerns regarding the microbiological quality of street-vended beverages and suggests possible deficiencies in sanitation, handling, preparation, and storage practices. Coliform bacteria were frequently reported and are commonly regarded as indicators of inadequate sanitary conditions, particularly in relation to contaminated water, utensils, ingredients, or preparation environments.

Among the identified microorganisms, *E. coli* was frequently detected across the reviewed studies. Balino and Badar (n.d.) reported *E. coli* contamination in all 12 juice samples examined, while Kusuma et al. (2025) detected the organism in 41.7% of analyzed samples. The presence of *E. coli* may indicate fecal or environmental contamination and raises concerns regarding hygiene and water quality during beverage preparation. In addition, the detection of *Salmonella* spp. and *S. aureus* is of particular food-safety significance because these organisms are associated with foodborne infections and intoxication. *S. aureus* contamination may also reflect inadequate personal hygiene or direct human contact during beverage preparation and handling. Yeasts and molds were also identified in some of the reviewed samples. Although their presence does not necessarily indicate the same health risks as bacterial pathogens, elevated levels may reflect poor microbiological quality, inappropriate storage, or beverage spoilage. Overall, the microorganisms summarized in Table 3 demonstrate that street-vended beverages may be exposed to contamination from multiple sources, including vendor handling, water quality, environmental sanitation, and storage conditions. These findings emphasize the importance of hygienic preparation, safe water use, proper storage, and appropriate sanitation practices to reduce microbial contamination and improve the microbiological safety of street-vended beverages.

CONCLUSION

The systematic review demonstrated that street-vended fruit juices and beverages in Southeast Asia are frequently affected by microbial contamination, which may pose potential health risks to consumers. Across the ten studies reviewed, contamination was associated with several contributing factors, including poor vendor hygiene, inadequate handwashing, improper food handling, contaminated water and utensils, unsanitary vending environments, and improper storage conditions. These findings indicate that contamination can occur at different stages of beverage preparation, from the handling of raw materials to the final serving of the product. The reviewed studies also identified several microorganisms of public health concern, including coliform bacteria, *Escherichia coli*, *Salmonella* e., and *Staphylococcus aureus*, as well as yeast and molds. Some studies reported substantial levels of bacterial contamination, including the detection of *E. coli* and *Salmonella* in street-vended beverages. The presence of these microorganisms indicates possible exposure to foodborne and gastrointestinal illnesses, particularly when beverages are prepared or stored under inadequate sanitary conditions. Overall, the findings emphasize the importance of improving food safety practices among street-vended beverage vendors. Proper handwashing, sanitation of utensils and preparation areas, safe water and raw material handling, protection of beverages from environmental exposure, and appropriate storage conditions are important measures for reducing microbial contamination. Regular microbiological monitoring and food-safety education may also help improve the microbiological quality and safety of street-vended fruit juices and beverages in Southeast Asia.

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