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# The influence of hygienic practices on microbiological quality of freshly squeezed sugar-cane juice sold by street vendors in Mbeya, Tanzania

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ABSTRACT

Sugarcane juice is a popular street beverage in Tanzania, yet its microbial safety remains a growing public health concern. This study evaluated the microbiological quality of freshly squeezed sugarcane juice and investigated the impact of vendor hygiene practices in Mbeya City. A cross-sectional study involved eight sugarcane juice vendors, with 32 juice samples collected from markets, bus terminals, and areas surrounding Mbeya University of Science and Technology. Microbial quality was assessed through total plate counts (cfu/mL), and hygiene practices were evaluated using structured questionnaires and direct observation. Data were analysed using SPSS Version 20, employing General Linear Models (GLM). Microbial counts ranged from 3 to 46 cfu/mL, with 68.8% of samples exceeding the Tanzania Bureau of Standards limit (3.0 cfu/mL). Vendors with poor hygiene had significantly higher microbial loads ($p<0.001$). The GLM showed that hygienic practices explained 78.2% to 82.5% of the variation in cfu/mL. Notably, juice sold near bus terminals and markets showed higher contamination compared to university areas, correlating with observed hygiene scores. Unhygienic handling practices significantly contribute to microbial contamination. There is a pressing need for hygiene education, improved infrastructure, and routine monitoring to ensure food safety, especially in high-traffic vending zones.

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## 1. Introduction

Sugarcane, Saccharum officinarum, is a perennial grassy plant in the family Poaceae grown for its stem (cane), which is primarily used to produce sucrose (1).

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Freshly prepared sugarcane juice is a widely enjoyed and nutritious drink found in tropical regions, including Tanzania (2). Rich in sugars, vitamins, and minerals, it serves as a refreshing beverage, particularly in hot weather (3). However, because of its high moisture and sugar content, coupled with a slightly

acidic pH, it creates an ideal environment for microbial growth, rendering it susceptible to contamination during preparation, handling, and storage (4).

Sugarcane juice has recently become a part of the daily diet in most communities, partly due to its thirst-quenching properties in hot tropical weather. However, due to its favourable pH of 3.6 to 4.8 (6) and its high water and sugar content, sugarcane juice tends to deteriorate quickly even when refrigerated (7). Sugarcane thrives in tropical and subtropical climates worldwide, such as Brazil and China, as well as in African countries like South Africa and Egypt (8, 9). In Tanzania, it is primarily cultivated in Morogoro, Kagera, and Kilimanjaro (10, 11). Street vendors commonly sell sugarcane juice in urban centres in Tanzania (2). Despite its popularity, concerns have been raised regarding the microbiological safety of these juices (12).

Research conducted in Dar es Salaam has shown that freshly squeezed sugarcane juices frequently contain microorganisms at levels that exceed acceptable standards (2, 3, 4). For example, Mwambete and Mpenda reported bacterial counts ranging from $1.44\times10^5$ to $6.0\times10^5$ cfu/mL and fungal counts from $1.36\times10^5$ to $2.64\times10^5$ cfu/mL, surpassing the established thresholds by 10 to 100 times (5). The most common bacterial isolates included *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*, whereas the fungal isolates included *Candida albicans* and *Aspergillus flavus*. Similar results have emerged from other investigations. Issa-Zacharia and Rwabunywenge (2) studied 60 samples of sugarcane juice In Dar es Salaam, it was found that about 90% of the samples exceeded the maximum limits recommended by the Tanzanian Bureau of Standards and Codex, which are 3.7 to 4 log cfu/mL. Unpasteurised raw and iced sugarcane juices contained 1.79 and 2.10 log cfu/mL of *E. coli*, respectively, indicating a risk of faecal contamination (2).

There are various potential sources of contamination, including the use of untreated water, poor handling methods, and unhygienic vending locations. Research has shown that many vendors lack understanding of food safety regulations and hygienic practices, which contributes to the microbial load in the juices (4). Additionally, factors such as the proximity of vending points to waste disposal sites and the use of contaminated ice have been identified as significant risks of contamination (4).

Considering the increasing consumption of sugarcane juice and its associated health hazards, evaluating the microbiological quality of freshly squeezed sugarcane juices sold in Mbeya is essential. This research has an objective of assessing the microbiological quality and examining the hygiene practices of freshly squeezed sugar-cane juice vendors to provide valuable information regarding its safety in Mbeya, Tanzania.

## 2. Materials and Methods

### 2.1. Study area and sampling

This study was conducted in Mbeya, a city in south-west Tanzania. Mbeya city was selected as it is the southern highland region's most populous and biggest multi-ethnic commercial city, and it was particularly chosen as the study region in which sugarcane juice is highly consumed. A total of 10 vendors, representing a variety of juice-selling locations. The sampling sites involved roadside kiosks/busy streets at market areas of the city, areas surrounding Mbeya University of Science and Technology, and areas near bus terminal

commercial areas (Table 1). The vendors were purposively selected using convenience sampling, ensuring diverse geographical representation across the city.

2.2. Study design

A longitudinal research approach was employed to gather socio-demographic and sugarcane juice samples. The study locations/streets were deliberately chosen based on the availability of raw sugarcane juice vendors. The study was conducted over two months of May and June 2024, and included vendors from markets, areas surrounding Mbeya University of Science and Technology (MUST), and the bus terminals. The selection of sugarcane juice vendors for the study was based on their willingness to participate, availability, and capacity to provide the required information.

2.3. Data and sample collection

Samples were collected directly from freshly squeezed sugarcane juice at eight points of sale located in three urban areas of Mbeya city (see Table 1). A total of 32 juice samples (4 samples from each vendor, with one sample taken each week) were collected in sterile, air-tight containers to minimize contamination during transport. Samples were stored in a cooler box with ice packs and transported to the Coca-Cola kwanza microbial laboratory located at Mbeya within 4 h of collection for microbiological analysis (5). In addition to juice samples, observations were made to assess the hygienic practices of vendors. A structured questionnaire was employed to gather data from the sugar cane juice vendors regarding characteristics, locations where sugarcane is prepared, the washing procedures, hand hygiene, cleanliness of juicing equipment, use of clean water, the presence of waste disposal areas, cleanliness of the vendor and their premises, waste management, and general maintenance of the juices (13).

2.3.1. Determination of total plate count

The total colony counts were determined on plate count agar (PCA) by the spread plate method on the petri dishes, and serial dilution was performed to which the diluent was distilled water. The volume of the sample was 30 mL, which was added to 270 mL of sterile diluent to make a total of 300 mL. Then, four test tubes were filled each with 9 mL of sterile diluent, and by using a sterile pipette, 1 mL of properly mixed culture was drawn into the pipette. The sample was then added to the first tube to make the total volume of 10 mL, then the test tube was closed and shaken. This provided an initial dilution of 10-1. The procedure was repeated to make the next dilution, in which 1 mL of the mixture was taken from the 10-1 dilution and emptied into the second tube. The second tube had a total dilution factor of 10-2. The procedure was repeated to make the next two dilutions.

The plates, after being plated with suspension of diluted samples of different dilutions (10-1, 10-2 and 10-3), were incubated at 37° C, and the colonies were counted after 48 h of incubation (14).

2.4. Hygienic practices assessment through observation method

The tool that was used in assessment of handling practices is "Vendor Assessment Tool" this tool involved the observation guide to assess the hygienic practices. The tool is designed to evaluate the vendor's compliance with food safety regulations and hygiene practices. The assessment tool typically includes a

checklist of items related to vendor hygiene, such as the cleanliness of their equipment ad utensils, the use of protective gear, the handling of raw materials, and the overall cleanliness of the environment in which the vendor operates.

2.5. Hygienic practices assessment through questionnaire method

The Vendor tool also included a set of questions related to the vendor's knowledge of food safety and hygiene practices, as well as their compliance with local regulations and laws. The purpose of the assessment is to identify areas where the vendor may be falling short in terms of food safety and hygienic practices in sugarcane juice and to provide recommendations for improvement.

2.6. Statistical data analysis

Quantitative data obtained from microbiological analysis and hygiene assessment were analysed using IBM SPSS Statistics Version 20. Descriptive statistics, including frequencies and percentages, were computed to summarize hygienic practices among sugarcane juice vendors across different sampling locations (markets, bus terminals, and the university area). The microbial counts (cfu/mL) were normalized using log transformation to meet assumptions of normality prior to inferential analysis. To determine differences in hygienic practices across different vending areas, Chi-square tests were applied, and the significance level was set at $p<0.05$.

To assess the influence of specific hygienic practices (independent variables) on microbial contamination (dependent variable-cfu/mL). General Linear Models (GLM) were applied using SPSS. Two separate GLM models were run. The first model was on self-reported hygiene practices and second model was on observed hygiene practices. Each model evaluated the effect of predictors on the dependent variable (log-transformed cfu/mL values). Model significance was determined using the F-test, with results reported as $R^2$ and adjusted $R^2$ to explain the proportion of variance in microbial load attributed to hygienic practices. Results from both models were visualized using bar charts to depict the relationship between hygiene practices and microbial load.

**3. Results**

3.1. Hygienic practices

3.1.1. Hygienic practices assessed through a questionnaire

The study employed a questionnaire survey and direct observation to assess the self-reported hygiene practices of sugar cane vendors in Mbeya, which included storage duration of juice (>4 h), discarding cloudy or leftover juice, and daily cleaning of containers and surroundings. The results from the questionnaire survey (Table 2) indicated that only 37.5% of the respondents store their sugar cane juice in a refrigerator, with the majority of them coming from bus terminals (25%), while the majority (62.5%) store the sugar cane juice in an iced cool box. Around 37.5% and 12.5% discard the clouded juice and leftover juice, respectively. The majority of respondents (75%) reported cleaning their surroundings daily. All mentioned hygienic practices are directly related to low microbial contamination (Table 2 and Fig. 1).

**Table 1.** Sample collection area

| Collection area | Location | Sample No. |
|---|---|---|
| **MUST surrounding areas** | Iyunga | MST1, MST2 |
| | MUST main campus | MST3, MST4 |
| | | MST5, MST6 |
| | | MST7, MST8 |
| **Bus terminal** | Main bus terminal | MBT1, MBT2 |
| | | MBT3, MBT4 |
| | Nanenane bus terminal | MBT5, MBT6 |
| | | MBT7, MBT8 |
| | Mwanjelwa | MBT9, MBT10 |
| | | MBT11, MBT12 |
| **Market areas** | Soweto market | MKT1, MKT2 |
| | | MKT3, MKT4 |
| | Uyole market | MKT5, MKT6 |
| | | MKT7, MKT8 |
| | Mwanjelwa market | MKT9, MKT10 |
| | | MKT11, MKT12 |

**Table 2.** Hygienic practices used by sugar cane vendors in Mbeya city assessed through questionnaire (n=32)

| Hygienic practices | Bus terminals n (%) | Markets n (%) | MUST nearby n (%) | Overall n (%) | p-value |
|---|---|---|---|---|---|
| **Juice storage** | | | | | |
| **Refrigerator** | 8 (25) | 4 (12.5) | 0 | 12 (37.5) | 0.007* |
| **Cool box** | 4 (12.5) | 8 (25) | 8 (25) | 20 (62.5) | |
| **Keep juice for > 4 hours- Yes** | 8 (25) | 4 (12.5%) | 4 (12.5) | 16 (50) | 0.277 |
| **Discard clouded juice-Yes** | 0 (0) | 8 (25) | 4 (12.5) | 12 (37.5) | <0.001* |
| **Discard leftover juice- Yes** | 4 (12.5) | 0 (0) | 0 (0) | 4 (12.5 | <0.001* |
| **Daily cleaning the area- Yes** | 12 (37.5) | 8 (25) | 4 (12.5) | 24 (75) | 0.018* |

n = Number of samples collected from three sampling areas with eight vendors (four samples from each vendor)

All p-values are based on a Chi-square analysis of numbers across three sampling areas
*Statistically significant at p<0.05

**Table 3.** The influence of self-reported hygienic practices on microbial contamination (cfu/mL)

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 11091.750[a] | 6 | 1848.625 | 14.922 | <0.001 |
| Intercept | 10751.615 | 1 | 10751.615 | 86.787 | <0.001 |
| Keep juice > 4hrs | 6844.500 | 1 | 6844.500 | 55.249 | <0.001 |
| Discard the cloudy juice | 2346.125 | 1 | 2346.125 | 18.938 | <0.001 |
| Discard leftover juice | 672.042 | 1 | 672.042 | 5.425 | 0.028 |
| **Cleaning of containers and surroundings** | 1250.000 | 1 | 1250.000 | 10.090 | 0.004 |

Dependent variable: cfu/mL

[a]$R^2$ = 0.782 (Adjusted $R^2$ = 0.729)

**Table 4.** Hygienic practices used by sugar cane vendors in Mbeya city assessed through Observation (n=32)

| Hygienic practices | Bus terminals n (%) | Markets n (%) | MUST nearby n (%) | Overall n (%) | p-value |
|---|---|---|---|---|---|
| **Juice storage** | | | | | |
| **Refrigerator** | 8 (25) | 0 (0) | 0 (0) | 8 (25) | <0.001* |
| **Cool box** | 4 (12.5) | 12 (37.5) | 8 (25) | 24 (75) | |
| **Surrounding cleanliness-Good** | 8 (25) | 8 (25) | 0 (0) | 16 (50) | 0.004* |
| **Wearing hairnet-Yes** | 12 (37.5) | 12 (37.5) | 8 (25) | 16 (50) | 0.004* |
| **Hand-washing facility** | | | | | |
| **Tap water** | 8 (25) | 4 (12.5) | 0 (0) | 12 (37.5) | 0.001* |
| **Water basin/bucket** | 4 (12.5) | 4 (12.5) | 8 (25) | 16 (50) | |
| **None** | 0 (0) | 4 (12.5) | 0 (0) | 4 (12.5) | |
| **Hand washing after handling the money** | 12 (37.5) | 12 (37.5) | 8 (25) | 32 (100) | ** |
| **Dispose of the leftover juice-no observation made** | 12 (37.5) | 12 (37.5) | 8 (25) | 32 (100) | ** |
| **Wearing apron-Yes** | 8 (25) | 8 (25) | 4 (12.5) | 20 (62.5) | 0.728 |
| **Trimmed nails-Yes** | 8 (25) | 12 (37.5) | 4 (12.5) | 24 (75) | 0.018 |
| **Waste disposal-Yes** | 12 (37.5) | 12 (37.5) | 8 (25) | 32 (100) | ** |

n = Number of observations made from three sampling areas with eight vendors (four observations per vendor)

*Statistically significant at $p<0.05$

**No statistics were computed because Hand washing after handling money is a constant.

**Table 5.** The influence of observed hygienic practices on microbial contamination (cfu/mL)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| **Corrected Model** | 11709.625[a] | 6 | 1951.604 | 19.679 | <0.001 |
| **Intercept** | 3901.389 | 1 | 3901.389 | 39.340 | <0.001 |
| **Juice storage** | 650.893 | 1 | 650.893 | 6.563 | 0.017 |
| **Presence of a hand-wash facility** | 1318.750 | 2 | 659.375 | 6.649 | 0.005 |
| **Wearing apron** | 2244.500 | 1 | 2244.500 | 22.633 | <0.001 |
| **Trimmed nails** | 2546.036 | 1 | 2546.036 | 25.673 | <0.001 |

Dependent variable: cfu/mL
[a]R Squared = 0.825 (Adjusted R Squared = 0.783)

**Table 6.** Microbial quality of the sugarcane juice samples vended at different locations

| Sample | Location | Mean Total Plate Count (cfu/mL) | Acceptability |
|---|---|---|---|
| A | University area | 3* | Acceptable |
| B | Market area | 17 | Unsatisfactory |
| C | Bus terminal area | 46 | Unsatisfactory |

*Acceptable limits as per the TBS standard limit of 3.0 cfu/mL

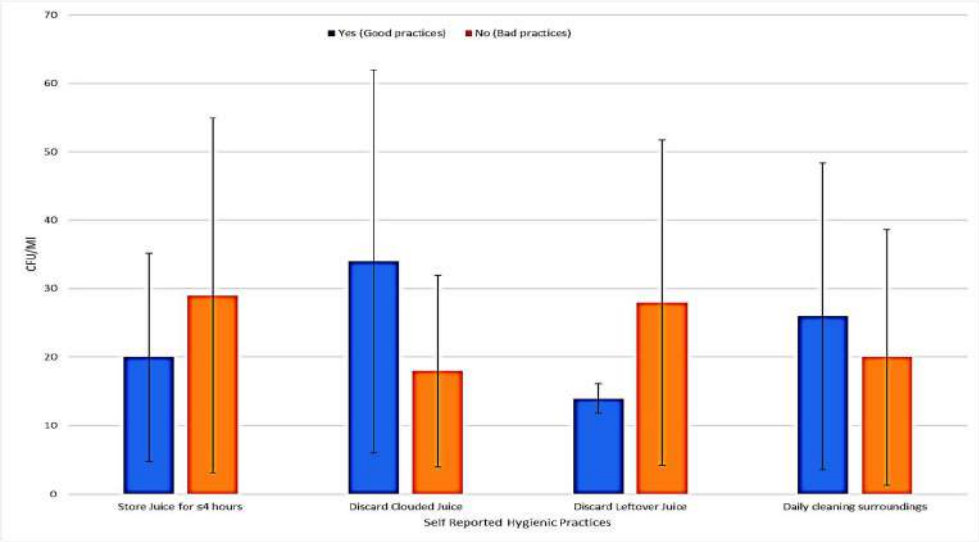


**Figure 1.** Self-reported hygienic practices vs mean bacterial count cfu/mL with their corresponding standard deviations

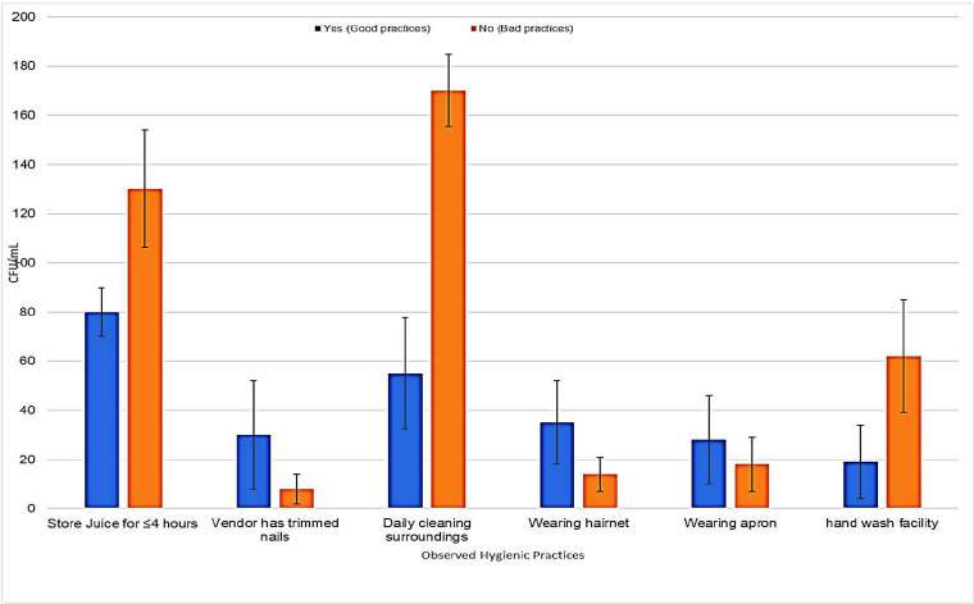


**Figure 2.** Observed hygienic practices vs mean bacterial count (cfu/mL) with their corresponding standard deviations

3.1.2. Self-reported hygienic practices using General Linear Model (GLM)

GLM in SPSS was run to assess the influence of hygienic practices (independent variables) on microbial contamination for different dependent variables (see Table 3 and Fig. 1). The overall model fit with a corrected model F (6, 25) = 14.922, p = <0.001, indicates that the model significantly explains variation in cfu/mL, with an overall $R^2$ = 0.782 (Adjusted $R^2$ = 0.729). This means about 78.2% of the variation in

microbial contamination is explained by the predictors (independent variables) included. F-values from GLMs exposed the impact of self-reported hygiene practices on microbial contamination (measured as cfu/mL) in sugarcane juice. Higher F-values indicate a stronger statistical influence on contamination levels. The strongest predictors among self-reported behaviours were keeping juice for more than 4 h (F=55.25), failure to discard cloudy juice (F=18.94), and lack of daily cleaning (F=10.09).

3.1.3. Hygienic practices assessed through observation

Observed hygiene practices, included, type of juice storage method (refrigerator or cool box), the presence and type of handwashing facility, wearing of an apron, and the presence of trimmed nails. The results from direct observations indicated that 75% of sugar juice vendors were using the iced cool box for storage, with the majority (37.5%) coming from market vendors (Table 4). It was also reported that 50% of the surroundings were in good condition, and 50% were using tap water as a source for hand washing. Seventy-five per cent were observed with trimmed nails, a practice that can help to lower the microbial contamination in the prepared sugarcane juice. All of the juice vendors (100) were properly disposing of waste (Table 4 and Fig. 2).

3.1.4. Observed hygienic practices using General Linear Model (GLM)

The Overall model is statistically significant with a corrected model $F(6, 25) = 19.68$, $p<0.001$. This indicates that the model significantly explains variation in cfu/mL, with an overall $R^2 = 0.825$ (Adjusted $R^2 = 0.783$) (Table 5 and Fig. 2). Which means that about 82.5% of the variation in microbial contamination is explained by the predictors (independent variables) included. Among observed practices, vendors who wore aprons (F=22.63) and maintained short nails (F=25.67) had significantly lower contamination levels. Availability of handwashing facilities and appropriate juice storage also showed moderate but significant influence (Table 5 and Fig. 2).

3.2. Microbial quality of sugarcane juice

The results were analysed and compared with the maximum limits specified in the TBS Standard for microbial count in sugarcane juice, which is said to be 3.0 cfu/mL (2). Total Plate Count levels in the sugarcane juice samples range from 3 to 46 (cfu/mL) (Table 6). The lowest level was observed in the samples collected from the areas surrounding MUST, and the highest level was from the samples collected from the bus terminals. Samples from market areas and bus terminals had a high total plate count exceeding the TBS standard limit of 3.0 cfu/mL (14), indicating high contamination. The high microbial counts indicate poor handling practices and insufficient hygiene measures during the processing and storage of sugarcane juice.

## 4. Discussion

This research examined the microbiological safety of freshly squeezed sugarcane juice and the impact of hygiene practices among street vendors in Mbeya City, Tanzania. The findings from this study indicated extensive microbial contamination, with more than two-thirds of juice samples surpassing the threshold set by the Tanzania Bureau of Standards (TBS) of 10 cfu/mL (5). These elevated levels are indicative of poor hygienic handling and possible contamination after processing. It is noteworthy that vendors who either claimed or were seen not discarding leftover juice,

failing to store juice under refrigeration, or not routinely cleaning their containers showed significantly higher microbial levels. These results align with previous research conducted in Dar es Salaam and other locations, which showed high microbial counts in untreated street-vended beverages, including sugarcane juice, stemming from insufficient hygiene and unfavourable environmental conditions (15, 16). For instance, Mwambete and Mpenda documented bacterial counts ranging from $1.44\times10^5$ to $6.0\times10^5$ cfu/mL and fungal counts from $1.36\times10^5$ to $2.64\times10^5$ cfu/mL, exceeding established thresholds by 10 to 100 times (5). Issa-Zacharia A and Rwabunywenge found that approximately 90% of the samples surpassed the recommended maximum limits set by the Tanzania Bureau of Standards and Codex of 3.7 to 4 log cfu/mL (2). Unpasteurized raw and iced sugarcane juices were reported to contain 1.79 and 2.10 log cfu/mL of *E. coli*, respectively, highlighting a potential risk of faecal contamination (2).

The most significant levels of contamination were found among vendors situated at bus terminals and busy market areas characterized by insufficient access to clean water, inadequate waste management, and densely populated spaces. This may be attributed to the fact that vendors operating in high-traffic public areas, especially bus terminals and markets, tend to have higher mean cfu/mL levels. These elements are consistent with environmental factors of microbial risk identified in urban vending contexts in Burkina Faso and India, where a lack of sanitation infrastructure and closeness to waste greatly impacted contamination (17, 18). The study from Burkina Faso reported numerous bacterial contaminations of 8.6 x 10 5 cfu/knife (17), while that from India reported that 88% of the food samples analysed were contaminated by bacterial pathogens (18). This is further corroborated by data from urban Nigeria and India, which showed that food contamination rates were highest in crowded, unregulated vending locations with *E. coli* contaminations in sugarcane juice of 2x105 cfu)/mL and 180 cfu/mL respectively (19, 20).

General Linear Model (GLM) analyses in this investigation established that both self-reported and observed hygiene practices were significant statistical predictors of microbial load. Hygiene-related actions such as washing hands, discarding leftover juice, and regularly cleaning utensils notably lowered cfu/mL counts. These findings are comparable to those reported from India showing high contamination of up to 100% of a mix fruit with a strain of bacteria (7, 21), which indicate that low-cost personal hygiene measures could significantly reduce microbial risks in informal food sectors. Observed hygiene indicators, including trimmed nails, wearing of aprons, and availability of handwashing facilities, were significantly linked to lower microbial levels. These aspects not only mirror vendor behaviour but may also act as practical indicators for regulatory oversight and public health inspections (22).

From a policy standpoint, these results emphasise the necessity for multi-layered interventions. Firstly, hygiene education programs specifically designed for informal vendors are crucial for increasing awareness of food safety hazards. Secondly, municipal authorities should invest in enhancing infrastructure, such as providing access to clean water and establishing designated sanitary areas in market zones. Finally, food

safety regulations should extend to informal vendors as well, reinforced by regular inspections and public evaluations of hygiene practices, as evidenced by successful pilot initiatives in Ethiopia and Ghana (23, 24).

The relationship between the location of vending and hygiene practices further highlights the necessity for interventions tailored to specific contexts. Vendors situated in university areas demonstrated comparatively better hygiene and lower contamination levels, likely due to their exposure to more educated customers and improved access to municipal services. Comparable socio-environmental inequalities were noted in research conducted in India and Uganda, where vendor conduct and microbial results were closely linked to the socioeconomic characteristics of the vending locations (25, 26). Crucially, the differences in hygiene practices and contamination rates reflect not only individual actions but also systemic obstacles, such as a lack of training, regulatory oversight, and adequate infrastructure. Numerous studies throughout sub-Saharan Africa have underscored that informal food vendors frequently do not have access to health education, food safety resources, and formal assistance systems (23, 27).

Consequently, tackling microbial contamination necessitates both behavioural changes and institutional dedication. This research has several implications for public health. First, the regular training and certification of food handlers should be formalised, particularly in high-risk zones such as bus stations and market places. Second, local authorities ought to prioritise the provision of clean water, sanitation, and affordable cold storage solutions for street vendors. Third, hygiene inspection systems like visible hygiene ratings might encourage better practices and empower consumers to make safer choices, as has been tested in various regions of South Africa and India (28, 29).

**5. Conclusion**

This study identified several key hygiene-related practices that significantly influenced microbial contamination levels in locally sold juice and identified significant associations with vendors' hygiene practices in Mbeya City. Observational variables such as the presence of appropriate juice storage facilities, handwashing stations, use of aprons, and maintaining short fingernails were all significantly associated with reduced colony-forming units (cfu/mL), suggesting better microbial safety. These findings reinforce the critical role of visible hygiene practices in preventing foodborne contamination in street-vended beverages. Given that the model explains over 78% of the variability in microbial counts, interventions targeting these specific hygiene behaviours could yield meaningful public health benefits. These findings suggest that enhancing hygiene behaviours among vendors can substantially reduce contamination risks and improve consumer safety. Strengthening enforcement of food safety guidelines, combined with targeted health education and infrastructure support, is essential to protect public health in informal food settings.

Local authorities should prioritise developing infrastructure that supports hygienic street vending, including provisions for clean water, waste management systems, and mobile sanitation units for handwashing. Vendors ought to be encouraged (and supported) to utilise refrigeration or cold storage

containers for juices, which would help reduce the proliferation of spoilage organisms and pathogens. Local governments must enhance food safety regulations and ensure that vendors comply with the guidelines set by the Tanzanian Bureau of Standards (TBS) regarding microbiological limits. This could involve conducting regular inspections, random sampling, and enforcing penalties for non-compliance. Establishing and enforcing standardised hygiene practices for street food vendors, akin to those in formal food establishments, could effectively reduce the incidence of contamination.

Initiatives aimed at raising community awareness about the dangers of consuming unregulated street food can lead to greater demand for safer options. This could generate consumer pressure on vendors to improve their practices. Local health agencies and NGOs can work together to provide outreach, educational initiatives, and support regarding food safety practices for both vendors and the community.

Future research should concentrate on larger and more diverse samples from various regions in Tanzania, as well as over extended periods, to obtain a clearer picture of differences in microbial contamination. Subsequent studies could evaluate the effects of interventions such as vendor training, enhancements in infrastructure, and community-driven campaigns on the reduction of microbial contamination in street food. Moreover, upcoming research might employ more advanced microbiological techniques, such as whole genome sequencing to identify specific sources of contamination and gain insights into the spread of foodborne pathogens.

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**Authors Contributions**

Diana Nicodemas: Conceptualization, methodology, Visualization, Writing - original draft, writing - review and editing. Chacha Nyagi: Methodology, Visualization, writing- review and editing.

**Declaration of Competing Interest**

The authors declare that they have no competing interests regarding the publication of this article.

**Data availability**

The datasets used and/or analyzed during the study are available from the corresponding author upon reasonable request.

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**References**

1. CABI Compendium. *Saccharum officinarum* (sugarcane). CABI Digit Libr. 2024. Available from: https://www.cabidigitallibrary.org/doi/full/10.1079/cabicompendium.48160
2. Issa-Zacharia A, Rwabunywenge SP. Evaluation of bacteriological quality and safety of sugarcane juice locally processed and vended in Dar es Salaam City, Tanzania. J Food Saf Hyg. 2023; 9(4):282-298.

3. Akter N, Linkon KMMR, Akter M, Hossain MA, Rahman MM, Khan T, et al. Assessment of physico-chemical and microbial quality of sugarcane juice sold by street vendors in three regions of Bangladesh. Food Nutr Sci. 2024; 15:263-276.
4. Rubaratuka JI, Mrema GD, Lyimo TJ. Microbial quality of fresh juices sold by street vendors and associated human health risks: the case of Ilala Ward, Dar es Salaam City, Tanzania. Tanzan J Sci. 2023; 49(5):996-1010.
5. Mwambete KD, Mpenda MH. Microbiological quality of freshly squeezed sugarcane juices vended in Dar es Salaam, Tanzania. East Cent Afr J Pharm Sci. 2019; 22(3):64-70.
6. Arif M, Haydar S, Farooq U. Assessment of microbial contamination in street-vended fruit juices and beverages in Pakistan. J Environ Health Sci Eng. 2019; 17(2):731-739.
7. Mahale DP, Khade RG, Vaidya VK. Microbiological analysis of street-vended fruit juices from Mumbai city, India. Internet J Food Saf. 2008; 10:31-34.
8. De Matos M, Santos F, Eichler P. Sugarcane world scenario. In: Sugarcane biorefinery: technology and perspectives. Academic Press; 2020. p. 1-19.
9. Verma KK, Song XP, Singh M, de Mello Prado R, Wu JM, Li YR, editors. Sugarcane cultivation and management: challenges and opportunities. 2024.
10. Tarimo AJ, Takamura YT. Sugarcane production, processing and marketing in Tanzania. Afr Study Monogr. 1998; 19(1):1-12.
11. Mhango SS, Ngowi RL. Perceived factors affecting sugarcane production among small-scale farmers in Kilombero District, Morogoro, Tanzania. East Afr J Agric Biotechnol. 2024; 7(1):161-172.
12. Subbannayya K, Bhat GK, Shetty S, Junu VG. Correspondence: How safe is sugarcane juice? Indian J Med Microbiol. 2007; 25:73-74.
13. International Organization for Standardization. ISO 22000:2018. Food safety management systems—requirements for any organization in the food chain. Geneva: ISO; 2018. Available from: https://www.iso.org/standard/65464.html
14. Tanzania Bureau of Standards. Microbiology of food and animal feeding stuffs—method for enumeration of microorganisms. Tanzania Standards Specification No. 118. Dar es Salaam; 2007.
15. Kitagwa AW, Gikonyo NK, Wambugu SN. Microbiological safety of raw sugarcane juice vended in Nairobi, Kenya. Afr J Food Sci. 2020; 14(5):125-134.
16. Subedi S, Pokhrel S, Tuladhar E. Microbial quality assessment of fresh sugarcane juice in retail shops inside Kathmandu Valley. SciTech Nepal. 2023; 17(1):101-115.
17. Barro N, Bello AR, Aly S, Ouattara CAT, Ilboudo AJ, Traoré AS. Hygienic status assessment of dishwashing waters, utensils, hands and money from street food processing sites in Ouagadougou, Burkina Faso. Afr J Biotechnol. 2006; 5(11):1107-1112.
18. Chumber SK, Kaushik K, Savy S. Bacteriological analysis of street foods in Pune. Indian J Public Health. 2007; 51(2):114-116.
19. Sharma M, Anand SK, Sood S. Street food microbiological hazards: a review of studies from India. Int J Food Microbiol. 2018; 290:12-17.
20. Oyedele AO, Akinyele BJ, Olorunfemi MA. Assessment of hygiene practices and microbial contamination in street-vended juices in Lagos, Nigeria. J Public Health Afr. 2021; 12(1):1064.
21. Tambekar DH, Jaiswal VJ, Dhanorkar DV, Gulhane PB, Dudhane MN. Street-vended food: hygiene and safety. J Public Health Epidemiol. 2011; 3(4):181-186.
22. FAO/WHO. Basic food safety for street-vended foods: training manual for street food vendors. Geneva: World Health Organization; 2010.

23. Mensah P, Yeboah-Manu D, Owusu-Darko K, Ablordey A. Street foods in Accra, Ghana: how safe are they? Bull World Health Organ. 2002; 80(7):546-554.
24. FAO. Street food vending in West Africa: practices and training needs in Ghana and Nigeria. Rome: Food and Agriculture Organization of the United Nations; 2016.
25. Muyanja C, Nayiga L, Brenda N, Nasinyama G. Practices, knowledge and risk factors of street food vendors in Uganda. Food Control. 2011; 22(10):1551-1558.
26. Mohan VR, Thangam TS, Ramesh N. Microbiological analysis of street-vended juices in India. Asian J Pharm Clin Res. 2014; 7(3):45-48.
27. Muinde OK, Kuria E. Hygienic and sanitary practices of vendors of street foods in Nairobi, Kenya. Afr J Food Agric Nutr Dev. 2005; 5(1):1-13.
28. World Health Organization. Basic steps to improve safety of street-vended food. Geneva: WHO; 2010.
29. Feglo P, Sakyi K. Bacterial contamination of street-vending food in Kumasi, Ghana. J Med Biomed Sci. 2012; 1(1):1-8.