


Research Article

Assessing Microbiological Quality and Safety of Fresh Fruits Sold at Nekemte Town, Western Ethiopia

Desalegn Amenu^{1, 2, *} , Ayantu Nugusa², Ra'el Desalegn³, Chimdesa Tolera³, Temesgen Tafesse⁴

¹Biology Department, Jimma University, Natural Sciences, Jimma, Ethiopia

²Department of Biology, College of Natural and Computational Science, Wollega University, Nekemte, Ethiopia

³East Wollega Zonal Health, Nekemte, Ethiopia

⁴Armauer Hansen Research Institute, Addis Ababa, Ethiopian

Abstract

There is ample evidence that eating fresh fruits has numerous health and nutritional advantages, making them an indispensable part of the human diet. They are one of the main causes of food-borne illnesses if they are not properly harvested, processed, stored, and handled. This study aimed to assess the microbial quality and safety of fresh fruits sold in Nekemte town. Sixty samples were collected from open markets and analyzed for their microbial quality and safety. The study found that the highest total viable count was found in avocado, followed by papaya, banana, and orange. The highest ASFBC count was found in banana, while the lowest was in orange. The highest total coliform count was found in banana. The study identified eleven bacterial genera, including *Enterobacter* spp, *Escherichia* spp, *Klebsella* spp, *Staphylococcus* spp, *Aeromonas* spp, *Bacillus* spp, *Shigella* spp, *Proteus* spp, *Pseudomonas* spp, *Salmonella* spp, and *Streptococcus* spp. The most dominated genera were *Staphylococcus* spp, *Escherichia* spp, *Streptococcus* spp, *Shigella* spp, *Aeromonas* spp, and *Proteus* spp. The results suggest that contamination during fruit harvesting or processing and handling could lead to foodborne illnesses. Regular supervision and training can improve the quality of fresh fruit.

Keywords

Antibiotic Susceptibility, Antibiotic, Fresh Fruits, Microbial Quality and Safety, Nekemte Town

1. Introduction

Fruit refers to the mature ovary of a plant, including seeds, covering, and tissue. Fresh fruits are essential for human diet and have health and nutritional benefits [1, 2, 5, 6, 13]. In Ethiopia, fruits like banana, mango, avocado, papaya, and orange are produced and exported, with potential for domestic

import and export markets and industrial processing [17]. Fresh fruits are increasingly recognized as crucial for nutrition and health, with increasing consumer demand and global trade leading to increased international fruit trade [15]. Common fruits in Ethiopia include pineapples, bananas, avo-

*Corresponding author: wadadesalegn@gmail.com (Desalegn Amenu)

Received: 29 March 2024; Accepted: 13 April 2024; Published: 7 December 2024



Copyright: © The Author(s), 2024. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

cados, mangoes, papayas, and grapes. However, post-harvest problems, such as harvesting activities, post-harvest handling, transportation, and storage, can significantly impact the quality and safety of fresh fruit, affecting its potential for domestic and export markets and industrial processing [7, 17].

Improper handling, inadequate transport, and low storage facilities pose significant problems in the production, marketing, and consumption of fruits. These issues expose fruits to microbial contamination, affecting product safety and quality. Fresh fruits are a significant source of foodborne pathogens, posing a potential health risk. Poor handling can damage fresh produce, making it susceptible to spoilage and pathogenic microorganisms. Damaged surfaces also allow microorganisms to enter plant tissues.

In Nekemte town, markets often sell supplementary fruits like papaya, banana, mango, and avocado. However, these

fruits are obtained from various farmlands without proper handling practices. Poor market conditions, such as poor hygiene, unsafe containers, and unsanitary marketing environments, contribute to contamination. This study investigates the microbiological quality and safety of fresh fruits sold online in Nekemte town.

2. Material and Methods

The study was conducted in Nekemte town, the capital of the East Wollega Zone, Ethiopia, from June 2018 to August 2018. The area is known for its coffee production and warm, temperate climate, with an average annual temperature of 21 °C and rainfall of 1497 mm (Figure 1).

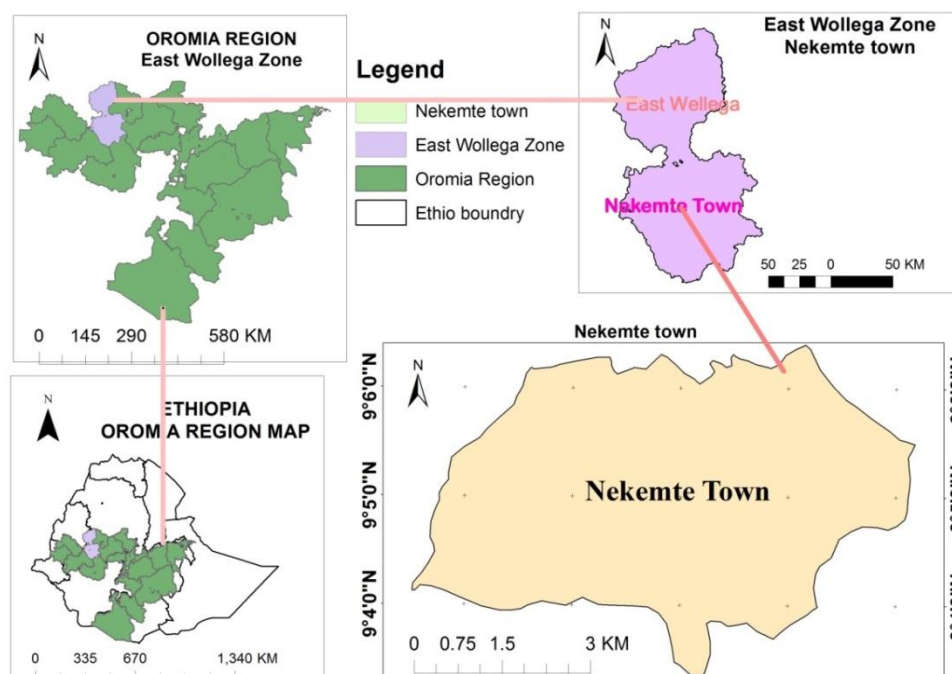


Figure 1. Map of the study area (Nekemte town).

2.1. Study Design

The study utilized experimental methods for the isolation and characterization of indicator organisms, pathogens, and dominant flora, followed by standard isolation methods, morphological, biochemical, and microscopic examination tests.

2.2. Isolation and Characterization

About 500mg of fresh fruits were collected and homogenized using laboratory tools. Diluted samples were transferred to sterilized water, homogenized, and serial dilutions prepared. The diluted samples were then spread on nutrient

agar and incubated at 32-37 °C for 24-48 hours.

2.3. Microbiological Analysis

The study used plate count agar to perform total colony count of bacteria. The total microbial count was recorded as colony forming units per milliliter (cfu ml⁻¹). Total coliform count (TCC) was obtained using the MPN technique, inoculating dilution tubes into Lactose Broth (LB) tubes and incubating at 35 °C for 48 hours. Fecal coliform count was calculated using the MPN method, inoculating tubes into EC broth and incubating at 45.5 °C. Staphylococci count (SCC) was performed by transferring dilutions into sterile Petri dishes and incubating them in Mannitol salt agar medium. The col-

onies were enumerated and tested by coagulase test after overnight sub-culturing in nutrient agar plates.

2.4. Detection of Major Bacterial Pathogens from Fresh Fruits

The FDA's guidelines were followed for pathogen detection, using a juice sample mixed with saline solution and incubated at 37°C for 24 hours, then streaked on various culture media [5, 6].

2.5. Identification of Micro-Flora

The study involved determining the bacterial load, randomly selecting four colonies from countable plates, purifying them, and identifying dominant aerobic viable bacteria through morphological and biochemical tests [10].

2.6. Antimicrobial Susceptibility Testing

The study used an in-vitro test to confirm the susceptibility of isolates to antimicrobial agents or detect resistance in a human pathogen. The test involved adjusting suspensions, using sterile cotton swabs, and using ten antibiotic discs. The zone of inhibition was measured and categorized as susceptible, intermediate, or resistant [1].

2.7. Data Analysis

Data from questionnaires were verified, filtered, and recorded

in MS-Excel. TVC, TCC, and FCC values were log transformed for symmetrical frequency distribution. Statistical analysis was performed using SPSS software, determining bacterial counts among fruit juice and vegetable salad samples.

3. Result and Discussion

A total of 60 fresh fruit samples from four markets in Nekemte town were analyzed for total viable bacterial count. The highest total viable count was found in avocado (7.09 log cfu/ml), followed by papaya, mango, banana, and orange. The mean bacterial count showed significant differences. The study found that all fruit samples had higher viable bacterial counts than permitted, with the mean total aerobic viable bacterial counts above Gulf standards (Table 1). This contradicts a previous study by Rahman et al. [12], which found higher total viable bacterial counts in fresh fruits compared to commercially packed juice samples. These variations in bacterial counts could be attributed to differences in sampling techniques, storage conditions, or geographical locations. The study found lower total bacteria count in mango compared to the author's findings. Factors like geographical variation, pH, seasonal variation, hygiene, incubation time, and storage may contribute to the difference. Microbes in food can be linked to improper handling, contaminated water, cross-contamination, and dirty processing utensils. Contamination is mainly due to poor water quality, unhygienic conditions, and vendor personal hygiene (Table 2).

Table 1. Total viable bacterial count (mean \pm SD (log cfu/ml) of fresh fruits, 2020.

Samples	TVBC	TTC	TFC	TSC	TASFBC
Avocado	7.09 \pm 0.71 ^a	3.29 \pm 3.47 ^c	4.69 \pm 2.86 ^c	4.87 \pm 2.42 ^c	5.45 \pm 2.58 ^{ab}
Mango	5.99 \pm 2.86 ^b	4.43 \pm 3.29 ^b	6.68 \pm 0.64 ^a	4.23 \pm 2.66 ^c	5.57 \pm 2.64 ^{ab}
Papaya	4.76 \pm 3.53 ^{bc}	5.18 \pm 2.47 ^{ab}	5.84 \pm 1.93 ^b	6.27 \pm 1.18 ^a	6.08 \pm 2.02 ^a
Banana	5.44 \pm 3.32 ^{bc}	5.83 \pm 1.90 ^a	2.64 \pm 3.27 ^{de}	4.68 \pm 2.95 ^c	6.28 \pm 0.61 ^a
Orange	6.15 \pm 2.06 ^b	5.75 \pm 1.90 ^a	5.14 \pm 3.14 ^{bc}	4.13 \pm 3.16 ^c	3.38 \pm 3.56 ^d
Total	5.88 \pm 2.72 ^{bc}	4.90 \pm 2.77 ^b	5.00 \pm 2.83 ^c	4.84 \pm 2.60 ^c	5.35 \pm 2.61 ^{ab}

Data represent mean \pm standard deviation, a, b, c, d= mean within column with the same letter for same count are not significantly different (P<0.05). Key note: TVBC (Total Viable Bacterial Counts), SD (standard deviation), TTC (Total Coliform Counts), TFC (Total Fecal Coliform Counts), TSC (Total Staphylococci Counts), TASBC (Total Aerobic Spore Forming Bacterial Counts).

Table 2. Total viable bacterial count (mean \pm SD (log cfu/ml) of fresh fruits, Nekemte town, 2020.

Sites	Samples	TVBC	TTC	TFC	TSC	TASFBC
Kebele 03	Avocado	6.91 \pm 0.75	6.39 \pm 0.63	5.89 \pm 0.50	5.89 \pm 0.50	4.48 \pm 0.89

Sites	Samples	TVBC	TTC	TFC	TSC	TASFBC
Kebele 04	Mango	7.11±0.87	6.34±0.39	6.89±0.72	6.89±0.72	4.34±0.79
	Papaya	4.70±0.10	6.13±0.45	6.60±0.69	6.60±0.69	4.18±0.64
	Banana	4.65±0.04	6.52±0.62	4.19±3.64	4.19±3.64	6.57±0.67
	Orange	4.48±0.90	6.01±0.72	6.85±0.79	6.85±0.79	0.00±0.00
	Total	5.57±2.93	6.28±0.52	6.08±1.80	6.08±1.80	3.91±0.33
	Avocado	7.26±0.88	0.00±0.00	4.27±3.72	3.56±3.11	6.60±0.53
	Mango	6.87±0.81	0.00±0.00	6.59±0.57	3.48±3.04	6.46±0.34
	Papaya	4.75±0.13	6.40±0.68	5.84±0.67	6.32±1.44	6.99±0.85
	Banana	5.07±0.40	6.19±0.23	0.00±0.00	6.54±1.10	6.00±0.83
	Orange	6.13±0.75	4.12±3.58	6.93±0.85	6.31±1.48	6.57±0.69
	Total	6.02±2.55	3.34±3.25	4.73±3.01	5.24±2.37	6.52±0.66
	Avocado	7.04±0.79	6.80±0.83	6.41±0.64	3.64±3.17	6.50±0.58
	Mango	4.92±0.28	6.80±0.62	6.83±0.85	3.62±3.17	4.74±0.12
	Papaya	4.80±0.17	2.20±3.81	4.45±3.87	6.18±1.09	6.43±0.79
	Banana	7.02±0.86	4.60±4.00	6.37±0.70	2.41±4.19	6.14±0.62
Kebele 05	Orange	6.86±0.77	6.67±0.69	6.76±0.54	3.77±3.28	0.00±0.00
	Total	6.13±2.56	5.41±2.85	6.17±1.80	3.92±2.95	4.76±0.02
	Avocado	7.14±0.86	0.00±0.00	2.20±3.81	6.19±0.81	4.24±0.70
	Mango	5.04±0.39	4.58±3.98	6.41±0.71	6.27±1.35	6.75±0.64
	Papaya	4.80±0.17	6.01±0.71	6.46±0.58	6.25±1.73	6.72±0.73
Kebele 07	Banana	5.03±0.37	6.03±0.62	0.00±0.00	5.97±1.31	6.40±0.51
	Orange	7.12±0.79	6.20±0.79	0.00±0.00	0.00±0.00	6.97±0.80
	Total	5.82±3.06	4.56±2.90	3.01±3.36	5.24±2.37	6.22±1.82

Data represent mean ± standard deviation, a, b, c, d= mean within column with the same letter for same count are not significantly different ($P<0.05$). Key notes: TVBC (Total Viable Bacterial Counts), SD (standard deviation), TTC (Total Coliform Counts), TFC (Total Fecal Coliform Counts), TSC (Total Staphylococci Counts), TASBC (Total Aerobic Spore Forming Bacterial Counts).

The study found that all fresh fruits had a mean ASFBC of 5.35 log cfu/ml, with banana having the highest count (6.28 log cfu/ml). All samples were contaminated with aerobic spore-forming bacteria, possibly due to poor handling or heat-resistant spore formation. Spore-forming bacteria in foods are crucial for resistance to heat, freezing, and chemicals during processing. Inline to this stud, in Dhaka, Bangladesh, a study found that 64.91% of samples had *Bacillus cereus*, indicating a higher prevalence of these bacteria than the current study [13].

A study of 60 fresh fruits revealed a mean total coliform count of 4.90 log cfu/ml, with banana having the highest mean (5.83 log cfu). This study found that the mean total coliform count was higher in banana than in papaya, mango, and orange. The variations may be due to poor sanitation

practices, inappropriate storage conditions, contamination rate of raw material, growing area, geographical location, and hygienic practices. The study's findings contradict previous studies.

The mean count of total coliform in all samples, which included sixty fresh fruits collected and analyzed for the purpose of determining the total coliform count (TCC), was 4.90 log cfu/ml. Similarly, bananas had the highest mean (5.83 log cfu) compared to papaya, mango, and oranges, which had 5.18, 4.43, and 5.75 log cfu, respectively. There was a significant difference in the mean total coliform counts ($P<0.001$). The highest TCC was found in avocados, which were found to have higher TCCs than those found in prior studies conducted in Hawassa (3.3.98±1.23 log cfu/ml) and Nagpur city (4 log cfu/ml) [16, 8]. The research's TCCs, however, were

lower than those of a related study conducted in Bahir Dar [9]. These variations may be due to poor sanitation practices, improper storage conditions, and contamination rate of raw material, growing area, geographical location, and hygienic practices.

The study found that all fresh fruits were contaminated with fecal coliforms, with the highest mean count recorded from avocado. In Bangladesh, most fresh fruits samples showed equal or slightly higher fecal counts than permitted, making them unfavorable for consumption [14]. Fecal coliform counts are efficient indicators of sanitization, but detection does not indicate the presence of pathogens. Potential causes of fecal contamination include exposure to feces during growth, poor water quality, unhygienic conditions, inadequate storage, and personal hygiene of vendors.

The study found that all fresh fruit samples showed colonial growth on mannitol salt agar (MSA) for staphylococcus species. The mean count of all types of fresh fruits was 4.84 log cfu/ml, with papaya having the highest count at 6.27 log cfu/ml. The presence of staphylococci indicates contamination from food handlers, inadequately cleaned equipment, or raw animal products. The study found that papaya had the highest number of staphylococcal species (Table 3). This finding is consistent with previous research, which found the highest number of staphylococcus species in avocado in Jimma and Nigeria [8, 3]. Out of 60 fresh fruits, 35% of *E. coli* was detected in avocado, while *S. aureus* was the most common in papaya, while *Salmonella* and *Shigella* were detected in a few percentages.

Table 3. Frequency of some bacterial pathogens detected from fresh fruits, Nekemte 2020.

Sample types	Sample	<i>E.coli</i>	<i>S.aureus</i>	<i>Salmonella species</i>	<i>Shigella species</i>
Avocado	12.00	7(35%)	3(15%)	1(5%)	2(10%)
Mango	12.00	4(20%)	1(5%)	2(10)	3(15%)
Papaya	12.00	3(15%)	4(20%)	1(5%)	4(20%)
Banana	12.00	2(10%)	3(15%)	3(15%)	1(5%)
Orange	12.00	3(15%)	2(10%)	2(10%)	1(5%)

The study found that *Salmonella* species and *Shigella* spp. were present in 1-20% of fruit samples, slightly lower than previous reports. In Bangladesh, 7.89% of fresh fruits were found to have *Salmonella* species, while in India, 50% of fruit and vegetables were positive [13].

In Amravati city, *E.coli*, *Salmonella* spp., and *S. aureus* were found in 40%, 16%, and 6% of street-vended fruit samples [16]. The incidence of bacterial pathogens was less than 35%. *E. coli* was found in 35% of samples, indicating cross-contamination and possibly due to poor hygienic practices. Factors such as geographical variation, pre-harvest and post-harvest practices, sanitary habits of juice makers, population demography, and high urbanization may contribute to the

low incidence of salmonella in Ethiopia.

The study found that eleven bacterial genera were detected in fresh fruit, including *Enterobacter* spp, *Escherichia* spp, *Klebsella* spp, *Staphylococcus* spp, *Aeromonas* spp, *Bacillus* spp, *Shigella* spp, *Proteus* spp, *Pseudomonas* spp, *Samonella* spp, and *Streptococcus* spp. *Staphylococcus* spp was the dominant organism, followed by *Escherichia* spp and *Streptococcus* spp (Table 4). Similar studies have been reported the same results with this study [4, 11, 14]. In Sudan, a study found *Bacillus* (17%) as the third most dominant genus in vegetable salad, following *Staphylococcus*, *Entrobacteriaceae* (25%), and *Bacillus* in fruit juices.

Table 4. Dominant bacterial pathogens isolated from fresh fruits collected from Nekemte town.

Isolated pathogens	Fruits	Total sample	Frequency	Percentages
<i>Staphylococcus</i> spp.	Avocado	12	3	5%
	Papaya	12	2	3.33%
	Banana	12	2	3.33%
	Orange	12	1	1.67%

Isolated pathogens	Fruits	Total sample	Frequency	Percentages
<i>Escherichia spp.</i>	Total	60	8	13.3%
	Avocado	12	3	5%
	Papaya	12	1	1.67%
	Orange	12	2	3.33%
	Total	60	6	10%
<i>Bacillus spp.</i>	Mango	12	3	5%
	Papaya	12	1	1.67%
	Orange	12	1	1.67%
	Total	60	5	8.33%
	Mango	12	1	1.67%
<i>Pseudomonas spp.</i>	Papaya	12	2	3.33%
	Banana	12	1	1.67%
	Orange	12	1	1.67%
	Total	60	5	8.33%
	Mango	12	1	1.67%
<i>Enterobacter spp.</i>	Total	60	3	5%
<i>Klebsella spp.</i>	Total	60	3	5%
<i>Salmonella spp.</i>	Total	60	3	5%
<i>Streptococcus spp.</i>	Total	60	2	3.33%
<i>Shigella spp.</i>	Total	60	2	3.33%
<i>Aeromonas spp.</i>	Total	60	2	3.33%
<i>Proteus spp.</i>	Total	60	1	1.67%

Four bacteria were tested for antibiotic susceptibility against eight common antibiotics: Amoxicillin, Ampicillin, Ciprofloxacin, Chloramphenicol, Erythromycin, Gentamicin, Tetracycline, and Vancomycin, determining resistance, intermediate, and susceptibility based on zone of inhibition (Table 5).

Table 5. Antimicrobial susceptibility patterns of pathogenic bacterial isolates from fresh fruits samples (frequency).

Antibiotics	Bacterial isolates											
	<i>Escherichia spp</i> (N=6)			<i>Staphylococcus</i> (N=8)			<i>Salmonella spp</i> (N=3)			<i>Shigella spp</i> (N=2)		
	R	I	S	R	I	S	R	I	S	R	I	S
Amox. (30µg)	0	0	6	4	2	2	1	1	0	2	0	0
Amp.(30µg)	1	4	1	5	1	2	3	0	0	2	0	0
Cipro. (5µg),	0	2	4	0	2	6	0	0	3	0	0	2
C. (30µg),	1	1	4	1	1	6	0	0	3	0	0	2
Ery. (15µg),	0	2	4	0	3	5	2	1	3	0	0	2
Gent.(10µg),	0	0	6	0	0	8	0	0	3	0	0	2
Tetra. (30µg)	4	1	1	1	1	6	2	1	0	2	0	0

Antibiotics	Bacterial isolates											
	<i>Escherichia spp</i> (N=6)			<i>Staphylococcus</i> (N=8)			<i>Salmonella spp</i> (N=3)			<i>Shigella spp</i> (N=2)		
	R	I	S	R	I	S	R	I	S	R	I	S
Vanco.(30µg)	6	0	0	8	0	0	3	0	0	2	0	0

Key notes Amox=Amoxicillin, Amp=Ampicillin, Cipro= Ciprofloxacin, C=Chloramphenicol, Gen=Gentamicin, E=Erythromycin, Te=Tetracycline, Va=Vancomycin, R=resistant, I=intermediate, S=susceptible.

Antimicrobial resistance in bacteria has increased over time, with *S. aureus* showing resistance to vancomycin, amoxicillin, and ampicillin, while *Staphylococcus spp.* showed high rates of drug resistance against ampicillin (93% and 92%). *E. coli* isolates showed high resistance rates to tetracycline and vancomycin, while some were sensitive to gentamicin, amoxicillin, and erythromycin. *Salmonella spp.* was highly susceptible to ciprofloxacin, gentamicin, chloramphenicol, and vancomycin, while *Salmonella spp.* was resistant to erythromycin and tetracycline with over 75%. This finding is consistent with previous reports in Ethiopia and Kenya [2, 3], but differs from Brooks et al.'s [3] finding that *Salmonella* isolates in Kenya were resistant to gentamicin. *Shigella spp.* showed higher susceptibility to almost all antimicrobial drugs, with gentamicin being highly susceptible. This may reflect variations in strain patterns from place to place.

Fresh fruits are essential for human health and nutritional benefits, and their consumption can prevent vitamin C and vitamin A deficiencies and reduce disease risk. A study in Nekemte town found that all fruit samples had higher microbial counts than permitted, reflecting poor hygienic conditions during harvesting, processing, and storage. The study found that eleven different bacterial genera were isolated from the fruits, with most being susceptible to gentamicin, ciprofloxacin, and chloramphenicol, and almost all being resistant to erythromycin and tetracycline. The study suggests that poor hygienic conditions, lack of training on food hygiene, improper storage, and improper handling of fruit may contribute to foodborne infections.

Abbreviations

TTC	Total Coliform Count
SCC	Staphylococci Count
TVC	Total Viable Count
FC	Fecal Coliform Counts

Author Contributions

Desalegn Amenu: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Su-

pervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Ayantu Nugusa: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Ra'el Desalegn: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Chimdesa Tolera: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Temesgen Tafesse: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Alice, Y. S. (1997). Socio - economic profile of street food vendors and microbiological quality of ready-to-eat salads in Lome. *International Journal of Food Safety*, 20(1): 65-70.
- [2] Beyene, G., Nair, S., Asrat, D., Mengistu, Y., Engers, H., Wain, J. (2011). "Multidrug resistant *Salmonella* Concord is a major cause of salmonellosis in children in Ethiopia." *J. Infect. Dev. Ctries.* 5(1): 2333.
- [3] Brooks, J. T., Ochieng, J. B., Kumar, L., Okoth, G., Shapiro, R. L., Wells, G. J., Bird, M., Bop, C., Chege, W., Beatty, M. E., Chiller, T., Vulule, J. M., Mintz, E., Slutsker, L. (2006). "Surveillance for bacterial diarrhea and antimicrobial resistance in rural western Kenya, 1997/2003." *Clin. Infect. Dis.*, (43): 393401.

- [4] Eni, A. O., Oluwawemitan, I. A. and Solomon, A. U. (2010). Microbial quables sold ulity of fruits and vegetables sold in Sango Ota, Nigeria. *African Journal of Food Science*, 4: 291-296.
- [5] FDA (2002). Bacteriological Analytical Manual, Enumeration of *Escherichia coli* and the Coliform Bacteria Online. Chapter 4: 16.
- [6] FDA, India (2010). Good manufacturing practice related to Food preparation.
- [7] Haidar J, Demise, T. (1999). Mulnutrition and xerophthalmia in rural communities of Ethiopia. *East Afr. Med. J.* 10: 590-593.
- [8] Ketema, T., Gaddisa, T. and Bacha, K. (2008). Microbiological safety of fruit juices served in cafes/restaurants, Jimma town, southwest Ethiopia. *Ethiopian Journal of Health Science*, 18(3): 98-100.
- [9] Kindu, G. (2015). Microbiological Safety of Fruit Juices Consumed in Cafes and Restorants of Debre-Markos Town, North Western Ethiopia.
- [10] McCance, W., Harrigan, F. and Margaret, E. (1998). Laboratory Methods in Food Microbiology 3rd Edn. London: Academic Press.
- [11] Osamwonyi, O. U., Obayagbona, O. N., Aborishade, W., Ollisaka, E., wadiae. U. and Igiehon, O. N. (2013). Bacteriological Quality of Vegetable Salads Sold at Restaurants Within Okada Tawn, Edo State, Nigeria. *African Journal of Basic and Applied science*, 5(1): 37-41, 2013.
- [12] Rahman T, Hasan S, Noor R. (2011). An Assessment of Microbiological Quality of Some Commercially Packed and Fresh Fruit Juices available in Dhaka City: *A Comprehensive Study. Stanford J. Microbiol.* 1(1): 13-18.
- [13] Shakir M, Ahmed U, Nasreen T, Feroza B and Parveen S. (2009). Microbiological Quality of Local Market vended Freshly Squeezed Fruit Juices in Dhaka City, Bangladesh. *Bandladesh Journal of Science and Industrial Research*, 44: 421-424.
- [14] Tasmina, Sabrina Hasan, and Rashed Noor. (2011). An Assessment of Microbiological Quality of Some Commercially Packed Juice and Fresh Fruit Juice Available in Dhaka city: A Comparative Study. *Stamford Journal of Microbiology*, PP. 1(1) 13-18.
- [15] Tetens, I. and Alinia, S. (2009). The role of fruit consumption in the prevention of obesity. *Journal of Horticultural Science & Biotechnology*. ISAFRUIT Special Issue 47–51.
- [16] Titarmare, A., P. Dabholkar and S. Godbole (2009). Bacteriological analysis of street vended fresh fruit and vegetable juices in Nagpur city, India. *Internet J. Food Safety* 11: 1-3.
- [17] Zeberga, S. (2010). Thesis on the production and quality evaluation of spray dried fruit production, Addis Ababa University, department of chemical engineering.