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Microbial Quality of Fresh Juices Sold by Street Vendors and Associated Human Health Risks: The Case of Ilala Ward, Dar es Salaam City, Tanzania

Juliana I. Rubaratuka[1,2], Godwill D. Mrema[1] and Thomas J. Lyimo[3*]
[1]*Department of Chemical and Process Engineering, University of Dar es Salaam, Tanzania*
[2]*National Environment Management Council, P.O Box 63154, Dar es Salaam, Tanzania*
[3]*Department of Molecular Biology and Biotechnology, University of Dar es Salaam, P.O. Box* 35179, *Dar es Salaam, Tanzania*
Email addresses: juli.kokuteta96@gmail.com; gdmrema@yahoo.com;
**Corresponding author: E-mail*: tjlyimo@udsm.ac.tz. Telephone: +255 754 375 924
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Abstract

Microbial food quality serves to indicate health risks associated with the consumption of contaminated foods. This study aimed to determine the microbial quality of fresh juices and the level of awareness and perception of the consumers and juice vendors at Ilala Ward, Dar es Salaam. Fresh samples of sugarcane, mango and mixed fruit juices were collected from four different sampling stations and analysed using standard methods for Total Coliform (TC), Faecal Coliform (FC) and Total Viable Count (TVC). The level of awareness and perception of 60 juice vendors and 60 consumers were also assessed by using questionnaires. The results showed that TC numbers ranged from the lowest mean of $6.100\pm4.180x10^6$ to $7.483\pm3.650x10^7$ MPN/ml, FC ranged from $2.566\pm0.989x10^6$ to $2.017\pm1.687x10^7$ MPN/ml while TVC ranged from $5.046\pm1.032x10^9$ to $5.871\pm0.835x10^9$ CFU/ml of fresh juices. The level of TC, FC and TVC was beyond the recommended international and Tanzanian standards showing that fresh juices posed a high risk for consumers. On the other hand, 42% of the juice consumers had low awareness of microbial contamination of fresh juices, which leads to high health risks. It is recommended that street juice vendors should adopt proper hygiene measures and undergo appropriate training on microbial quality, food safety and sanitation.

Keywords: Total Coliform, Faecal Coliform, Total Viable Counts, Fresh Juice, Hygiene, Health risks

Introduction

Fresh juices are drinks made from the extraction of the natural liquid from raw materials such as fruits and sugarcane stems and are well recognized for their nutritive value and health benefits such as regulating blood sugar levels, lowering cholesterol and slowing the transit of food through the digestive tract (Simforian 2013). The current trend has shown an increasing rate of interest in fresh juices business that has offered amount of employment to people with little education and makes a sizeable contribution to the economies of developing countries (Bhunia 2018). However, the minimally processed fresh juices coupled with improper handling and storing methods have become potential sources of food-borne pathogens due to improper handling and storing methods (Bhunia, 2018, Kaddumukasa et al. 2019). Contamination can be attributed to poor sanitation, hygiene and the use of contaminated water from open channels and wells, where by World Health Organization findings, (WHO, 2017) the risk of contamination indicated that in Tanzania

about 87% of the water used for the preparation of fresh juices was contaminated with *Escherichia coli*.

Muinde and Kuria (2005) have reported that food-borne illnesses and water-borne diseases are problems in most developing countries due to inadequate food safety programs and scarcity of potable water. Contaminated fresh juices and water may contain pathogens, which leads to health risks such as typhoid, cholera, amoebiasis and dysentery (Lugomela et al. 2014, Kaddumukasa et al. 2019). For the case of cholera, Penrose et al. (2010) reported that in 2006 there were 8753 cases of cholera in Dar es Salaam, Ilala municipality leading to 42.8% incidences followed by Kinondoni (32.5%) and Temeke (24.7%). In Ilala municipality, high rate of cholera was attributed to high informal residents, high population density, poor sanitation and close distance to the nearest cholera clinic within the ward compared to other municipals.

Microbial quality assessment is very important in fresh juices because it shows the probability of the presence of pathogens that can cause diseases to humans. According to WHO (2017), in Africa there is an increase in diseases that are associated with the consumption of fresh juices therefore raising a concern about whether they are safe or not for consumption. Studies on hygienic knowledge, handling practices, microbial contamination, consumer and vendors awareness and perception on quality of fresh juices are important, but are also few. Hence, this study aimed to assess the microbial quality of the fresh juices sold by street vendorsin relation to the national and international standards, and the level of awareness, perception and potential health risks in Ilala Ward, Dar es Salaam, Tanzania.

Materials and Methods

Study area

The samplings were conducted at Ilala ward in the Ilala municipality Dar es Salaam region, Tanzania, in four different stations (sampling points) namely Ilala Sokoni, Ilala Boma, Amana area and Sharifu Shamba as shown in Figure 1. This area is located at Dar es Salaam city centre, with large population of about 95,936 people (NBS 2017). The area was selected because it represents high population with many juice vendors and consumers and main socioeconomic activities included commercial businesses such as markets, shops and restaurants as well as health services. The sampling stations were situated at very close to garbage, wastes placed in open sacks and uncovered dustbins which promoted the presence of flies. On the other hand, some street juice vendors had dirty nails, did not cover their hands during handling practices, stored the fresh juices in plastic buckets which were dirty and in cool boxes because they are easily affordable compared to refrigerators.

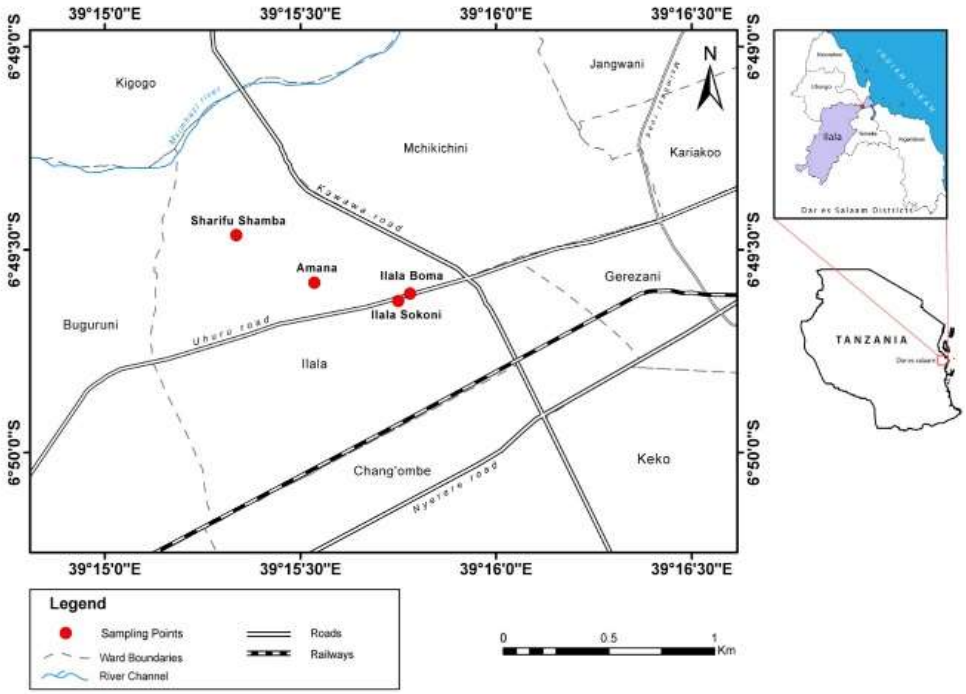

Figure 1: A map of Dar es Salaam City showing sampling points at Ilala Ward

Samplings

Sampling for microbiological analysis was done by collecting fresh juice samples namely sugarcane, mixed fruit (avocado, passion and mango) and mango juices from storage buckets of juice vendors using sterile cups and filled in 250 ml sterile bottles. The same was done for water used for the preparation the juices. The samples, 144 in total, were collected at a weekly interval for six weeks from March to April 2021 as summarized in Table 1. Collected samples were packed in cool boxes with ice packs at a temperature of about 4°C and transported for analysis at the Department of Molecular Biology and Biotechnology, University of Dar es Salaam.

Assessment of potential health risks and community awareness on fresh juices was conducted from the same locations through physical site visits and questionnaires to juice vendors and consumers.

Table 1: Number of samples collected from different stations at Ilala Ward

Type of fresh juice and water	Ilala Boma	Ilala Sokoni	Am ana	Sharifu Shamba	Total samples
Sugarcane	6	6	6	6	**24**
Mixed fruit	6	6	6	6	**24**
Mango	6	6	6	6	**24**
Sugarcane water	6	6	6	6	**24**
Mixed fruit water	6	6	6	6	**24**
Mango water	6	6	6	6	**24**
Total	**36**	**36**	**36**	**36**	**144**

Microbiological Analyses

Upon arrival of the samples into the laboratory (1-3 hr after sampling), they were

immediately analysed for TC, FC and TVC according to APHA (2017). Thus, TC and FC were analysed using MacConkey broth purple medium by dissolving 40.01g in 1000 ml as described by manufacturer (HiMedia Laboratories Ltd, Mumbai, India). The medium was dispensed in test tubes at aliquots of 9 ml to allow serially dilution of up to 10^7 folds using 3 tubes series as described by De Man (1983). After sterilization and cooling down, 1 ml of sample was inoculated in the first tube followed by serial inoculation making dilutions of 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} and 10^{-7}. The inoculated test tubes were incubated at 37±0.5°C and 44.5±0.5°C to allow the growth for TC and FC respectively. All test tubes that showed gas production and colour change from purple to yellow due to acid production indicated presumptive positive results. Three to five randomly selected positive tubes from highest dilution were used for a confirmatory test by aseptically streaking in Eosin Methyl Blue (EMB) agar (prepared as described by manufacturer by dissolving 27.1 g of EMB powder in 720 ml of distilled water). The inoculated plates were incubated at temperature of 44.5±0.5°C. The positive results were colonies appearing bluish by transmitting light with a greenish metallic sheen and signify the presence of thermo tolerant *Escherichia coli*. The MPN numbers were obtained by using the MPN tables for three tube series (De Man 1983).

The TVC were analysed by spread plate method using nutrient agar made by dissolving 23.5 g of nutrient agar powder in 1000 ml of distilled water (as described by manufacturer) followed by sterilization and pouring in Petri dish plates. 1.0 ml of fresh juices and water samples were serially diluted to 10^{-7} and spread onto the nutrient agar plates for incubation at 37±0.5°C for 24 hours to support bacteria growth. After incubation, all colonies that grew were counted and the results were computed as CFU/ml.

Vendors and Consumers awareness and Perception levels

The information on the vendors and consumers awareness as well as perception levels relevant for the quality of fresh juices and water used in preparation of the juices was collected using structured questionnaires administered using face-to-face interviews. A simple random sampling method was used to select the fresh juice vendors and on site consumers as described by Kothari (2004). Information gathered included sources of water, fruits and sugarcanes, storage facilities, educational status, potential health risks, level of awareness on microbiological quality and their satisfaction level. The sample size was determined using the following formula described by Kothari (2004) and shown in Equation 1:

$$\text{Sample size, } \mathbf{n} = \frac{N}{1+N(e)^2} \qquad \mathbf{1}$$

Where, n=Sample size, N=Population size, e=Margin of error

Perception and awareness of consumers was assessed through surveys and feedback forms (questionnaires) which gathered customers' opinions and perceptions. The questions were related to their experiences with consumption of fresh juices. Also, the customer feedbacks were collected, reviewed and analysed.

Potential Health Risks

The information on the potential health risks that from consuming the fresh juices was gathered from 60 consumers. A simple random sampling method was used to select on the site consumers. Among the most probable diseases that result from consuming the fresh juices were typhoid, cholera, amoebasis and gastroenteritis possibly from contamination.

Health Risks assessment

Qualitative microbial risk assessment (QMRA) was conducted following the four basic steps: hazard identification, exposure assessment, risk characterization and dose-response analysis. For the dose-response, Beta-Poisson model described by Haas et al. 1999 was used (USEPA 2012) as shown in Equation 2. In characterization of risk, the

average risk of infection from ingestion of fresh juices assumed that any bacteria that is ingested can multiply and is capable of causing infection (USEPA 2012).

$$P_{inf} = 1 - (1+d/\beta)^{-\alpha} \quad \textbf{2}$$

Where, Pinf = the probability of infection, d = the average dose; α and β = parameters corresponding to the beta Poisson distribution parameters for specific ranges, α = 0.1778 and $\beta = 1.78\times10^6$.

The annual probability of infection was determined by the following formula indicated in Equation 3:

$$P_{yr} = 1 - (1 - Pinf)^n \quad \textbf{3}$$

Where P_{yr}= Annual probability of infection, Pinf=the probability of infection, n = number of exposure events per year (event/year).

Statistical Analysis

Microsoft Excel was used in arranging, recording and making graphs for the obtained data from the laboratory experiments as well as questionnaires results. Descriptive analyses were used to compute percentages of respondents' demographic characteristics and knowledge, awareness and perception levels. Non-parametric tests and Spearman's rank correlation analysis were performed for the microbiological data using GraphPad Instat 3. Kruskal–Wallis (KW) tests for grouped data were used to assess differences between fresh juices and the sampling stations while the Mann–Whitney U test was used to test the difference between values obtained for TC and FC. Significance difference was determined at the 95% confidence level in all cases.

Results

Microbial Quality

Total Coliform for Juice and Water Samples

The average number of TC in different fresh juices at various stations is as shown in Figure 2. The TC numbers ranged from lowest mean of $6.100\pm4.180\text{x}10^6$ MPN/ml recorded in mixed fruit juice at Sharifu Shamba to highest mean of $7.483\pm3.650\text{x}10^7$ MPN/ml recorded in sugarcane juice at Ilala Boma. The TC numbers in the water used to prepare the fresh juices ranged from lowest mean of $4.800\pm1.561\text{x}10^6$ MPN/ml recorded at Sharifu Shamba to $4.080\pm2.040\text{x}10^7$ MPN/ml recorded at Ilala Boma. Statistical analysis showed that TC numbers in the different types of fresh juices (when all data are pooled together) were not significantly different (P=0.2998, KW=2.4090). However, the TC numbers from different sampling stations were significantly different (P=0.0036, KW=13.547), with Dunn's multiple comparison test showing the significant lower number at Sharifu Shamba than Ilala Boma (P<0.01), Ilala Sokoni (P<0.001) and Amana (P<0.001). On the other hand, the TC numbers in the water used to prepare the fresh juices did not differ significantly with the numbers in fresh juices. In addition, there was no significant correlation between numbers in fresh juices and in the water used for their preparation.

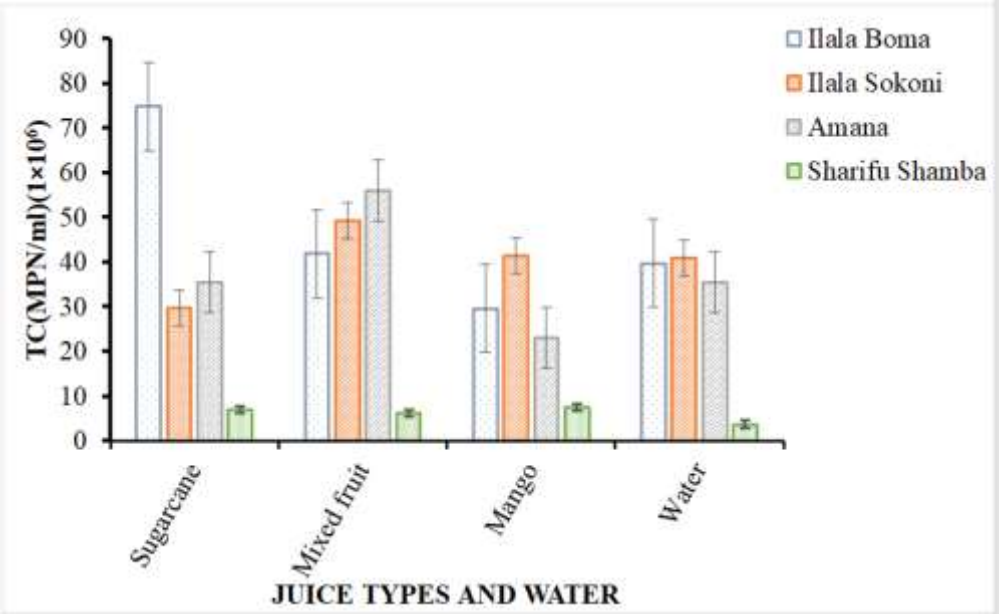

Figure 2: Average number of TC in various samples of fresh juices and water

Faecal Coliform Bacteria Counts for Juice and Water Samples

The average number of FC in different fresh juices between different stations is as shown in Figure 3. The FC numbers in the fresh juices ranged from a lowest mean of $2.566\pm0.989x10^6$ MPN/ml recorded in mango juice at Amana to a highest mean of $2.082\pm1.687x10^7$ MPN/ml recorded in mango juice at Ilala Boma. The FC numbers in the water used to prepare the fresh juices ranged from a lowest mean of $5.820\pm2.644x10^6$ MPN/ml recorded at Sharifu Shamba to a highest mean of $2.614\pm1.259x10^7$ MPN/ml recorded at Ilala Boma. Statistical analysis showed that FC numbers in the different types of fresh juices were not significantly different (P=0.3071, KW=2.3610). However, the FC numbers from different sampling stations were significantly different (P=0.0204, KW=9.7960), with Dunn's multiple comparison test showing the significant lower number at Sharifu Shamba than Ilala Boma (P<0.01), Ilala Sokoni (P<0.05) and Amana (P<0.05). Similarly, the FC bacteria numbers in the water used to prepare the fresh juices did not differ significantly with the numbers in fresh juices.

As expected, when compared the numbers of TC with those of FC in juices and water, the results showed that the numbers of TC in fresh juices and water from different sampling stations were significantly higher than the FC numbers (P<0.0001, U=5458.5). There was also a significant positive correlation between TC and FC (p=0.0073, r=0.3136).

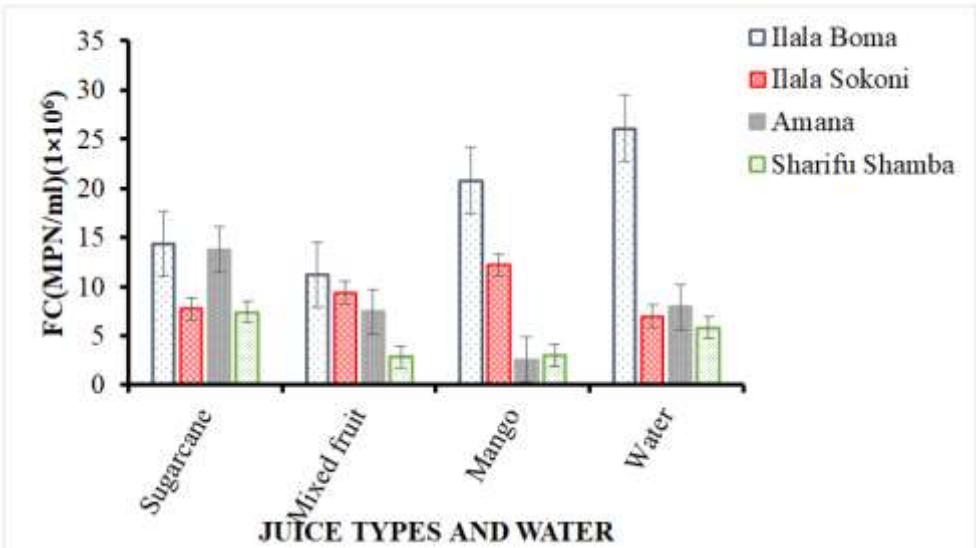

Figure 3: Average number of FC in various samples of fresh juices and water

Total Viable Counts for Juice and Water Samples

The average numbers of Total Viable Counts of bacteria (TVC) in different fresh juices at different stations are as shown in Figure 4. The TVC in the fresh juices ranged from the lowest mean of $5.046\pm1.032x10^9$CFU/ml recorded in mixed fruit juice to the highest mean of $5.871\pm0.835x10^9$CFU/ml recorded in sugarcane juice. Statistical analysis showed that TVC in the different types of fresh juices and among sampling stations were not significantly different. Likewise, TVC in waters used for preparation of different types of fresh juices did not significantly differ (P=0.3343, KW=5.7210) from numbers in juices. There was also no significant correlation between TVC in water and in juices (r=0.0579, p=0.6293).

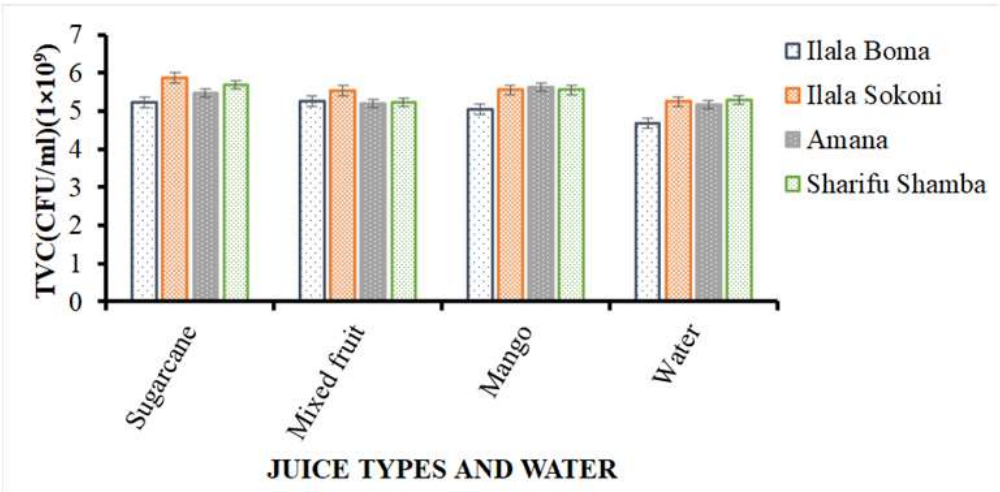

Figure 4: Average TVC of bacteria in various samples of fresh juices and water

Vendors and Consumers Awareness and Perception levels

Sociodemographic characteristics of the study participants

The study included 120 participants, of whom 60 were juice vendors and 60 were juice consumers. The majority 67% of the juice venders were male and the remaining 33% were female. Likewise, majority of consumers were male 60% and the female were 40%. The juice vendors and consumers of age group 23-31 years old were the majority, 40% and 37% respectively. Majority of the juice vendors 38% had primary education and none had higher education or vocational training or training in food hygiene and safety. On the other hand, 26% of the consumers had secondary education, few 12% had higher education and 17% had vocational training. Some participants, 20% of consumers and 25% of vendors had no formal education. The summary of the sociodemographic characteristic of the participant is as shown in Table 2.

Table 2: Sociodemographic characteristics of the participant

		Female (n=20)		**Male (n=40)**		**Total (n=60)**	
		n	**%**	**n**	**%**	**n**	**%**
	Age Range						
Vendors	14-22	16	40	2	10	**18**	**30**
	23-31	18	45	6	30	**24**	**40**
	32-40	4	10	8	40	**12**	**20**
	41 & above	2	5	4	20	**6**	**10**
Consumers	14-22	9	25	5	21	**14**	**23**
	23-31	13	36	9	38	**22**	**37**
	32-40	8	22	6	25	**14**	**23**
	41 & above	6	17	4	16	**10**	**17**
	Educational Level						
Vendors	Informal education	10	25	5	25	**15**	**25**
	Primary education	14	35	9	45	**23**	**38**
	Secondary education	16	40	6	30	**22**	**37**
	Higher education	0	0	0	0	**0**	**0**
	Vocational training	0	0	0	0	**0**	**0**
Consumers	Informal education	7	19	5	21	**12**	**20**
	Primary education	8	22	7	29	**15**	**25**
	Secondary education	10	28	6	25	**16**	**26**
	Higher education	5	14	2	8	**7**	**12**
	Vocational training	6	17	4	17	**10**	**17**

Vendors' preparation and handling practices of fresh juices

Results on types and sources of materials vendors use to make fresh juice and on how they handle utensils for serving juices are as shown in Table 3. Half of vendors 50% were making sugarcane juice and majority 92% collected the raw materials for fresh juices from the nearby markets while few of them 8% collected from other sources (e.g. auction). Majority of juice vendors 83% used tap water for preparing the fresh juices while 17% used well water. Also 80% of the juice vendors did not treat the water before using it because they believe the clear waters by appearance were safe and free from contaminants. When asked about handling of fresh juices, 75% of the juice vendors stored bulk of their fresh juices in 10-20 litres bucket while 25% filled the fresh juices in small recycled bottles (0.5-1.5 litres) and stored them in cool boxes with ice blocks as they are easily affordable compared to refrigerators. In addition, the majority of the vending sites (54%) were situated very close to garbage and other wastes placed in open sacks and 46% uncovered dustbins that promoted the presence of flies in the vending area. Results for other attributes were as shown in Table 3.

Table 3: Types and sources of raw material, preparations and handling practices of juices by vendors

Variables	Female (n=20)		Male (n=40)		Total (n=60)	
	n	**%**	**n**	**%**	**n**	**%**
Type of fresh juices sold by vendor						
Sugarcane	27	67	3	15	**30**	**50**
Mixed Fruit	7	18	11	55	**18**	**30**
Mango	6	15	6	30	**12**	**20**
Source of raw material for making juices						
Markets (Buguruni and Ilala)	37	93	18	90	**55**	**92**
Other sources (e.g. Auction)	3	7	2	10	**5**	**8**
Source of water for making juices						
Tap water	33	83	12	60	**45**	**75**
Well water	5	12	5	25	**10**	**17**
Bottled water	2	5	3	15	**5**	**8**
If treat water for making juice						
I don't treat	37	92	11	55	**48**	**80**
I treat	3	8	9	45	**12**	**20**
Utensils for serving customers						
Glasses	22	55	10	50	**32**	**53**
Reused bottles	17	42	7	35	**24**	**40**
Disposal cups	1	3	3	15	**4**	**7**
Water for cleaning utensils						
Cold water with soap	25	63	10	50	**35**	**58**
Cold water without soap	15	37	10	50	**25**	**42**
Hot water	0	0	0	0	**0**	**0**
Running water	0	0	0	0	**0**	**0**

The assessment of exposure, the study identified them by on-site survey of the vending site and its surroundings i.e. by assessing handling during preparation, storing and distribution of fresh juices to consumers. During preparation of fresh juices, street

vendors did not cover their hands and were in direct contact with the raw materials (fruits), and the way they handled (with bare hands) and stored (in dirty buckets) the fresh juices was very poor.

Perceptions and awareness of consumers on microbial quality of fresh juices

Fresh juice consumers were asked to respond on their perception and awareness of microbial quality of fresh juices such as frequency and reason for consumption, hygiene practices of vendors, and probability of pathogenic bacteria contamination as well as possible disease that may be caused. The results were as summarised in Table 4. The majority of consumers (60%) responded that they consume fresh juices every day and main reason for consuming was its taste (40%) and health benefits (23%). Many (52%) of the consumers were satisfied with the hygienic practices of the vendors in processing the fresh juices and their vending sites while 48% were not satisfied. The majority of consumers (58%) were aware that there is probability of bacteria contaminations in the prepared fresh juices because sometimes they had experienced discomfort after consuming the fresh juices 63%. They cited typhoid 47% as most likely disease to occurby consuming contaminated juice followed by other common foodborne diseases as shown in Table 4.

Table 4: Perception and awareness assessment of fresh juice consumers

Variables	Female (n=24)		Male (n=36)		Total (n=60)	
	n	%	n	%	n	%
Frequency of juice consumption						
Everyday	24	67	12	50	**36**	**60**
Once per week	9	25	6	25	**15**	**25**
Once per month	1	3	2	8	**3**	**5**
Others	2	5	4	17	**6**	**10**
Reason for consumption						
Health benefits	8	22	6	25	**14**	**23**
Taste	14	39	10	42	**24**	**40**
Aesthetic appeal	6	17	4	17	**10**	**17**
Other reason	8	22	4	16	**12**	**20**
If satisfied by Hygiene practices of vendors						
Yes	20	56	11	46	**31**	**52**
No	16	44	13	54	**29**	**48**
Probability of bacterial contamination						
Yes	18	50	17	71	**35**	**58**
No	16	44	6	25	**22**	**37**
Not sure	2	6	1	4	**3**	**5**
Most probable diseases						
Typhoid	16	44	12	50	**28**	**47**
Cholera	6	17	4	16	**10**	**17**
Gastroenteritis	3	8	2	8	**5**	**8**
Amoebiasis	3	8	3	13	**6**	**10**
Not sure	8	22	3	13	**11**	**18**

Health risks

Following the Beta-Poisson model, values for each assessed indicator bacteria were determined since each has its specific probability of infection and the results are as shown in Table 5. The annual risk of a consumer getting TC, FC and, or TVC infection from consuming the studied fresh juices was 10^{-1}. That means, there will be a risk of one infectious bacteria per 10

consumers per year, which has exceeded the benchmark scenarios by a 3 order of magnitude (10^{-3}). Consumers may be at risk of contracting diarrhoeal diseases.

Table 5: Annual probabilities of TC, FC and TVC of bacterial infection associated with the ingestion of fresh juices

Bacteria	Sugarcane Juice		Mixed Fruit Juice		Mango Juice	
	P_{inf}	P_{yr} (n=52)	P_{inf}	P_{yr}(n=52)	P_{inf}	P_{yr}(n=52)
TC	4.68×10^{-3}	2.16×10^{-1}	5.07×10^{-3}	2.32×10^{-1}	5.16×10^{-3}	2.40×10^{-1}
FC	3.00×10^{-3}	1.44×10^{-1}	2.94×10^{-3}	1.42×10^{-1}	2.16×10^{-3}	1.07×10^{-1}
TVC	2.23×10^{-1}	9.90×10^{-1}	2.18×10^{-1}	9.90×10-^{1}	2.20×10^{-1}	9.90×10^{-1}

Discussion

Microbiological quality of fresh juices

The results of TC and FC numbers in this study were very high exceeding safety standards. According to the World Health Organization standards (WHO 2017) and the Tanzanian National Standards (TBS 2017), the limit values for TC and TVC in fresh juices should not exceed $1.0x10^3$ MPN/ml and for FC should be absent (0 MPN/ml). This means that all fresh juices were microbiologically not safe for consumptions as they exceed the recommended standards above. The results were similar to study by Mwambete and Mpenda (2019) who showed that freshly squeezed sugar-cane juices vended in Dar es Salaam were microbiologically of low quality beyond the acceptable limits.

Microbial quality assessment is very important for the safety of fresh juices because it shows whether it is fit or unfit for human consumption that directly translates to the health status of a particular locality (Ahmed et al. 2017). The quality of fresh juices prepared by the street vendors depends on handling from the initial stage of the raw materials, gathering, preparations and storage to the final stage of consumption (Mwambete and Mpenda 2019). Many studies in Africa reported that most of the fresh juices prepared by the street vendors do not meet safety standards and are responsible for various food-borne diseases such as typhoid and cholera (Wadamori et al. 2017, Asghar et al. 2018, Mahamuda et al. 2017). The awareness of vendors and consumers on microbial quality of the fresh juices is therefore important because it will most likely influence an improvement in food safety, proper processing methods and hygiene practices (Ndiege 2016).

On comparison of different fresh juices and water, our results showed no significant different in TC, FC and TVC numbers in fresh juices as well as with the water used to prepare the fresh juices. However, the highest bacterial contaminations were found in sugarcane juices compared to mixed fruit and mango juices probably due to the fact that sugarcane stems are largely placed on the ground which may allow easer microorganisms contaminations as compared to other fruits. The other reason for higher contamination in sugarcane juice may be due to favourable condition for microbial growth as explained by Mwambete and Mpenda (2019) who showed that sugarcane juices were highly contaminated with coliforms due to pH level, sugar content and unsafe water used for the dilution process. Other researchers have reported similar results from outside Africa including Asghar et al. (2018) in Lahore City Pakistan who established highermicrobial contaminations in sugarcane juice compared to the other fresh juices. They also associated higher contamination ofsugarcane juice with favourable pH level, sugar content, improper handling of raw materials and use of unsafe water for dilution process. On the other hand, the lack of significant difference with water shows that the water used for preparation of the fresh juices may be the main source of contamination in the fresh juices. Mwambete and Peter (2011) had similar conclusion that TC, FC and TVC in the fresh juices can be attributed to the use of unsafe water during

processing and preparation. These findings were similar to other studies conducted in India (Adjrah et al. 2012 and in Tanzania (Simforian 2013) which reported that the fresh juices sold in the streets were highly contaminated with TC, FC and TVC than the water used to prepare the fresh juices.

Vendors and consumers awareness and perception levels

The majority of street fresh juice vendors were male showing dominance of male in the fresh juice vending business. Most of them were youth aged between 23-31 years. This finding were similar to other studies conducted in Kenya (Ndiege 2016, Muinde and Kuria 2005) and in Tanzania (Simforian 2013) which reported that the street juice vending business is dominated by male with the age group between 21-35 years, which is the most active group in business in developing countries. Regarding the education level, the findings are in agreement with other studies that majority of the juice vendors had primary and secondary education level (Muinde and Kuria 2005, Adjrah et al. 2012). The education level (formal education) has been argued to have an influence on the handling practices because educated vendors are more likely to have good skills and knowledge of hygienic practices, handling and preparation of fresh juices (Kaddumukasa et al. 2019).

On assessment of possible sources of juice contamination, it was found that the water used for juice preparation could be the main sourceas majority of respondents did not treat water before using. Although majority said that they used tap water 83% and only few 17% used well water, the results showed that the used water samples were highly contaminated. This means the tap water used at the studied site might be from unreliable sources. In Dar es Salaam, some residents fetch water from wells (from ground) and supply to neighbours as tap water without treatment. In most cases, vendors buy contaminated water without knowledge that it is from wells (personal experience). Due to this fact, the Dar es Salaam City Council recommends to boil water for drinking or when used for food preparation. However, as can be seen in this study, only 20% of the fresh juice vendors treated the water before using while majority 80% did not treat it, this is because the fresh juice vendors believed that the water was clean by appearing colourless, thus it was safe (also see Lyimo et al. 2007). This may expose consumers to health risks. The findings by Ndiege (2016) in Kenya and Mwambete and Mpenda (2019) in Tanzania revealed similar results that majority of the street juice vendors did not treat the water before using it, hence contaminating the prepared fresh juices.

Other sources of contamination could be using dirty storage utensils and from the working environment. The same observation has been reported being practiced by many other street vendors in the developing countries (Muinde and Kuria 2005, Simforian 2013, Nonga et al. 2014, Ndiege 2016). For example, Muinde and Kuria (2005) and Ndiege (2016), reported that fresh juice vendors in their community put wastes in sacks in the open and close to the juice vending sites while other waste were put in open dustbins promoting flies to the vending area. These flies can easily carry contaminants to serving utensils and in-turn to the juices. A study by FAO (2011) recommends that, “the place of preparation of food should be kept clean all the time and should be far from any source of contamination

Perceptions and awareness of consumers on microbial quality of fresh juices

Regarding the consumers' awareness on hygienic practices of the street juice vendors, majority of the respondents were satisfied, despite the fact that fresh juices were prepared with untreated water, washed utensils with cold water and stored in dirty plastics buckets that could lead to contaminations. This indicated that the vendors and consumers awareness of hygienic practices and safety measures were low. Similar findings have been reported by researchers such as Simforian (2013) in Dar es Salaam, Muinde and Kuria (2005) in

Kenya that the consumers were not aware on microbial issues but satisfied with the hygienic practices of the street juice vendors which contributed to contaminations of the fresh juices. Majority of the respondents were aware of microbial contaminations and the risks they are likely to incur by consuming the fresh juices. They pointed typhoid and other food borne diseases as outcome of consuming contaminated foods. Luckily, majority of the consumers 63% did not experience any discomfort from consuming the fresh juices. Even those who had experienced discomfort, most of them continued to consume street vended juice as they are not sure of what caused the illness. A study carried out by Srisangavi and Sivapriya (2021) reported that consumers feared that by consuming the contaminated fresh juices prepared by the street vendors they could contract diarrhoeal diseases although none of them knew the sources for contamination. Another study by Mahamuda et al. (2017) showed that bacteria can pose health risks to consumers due to consumption of fresh juices. Generally, the preparation practices and personal cleanliness of the juice vendors in Ilala Ward were observed to be unsatisfactory posing health risks to consumers.

In the hazard identification, microorganisms from the raw materials, unhygienic surrounding environment and water used for juice preparation could potentially be found in the fresh juices. As shown in the results, majority of street vendors did not cover their hands, were in direct contact with the raw materials (fruits) and stored the fresh juices in dirty buckets. Different literature show that pathogenic bacteria can enter in juices during preparation and storage practices and in turn pose adverse health effects. The consumers get contaminated through ingesting this fresh juices andthe vulnerable groups are adults and immunocompromised individual (Mwambete and Mpenda 2019).

Some consumers due to consumption of contaminated fresh juices may develop a clinical illness and symptoms that are recognisable (USEPA 2012). The results obtained from the study were found to be above tolerable limit. Other infections may lead to illness and subsequently death although there are infections that remain subclinical. Individuals with pre-existing immunity may be protected from infection and illness at low doses (USEPA 2012). Proper handling practices can be adopted to minimise the risk of infection by fresh juice consumption.

Conclusions and Recommendations

The fresh juices investigated were not microbiologically safe because the numbers of TC, FC and TVC were above recommended safe limits. The sources of contamination were mainly due to poor hygiene practices of the juice vendors, use of unsafe water and poor vending environment. Consumption of fresh juices exposeconsumers to health riskof contracting diarrhoeal diseases since the annual risk of infection exceeded the tolerable risk per person per year. It is recommended that street vendors adopt proper hygiene measures in handling and preparation of fresh juices to safeguard good health of fresh juice consumers. In this regard, appropriate short-course training on the microbial quality, food safety, sanitation and hygienic practices about preparation of the fresh juices should regularly be planned and offered to respective vendors and consumers. There is also an urgent need of authorities to enforce policy on vending practices and conduct regular inspections on street vending sites to ensure appropriate practices are adhered to all the time and at all stages of fresh juices. The public should be provided with education (awareness) on risks and health problems they could face by consuming contaminated street fresh juices. In addition, it is recommended to extend the study to other urban areas in Tanzania.

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