Critical SWOT analysis of fresh fruit handling practices by traders in Uganda's Capital City. A rapid cross-sectional study

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Abstract

Poor fruit handling practices causes physical damage to fruits and exposes them to pathogenic microbial contamination with *Salmonella spp*, *E. coli* and *Vibrio spp*. These contribute to food borne illnesses such as Salmonellosis, Shigellosis, Cholera, *E. coli* O157:H7 infection Campylobacteriosis among others. An estimated 14 percent of all diseases registered at health centers are food borne related in Uganda making this a public health concern. The economic burden of foodborne diseases was estimated at about 300 million United States Dollars in 2016.

A rapid cross-sectional study was conducted using a SWOT framework to understand the fruit handling practices by traders in one of the markets in Uganda's Capital City (Kampala).

Our study showed that there existed some strengths such as Presence of an established market leadership and presence of organized registered and unregistered trade and social groups. Furthermore, there existed weaknesses that needed immediate attention such as (a) lack of clean water, (b) selling fruits on dirty market floor which exposes consumers to contaminated fruits, (c) disposal of spoilt fruits in open waste areas contaminates the soil, clogs drainage channels, creates a bad smell in the market and attracts rodents to feed on disposed fruits. We therefore recommend, establishing a 'One Health' market task force made up of traders, suppliers, farmers, consumers, local council, public health scientists and Kampala Capital City Authority (KCCA) that can work with Ministry of Local Governments and Ministry of Health to train traders to implement appropriate fruit handling practices as detailed in KCCA market laws. The One Health task force can work with Ministry of Science and Technology to design and develop tools such as insulated fruit crates, raised fruit stands, and closed waste bins that could be used by market traders to improve fruit hygiene practices. The One health market taskforce will be in position to link with private international organizations such WASH international to draft proposals to provision for free clean water for the market which could improve fruit hygiene and market sanitation.

Background

The One Health approach is an integrated approach where specialists from multiple disciplines and sectors collaborate to tackle health threats to animals, humans, plants and environment (1). In agriculture, One Health works to promote sustainable agricultural practices, improve food safety, promote healthy diets and control zoonoses arising from relationships between animals, people, plants and environment (1). Food borne illnesses have become a One Health challenge as food borne-pathogens have become increasingly more diverse ranging from bacteria to viruses, parasites, toxins, allergens and much more. Eighty percent of FBDs are attributed to microbial pathogens, such as non-typhoidal *Salmonella spp*, *Listeria spp*, *Campylobacter spp*, *E. coli*, Noroviruses majority of which are zoonotic (2). Worldwide, 600 million cases of food borne diseases (FBDs) are reported annually and 420, 000 deaths occur among those cases of which, 30% of deaths occur in children below five years old (3). World health Organization estimated that 33 million healthy lives were lost due eating contaminated food which number is likely underestimated (3). A third of the FBDs reported annually occur in African region

amounting to 135 million cases and 180,000 mortality cases. Diarrheal diseases caused by microbial infections such as non-typhoidal *Salmonella*, toxigenic *E. coli*, *Vibrio cholerae*, Noroviruses and *Campylobacter* species contribute to 80% of FBDs in Africa (3,4).

A World Bank study in 2016 estimated the productivity loss due to FBDs in Africa at 20 billion United States Dollars (USD) and an additional 3.5 million USD lost due to treatment costs (4). In Uganda, 14 percent of disease treated annually are due to FBDs which imposed an economic burden of at least 300 million USD in 2016 alone (4). Contamination of food occurs along any point of the food production chain, during handling or at consumption stage. Foods eaten raw or with minimal processing are the largest vehicles of zoonotic food borne microbes which are directly transmitted between humans, animals and environment (5). Vegetables and fruits are the products most involved in transmission of FBDs in sub-Saharan Africa (4).

Fruits provide a rich source of vitamins, minerals, antioxidants and fiber which are all important in maintaining normal body functions. Fruits provide vitamins such as A, C, D, K, and minerals such as zinc, potassium and magnesium which are important in building energy, bone structure and maintaining cell growth (6). Fresh fruits contain fiber which is important in maintaining good gastrointestinal health (7). Colored fruits such as watermelons, guavas, papaya and passion fruits have range of polyphenols such as anthocyanins and flavonoids that act as antioxidants, antibacterial or anti-hypertensive so they are used to prevent/control certain diseases such as cancer and cardiovascular diseases (8).

Post-harvest treatments of fresh fruits is globally done to reduce physiological process of maturation, inhibit physiological damage and reduce the risk of microbial contamination (9–11). Developing countries use postharvest various technologies as described by (9,10) ; (a) pre-cool non-ripe harvested fruits in cold rooms, (b) wash and disinfect fruits using chemical solutions like ozone, nitric oxide, or peroxyacetic acid (c) control fruit ripening by externally applying ethylene to enhance ripening or cyclopropenes to slow ripening (d) Control fruit respiration by applying chitosan, wax or *Aloe vera* (e) sort and package fruits in insulated containers fiberboard cartons, clamshells, insert trays or reusable plastic containers (f) use lifters in grocery stores when unloading or when moving fruit containers and store or sell the fruits at ambient temperature. All this minimizes fruit damage, contamination and increases shelf life which makes fruits available even after end of the season.

Uganda produces up to 5.3 million tonnes of fruit per year and is the second largest fruit producer in Sub-Saharan Africa but post-harvest losses range between 20 to 40% due to limited use of post-harvest treatment technologies (12,13). In Uganda, partially ripe fruits are harvested making them susceptible to physical damage (14). Fruits are often pre-cooled under trees where temperatures are not optimal and they are not normally disinfected on farms. Fruits are packed in plastic sacks without insulation or in over-packed wooden crates (13). In the markets, the heavy fruit packages are manually and roughly offloaded from trucks which increases risk of physical damage (14). This explains the high post-harvest losses in Uganda and in other low developing countries. Post-harvest food loss is one of the major concerns of food security and a contributing factor to global hunger in developing countries (15).

All markets whether public or private in Kampala are under direct government intervention through Kampala Capital City Authority (KCCA) as the governing body that regulates and maintains the markets. Nateete market in Rubaga division, Kampala is under KCCA management but is owned by the market traders association led by an elected chairperson. The KCCA delegates some of its responsibilities to the market chairperson who is responsible for maintaining market vendors' register, collection of market charges, ensuring security and trade order (16). The KCCA approves layout of market space and all commodities to be sold, collects market waste, de-silts drainage systems and ensures that the traders comply with public health regulations to prevent food contamination (17). Different market charges collected provide financial means to oversee the above-mentioned activities.

The highlighted challenges in fruit handling by traders in this study will show KCCA and the market traders association the major public health weaknesses they need to focus on and some of the interventions Nateete market traders can implement to improve appropriate fruit handling practices. Regulation and implementing of proper fruit handling practices will reduce fruit spoilage and financial losses suffered by market traders. Proper fruit handling practices will reduce fruit contamination, promote selling of healthy fruits to Kampala population which will have a positive impact on reduction of food borne illnesses. This study sought to investigate (a) handling methods of fruits by traders, (b) market organization and infrastructure plus (c) sanitation and hygiene in Nateete market located in Kampala, Uganda.

Methodology

Study design and setting

A cross-sectional observational study was conducted through interviews of Nateete market fruit traders using a semi structured questionnaire that had both closed and open questions that yielded quantitative and qualitative data respectively. The questionnaire was administered to purposively selected fruit traders in Nateete market that is located in Kampala, Uganda. Nateete Market is one of the oldest markets located in Kampala district as shown in appendix 2. The market was purposively selected for this study because it is strategically located at the intersection of many connecting routes making it easily accessible for consumers and a good choice for business for many traders. This market serves at least 13 villages of more than 20,000 people.

Study population and sample size

The total number of registered fruit traders in Nateete market based on the market records shared by the market chairperson was 33. The sample size was not calculated in this study since the population size of registered fruit traders was small. However, from that population of fruit traders, purposive sampling was used to get a sample of fruit traders who had good knowledge and experience in fruit business in Nateete market. We excluded fruit traders who had not traded in fruits for at least two years and unregistered fruit traders working within the vicinity of the market but outside the market area as these traders only sell fruits once in a while. We included fruit traders that were above 18 years old, registered and had worked in

fruit trade and Nateete market for at least 3 years. Only 19 fruit traders met the inclusion and exclusion criteria so they were purposively selected for interviews using a semi-questionnaire. The market chairperson was also interviewed as a key informant individual using the same questionnaire used for the fruit traders. Hence a total of 20 study participants were interviewed in this study.

Data collection

A semi-structured questionnaire was divided into two sections; section a contained closed questions while section b had open questions. The questionnaire was administered to selected fruit traders in Nateete market. The closed questions were divided into different categories that included questions on; Education of traders, transportation of fruits, market infrastructure for the traders and sanitation and hygiene for fruits and the traders. Section B contained three open questions which sought information on post-harvest losses during handling of fruits in the market at stages of offloading, cleaning, sorting, grading, storage and marketing of fruits. Section B was meant to supplement and provide justification for information provided by fruit traders in section A of the questionnaire. Responses from fruit traders to open questions were recorded by taking written notes. The questionnaire in this study shown in appendix 1 was adopted from information in previous studies by (13,14). The questionnaire was pre-tested on 5 fruit traders in Nateete market prior to data collection, the resulting information was analyzed for accuracy and completeness then certain questions were adjusted accordingly. Each interview lasted about 20 minutes.

SWOT analysis method was chosen for this study because it showed how fruit traders in Nateete market were handling the fruits and pointed out the challenges traders' face that can be improved upon to create a healthier market. This study used the SWOT analysis method to draw from observations and interviews on fruit handling practices by Nateete market traders, Uganda to do a systematic analysis on implications of fruit spoilage and One Health challenges.

Statistical analysis

Responses to closed questions (quantitative data) obtained were entered in SPSS version 25 (SPSS Inc USA). The Frequencies were computed and are presented in table 1 which included key outputs on; (a) transportation management of fruits, (b) packaging, (c) sanitation and hygiene handling of fruits and the surrounding market environment together with (d) the overall market infrastructure available to fruit traders. The qualitative written responses from challenges in fruit handling, issues of fruit spoilage and market leadership were read several times to get an overall understanding and identify the main themes on fruit handling fruits including using inductive approach. Themes and codes were generated following standard guidelines and their relationships were analyzed in terms of differences and similarities using ATLAS.ti software. The quantitative responses and the generated themes were analyzed to identify weaknesses and threats that promote poor fruit handling practices and strengths and opportunities within the market that can be capitalized on to improve appropriate fruit handling. Based on those findings, strategies were suggested that can be implemented to improve fruit handling practices of traders and the overall health of Nateete market.

Results And Discussions

Strength analysis

Presence of certain market infrastructure such as concrete market floor, fruit section, electricity and security in Nateete market

The fruit traders identified several established market infrastructure that supported their fruit business such as; (a) A well sectioned market, (b) presence of concrete market floor, (c) reliable electricity and (d) good security as seen in Figure 1. Majority of the respondents 18/20 pointed out that the market was well sectioned into; fruit and vegetable section, root crops, beef, chicken, fish and other sections with various built in physical separators. A healthy food market needs to be sectioned to reduce the risk of cross contamination of different foods with various food hazards like microbes (3). Sectioning the market has been done successfully to reduce transmissions of zoonotic diseases in certain markets in low resource countries such as avian influenza in South East Asia low and Ebola viruses in certain West and Central Africa among others (18). Most of the fruit traders, 19/20 noted that the market floor was made of concrete which made it easier to clean and drain away rain water especially during the rainy season. Most of the fruit traders 19/20 noted that Nateete market had reliable electricity with good security which had encouraged them to continue working in the market for more than three years as noted in the responses to the open questions.

Clear leadership and management authority

Among the themes identified qualitatively included the presence of a clear market leadership and management noted by majority of the interviewed fruit traders. The study participants noted that the market is managed by Kampala Capital City Authority (KCCA) which regulates activities for all markets in Kampala. The KCCA management ensures that the market traders adhere to the stipulated food quality and health hygiene standards. KCCA cleans and collects waste in the market as well ensuring trade order (17). The market vendors elected a market chairperson who works with KCCA to directly oversee and enforce health regulations and other trade activities (16,17). The market chairperson also serves to share the interests of fruit traders to KCCA. Turning Nateete market into a healthy food and fruit market would need strong leadership and management which already exists in the market. Strong leadership has been noted as a core requirement needed to offer support, commitment and advocacy for establishing a healthy food market (19).

Organized trade and social groups

Another theme revealed from qualitative data was that all fruit traders were attached to at least one trade or social groups in the market. Based on the market records provided by the market chairperson, the market had four official registered trade groups used by market traders to access credit and savings services. Other small non-registered groups were also available in the records such as women's groups existed offered limited financial services while other social groups such as religious groups which offered

psychological counselling to market traders. These organized groups offer foundation to gather fruit traders and provide innovative products that can improve proper fruit handling such as provision of fruit crates and fruit stands on credit. These groups can also be used to provide education and trainings to improve on existing levels of awareness on fruit and personal hygiene of fruit traders. Information provided through these already trusted groups might be more acceptable to fruit traders which would ensure sustainability of any provided education trainings on creation of a healthy fruit market and would encourage behavior change among fruit traders.

Weaknesses

No free clean running water in the market

Majority of the respondents, 19/20 mentioned there was no clean water within the market as shown in table 1, which was also noted as a major challenge faced by fruit traders from qualitative data analysis.

I buy the water outside the market which is expensive so I cannot wash dirty fruits most times, other times I have to save water I used to wash vegetables first then use it to wash fruits. I have no choice, besides there is no space where to even wash the fruits so most times I just leave the fruits alone and not bother. (Nateete market fruit trader)

The lack of free clean water in the market potentially explains why less than half of the fruit traders interviewed 5/20 washed fruits as noted in table 1. Failure to wash dirty fruits potentially exposes other fruits to contamination with microbes which could explain why fruits ending up rotting on the fruit stalls as mentioned by majority of the fruit traders. The fruit traders also mentioned that basic personal hygiene is not always followed because toilets often lack soap and water needed to wash hands after. This poses the likelihood of introducing fecal bacterial contamination to the sold fruits both by the market traders and consumers who use the toilet facilities. According to World Health Organization provision of sanitation facilities such as clean water and toilets is the first key principle to promoting a clean and a safer healthy market (19). In July 2019, Uganda recorded 184 cases of dysentery and 875 cases of typhoid fever which are all food borne infections related to poor sanitation and hygiene that is derived by lack of access to enough water (20).

Open waste dumping site and exposed sewage channels

Nateete market had an open waste dumping site inside the market as seen in figure 2A and lacked closed waste bins as noted by 18/20 fruit traders in table 1. Spoilt fruits and other organic wastes are dumped in the open waste disposal site and majority of the fruit traders noted this often creates a bad smell inside the market. Most of the fruit traders, 15/20 noted that the sewage and drainage systems are not unclogged regularly as seen in figure 2C and table 1 which contributed to the bad smell and attracted houseflies in the market. Houseflies are agents of food borne disease causing organisms like *E. coli*, *Shigella dysenteriae*, *Vibrio cholera* which cause gastroenteritis (21).

Table 1: Sanitation and hygiene (n=20)

Factor	Frequency	
	Yes	No
Clean water present in the market	1	19
Wash dirty fruits	5	15
Raised stands for fruits	6	14
Market floor is cleaned regularly	12	8
Fruit stall clean	9	11
Waste disposal site is present	20	0
Closed waste bins are present	2	18
Drainage and sewage channels are present	20	8
Sewage channels are unclogged regularly	5	15

Placing fruits on dirty market floor

Only 6 out of 20 fruit traders interviewed had fruit stands, majority of the traders placed the fruits directly on the market floor as seen in figure 2A and 2B. Fruit traders sold the fruits directly from the dirty market floor or place them on dirty plastic sheets that were neither washed nor disinfected based on the qualitative responses provided. More than half, 12/20 of the fruit traders noted the market floor was cleaned regularly by sweeping every morning but all the fruit traders said they had never seen the market floor being disinfected. Indeed, as observed in table 1, most of the fruit traders 11/20 noted their fruit stalls were not clean.

The market is swept in the morning, but there many of us that use this floor. For me when I come to work, I just place this old plastic bag on the floor to put my fruits. But as you can see it used to be white but now you cannot tell because of all the soil on the floor. I cannot wash this plastic sheet because it will need a lot of water and then it will just get dirty the next day. (Fruit trader).

The market floor was by many people from different places which exposed fruits to dust and soil that likely contained pathogenic microbes such as *E. coli spp*, *Salmonella spp*, *Noroviruses* which cause gastroenteritis in consumers (21). It was also noted that majority of the fruit traders, 19/20 had never received any training on post-harvest fruit handling and majority of them 13/20 had no education at all as observed in table 2. This probably explains why fruit traders placed fruits on dirty market floor and not stands.

Table 2: Education level of fruit traders

Fruit traders (n = 20)		Frequency
Fruit handling knowledge	Formal training/education on post-harvest fruit handling practices	1
Education level	None	13
	Primary	6
	Secondary	1
	Tertiary	1

Lack of roofed sections on several fruit market stalls

More than half of the fruit traders, 12/20 sold their fruits in open unroofed spaces of the market without any shade protection for the fruits as observed in figures 1 and 2A. The fruits sold in open spaces were exposed to the environmental elements such as the hot sun that caused evaporation and wilting and in the rainy seasons the fruits were exposed to rain water which led to fruit rotting. Many traders lacked umbrellas and 15/20 did not have wooden stands to place their fruits on so they were forced to sell their fruits from floor as seen in figure 2B and table 1. Fruit traders noted this was especially a challenge during the rainy season since rain showers often carry waste water through the fruits sold on the floor exposing them to contamination with fruit spoilage microbes like fungi and food borne pathogens such as *E. coli* and *V. cholerae*. Qualitative analysis showed that traders faced the highest fruit spoilage losses during the rainy season which was also the time this study was done as noted in the quote:

My fruits get spoilt a lot during the rainy season, as you can see it rained two hours ago, the, the floor is wet and muddy. When the rain came I could not move the fruits they are to many, were would I even put them. I just covered them with some plastic sheets but that really does not help, I most worry about the fruits directly on the floor bottom, the rain water goes through them and it is really dirty water. When I sell off the top ones most of the ones down have rotted and I just throw them away. You must understand also that the rainy season is when fruits are abundant in this country yet I throw away so many. (Fruit trader).

No Sorting and grading of fruits

Most of the fruit traders, 14/20 did not have fruit stands as observed in figure 2 and table 1 and many of them had limited space since space in the market is limited and large spaces are also too expensive for most market vendors. Due to the space limitation and lack of well-built fruit stands that could utilize small spaces efficiently, traders failed to sort through all fruits in the plastic sacks and boxes. Not sorting

fruits leaves damaged, infected and health fruits together which causes the spread of infection to healthy fruits. Sample quote from trader on why fruit sorting is not done:

As you can see, I am selling my oranges directly from the sack, I have no space to pour out all of them to remove the bad ones. It is the same for tomatoes, the few batches you see here on display, I have picked from the big box over there, sadly by the time I reach the ones at the bottom, many have started rotting away. (Fruit trader).

Fruit traders also mentioned that their fruits also get spoilt because of consumer rejection and one of the reasons for this rejection was poor quality of fruits sold. Fruit traders mentioned, that they have a problem of farmers who harvest immature and very unripe fruits that end up being rejected by consumers because of poor taste so a lot of fruits get spoilt on stalls. (22) noted that papaya fruits harvested at maturity stage had superior flavor and appearance compared to immature papaya.

Over-packed fruits without insulation

Majority of the fruit traders, 17/20 mentioned that fruits were packed poorly for transportation as noted in Table 3. Qualitative analysis revealed that traders thought most of the fruits were physically damaged during transportation. A study by (23) noted that 15 % of all produced food bananas in Uganda suffered post-harvest deterioration. The study showed that 5 % of food banana losses occurred at farm level, 14 % at wholesale and the highest loss of 18 % occurred at retail level which is market level.

Most of the fruit traders agreed that fruits such as avocados, passion fruits and citrus fruits among others were often over-packed and transported in sacks because they are cheap. Sacks were not insulated or ventilated. Traders noted that woven baskets and deep wooden boxes which are more expensive were occasionally used but these were often over filled and fruits were congested and overheated. Overheating of fruits accelerates microbial processes, fruit damage and contamination, all of which eventually reduce shelf life of fruits (24,25). A study by (23), noted that 7.7 % of food bananas produced in Uganda are minimally damaged during transport so they are sold off at reduced prices while 7.7 % deteriorate completely and are discarded by retailers. All these explains why fruit traders mentioned high financial losses as one the challenge they face in fruit business in Nateete market. Similar findings were noted in Uganda on pineapples by (26).

To reduce transportation costs, fruits were often loaded onto trucks carrying other kinds of foods such as bananas, cassava as noted in Table 3. That often squeezes the poorly packed fruits causing them further mechanical damage. This kind of fruit transportation was noted in other East African countries by (13). As seen in Table 3, many of the traders, 14/20 noted that the fruits were roughly handled during offloading and movement within the market. The rough handling of fruits was attributed to the overloaded fruit containers that have to be manual handled.

Table 3: Transportation (n=20)

Factor	Frequency	
	Yes	No
Fruit trucks are usually overloaded	20	0
Fruits trucks are loaded with other food types	20	0
Fruits are offloaded gently from the truck	6	14
Fruit containers are manually offloaded	20	0
Fruits are packed in appropriate insulated and ventilated containers for transportation	3	17

Poor marketing strategies of fruits

Poor quality fruits sold on the market floor, unsorted, overripe, immature and bruised fruits have led to high consumer rejection of which has also led to high fruit spoilage and financial loss for the fruit traders.

Opportunities

Partner with private organization to provide water infrastructure

Promotion of a healthy fruit market would require a multi-disciplinary market task force made of partnerships and collaborations among all stake holders including market vendors, market leaders, consumer groups, academic institutions, KCCA and the local government so that the available resources and knowledge could easily be shared to address the major concerns of all the stakeholders. All the fruit traders interviewed, implored the market leaders to provide water to the market. Water is a key component to proper sanitation and hygiene in healthy markets (19). The market task force could be in position to partner with private organizations like WASH International, World Vision and Amref already present in the country to co-fund development of free water sources like boreholes, provision of water tanks to store rain water. Washing and drying fresh fruits with water reduces surface microbial loads of spoilage yeasts, molds and other bacteria which increase fruit shelf life. Washing also reduces bacteria loads of zoonotic pathogenic species of *Salmonella*, *E. coli*, *Listeria spp*, *Yersenia spp* that are also capable of causing food borne infection to consumers (21).

Partner with private partners to receive financial support for market re-development

The created multi-disciplinary market task force can work with private organizations on financial proposals to support building fruit stalls. That will protect the fruits from the sun and rain which could potentially increase their shelf life. Well-designed built fruit stalls could give traders an opportunity to sort their fruits before displaying them which will increase their marketability and reduce fruit spoilage. United

Nation (UN) Development program and UN International Fund for Agricultural Development can be approached as they have funded similar initiatives in other markets in Uganda. This multidisciplinary task force can monitor the progress towards turning Nateete market into a healthy food market.

Research and product development of insulated fruit packaging containers

A market research team under the main multi-disciplinary market task force could be assembled to handle product development that can improve fruit handling practices of traders. The local national universities and private industries can be used to assemble a multidisciplinary research team to design and develop the required products and could comprise of agriculture, engineering, technical wood work schools, business, and chemical engineering students. Among the requests made to the market leaders by the fruit traders was the need for well-built fruit stalls and durable cost effective fruit crates. The research team could design cost effective and durable polycarbonate and or wooden crates that could withstand rough handling and still protect the fruits from mechanical damage. The registered trade groups could be used by the local government to provide funding on the designed packaging materials such that fruit traders could access them on subsidized fees and loan basis. That could promote uptake of the designed products and improve fruit quality and access to healthy fruits for the consumers.

The research team could design specialized disposal tanks with lids at the waste disposal site which would indirectly encourage inorganic and organic waste sorting leading to easier waste disposal and encourage organic waste recycling due to easier access for collection by the urban farmers who can use the waste for rearing maggots as a feed protein source (27).

Training traders on appropriate fruit handling practices

Majority of the fruit traders, 19/20 had never received any formal training or education on post-harvest fruit handling practices as observed in table 2. Most of the fruit traders, 13/20 had no education at all while only 6/20 had primary education. That showed a huge knowledge gap among traders on how to reduce post-harvest fruit losses and showed the need for developing training programs for them. The market task force advisors including; public health scientists, agriculturists and food nutritionists can design appropriate post-harvest handling practices that could be employed by the fruit traders after training. The Public health scientists on the task force can also train the public on appropriate washing and disinfection of fruits they buy from markets which can reduce occurrence of food borne infections. The market organizations could be used to mobilize different stake holders for education and training. Interview with the market chairperson reiterated the need for training of market vendors on appropriate fruit handling:

I have reached out to KCCA on numerous occasions and requested to bring more education and training to our market but with success. Our traders need the training to know how handle fragile fruits, to understand why they should not place food on the floor among other things. Most of our traders really do not know these things. I hope we can get some of those trainings here in our market as well. Nateete Market chairperson.

Re-using and composting spoilt fruits

Training urban farmers from registered associations on cost effective composting processes of spoilt fruits from the market to allow re-using of the fruit-waste. The urban farmer groups could also be trained on re-using spoilt fruits waste by rearing snails or black soldier maggots that can be used a protein substitute in animal feeds as has been tested and suggested by (27) in Cameroon. The National Agricultural Research Laboratories (NARL) specialized in agricultural product research and can design simple methodologies that can be used by urban farmers to compost spoilt fruits or reuse them for rearing snails/maggots.

Threats

Exposure of humans to food borne infections

There is a threat of fruit contamination with zoonotic pathogenic species of micro-organisms that cause gastroenteritis such as *E. coli* O104:H4, *Salmonella spp*, *V. cholerae*, *Noro-viruses* due to poor fruit handling practices (21). Practices such as;

- a. Placing fruits on dirty floor as seen in figures 2A and 2B exposed fruits to contamination especially during the rainy season when the usually unclogged sewage systems seen in figure 2C overflowed directly into fruits on the ground.
- b. Lack of clean water in the market as mentioned by 19/20, fruit traders forced most of the fruit traders not to wash dirty fruits and a few of those that washed their fruits re-used water that washed vegetables to also wash fruits, a practice most fruit traders admitted to engaging in to conserve water.
- c. The lack space and well-built fruit stalls was one of the major reason fruit traders gave for why they did not sort infected fruits from healthy ones.
- d. Rough handling of fruits during offloading and movement within the market breaks their skin.

All the above practices expose fruits to surface and internal microbial contamination with fruit spoilage and food borne disease causing microbes. Ready to eat fruit juice sold by street vendors in Kampala have previously been reported to contain *E. coli*. In 2019, July, there was typhoid fever outbreak in Uganda and 875 cases were reported. *Salmonella enterica typhi* causes typhoid fever and can easily infect fruits sold on the market floor (20). In Uganda, it is estimated that 14 percent of all illnesses treated annually are food borne related and diarrhea diseases kill over 33 children every day (28).

Contamination of the environment with fruit spoilage and other pathogenic microbes

Poor fruit handling causes fruit spoilage which generates a lot of organic waste that ends up being disposed off in open dumping site inside that market. The discarded spoilt fruits ferments creating a bad smell inside the market. The rotting fruit leachate contaminates soil and underground water sources below with bacterial and fungal organisms. Contamination of drinking water sources with *E. coli* and

Salmonella species in Kampala during typhoid fever outbreak was reported by (21). The rotten fruits are often carried by rain water to open sections of sewage channels and end up blocking them. Majority of the fruit traders 15/20 noted that sewage and drainage channels are not regularly unclogged making them liable to overflowing contaminating the market floor, market food place on the floor and nearby water sources. The exposed sections of the unclogged drainage channels and open disposal waste site attract house flies during the dry season. House flies are known carry disease causing organisms like *E. coli*, *Shigella dysenteriae* and *Vibrio cholera* which cause gastroenteritis (21).

Animals feeding on contaminated fruits

Rodents such as rats and mice feed on the spoilt fruits disposed off in open waste sites inside the market. Majority of the fruit traders, 17/20 lacked access to stores and mentioned that they faced a problem of rats in the market that fed on their fruits causing fruit damage and spoilage.

I stay just in those houses you see overlooking the market and all of my neighbors, we all struggle with rats in our homes. Not a week goes by that we don't kill a rat in my house. Those rats have eaten away all my sofa chairs at home and destroyed my children's clothes. And I know they feed from the food here in the market, they are a big problem especially during the cold days and they come to seek shelter in our homes. Nateete market fruit trader.

Rats often carry zoonotic pathogens like *Salmonella spp* to human households close to the markets (29). Rats can get in close contact with domestic animals and nearby wildlife animals so can potentially spread disease causing organisms.

The problem of houseflies was noted as a major issue in the market by traders because of poor sanitation and hygiene. Houseflies contaminate the fruits in the market with food borne pathogens like *E. coli* and *Shigella dysenteriae* which cause gastroenteritis (21). Qualitative analysis revealed that urban pig farmers bought some of spoilt fruits from vendors to directly feed pigs which creates a possibility of cross contamination of organisms from plants to pigs then to human consumers.

Table 4. Summary of SWOT analysis of fresh fruit handling practices by market traders in Nateete market			
Factor	Content		
Strengths	1. Presence of certain market infrastructure	2. Clear leadership and management	3. Organized trade and social groups
Weaknesses	1. No clean running water 4. No roofs/ umbrellas on some fruit sections	2. Open waste dumping site and exposed clogged sewage channels 5. No sorting and grading of fruits	3. Placing fruits on dirty market floor 6. Over-packed fruits without insulation or ventilation during transport
Opportunities	1. Partner with private organization to provide water infrastructure 4. Reusing and composting spoilt fruits	2. Design and development of fruit packaging containers	3. Training traders on appropriate fruit handling practices
Threats	1. Exposure of humans to food borne infections	2. Contamination of the environment with fruit spoilage and foodborne pathogenic microbes	3. Animals feeding on contaminated fruits

Study limitations

The study only focused on fruit traders in one market in Kampala which was Nateete market hence generalization of the quantitative findings to other markets in Kampala might not be possible. Quantitative analyses did not yield information on types of fruit losses, duration of selling fruits, quantities of fruits sold among others which information is needed to design locally sensitive fruit handling interventions. The study looked at only fruit retailers and did not engage wholesale fruit traders and farmers so their competence at post-harvest fruit handling and impact to fruit damage remained unknown. The qualitative phase did not include all fruit traders in the market. Qualitative inquiry did not

yield information on why KCCA did not regularly unclog the market sewage systems, why they were no closed waste bins in the market, why they did not provide water to the market and why they did not enforce the law that prohibited placing food on the floor yet it part of the market ordinance 15 law. There was need to do key informant interviews with KCCA to find out that information.

Conclusions

The study documented lack of free clean water in Nateete market and placement of fruits on the dirty market floor by traders. A multi-disciplinary market task force comprised of traders, consumers, existing market leaders and advisors from agricultural, health and academia sectors needs to be created. The task force will be in position to partner with local government and private organizations to co-fund development of water infrastructure and well-designed fruit stalls. That will be coupled with sensitization of traders on appropriate post-harvest fruit handling practices to improve fruit hygiene and ensure more healthy fruits for consumers.

Declarations

Acknowledgment

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Conflict of interest

The authors declare no conflicting interests

Ethical considerations

The chairperson local council 1 and the market chairperson granted approval for the study to be done in Nateete market. Informed consent was provided by all the study participants after the purpose, procedures, benefits and possible harmful effects of the study were clearly explained to them and after all their concerns were addressed. The data from all the study participants was made completely anonymous.

Author's contributions

Author(s)	Contribution(s)
Suzan Nakayiza, Abel Walekhwa	:Conceptualization
Suzan Nakayiza, Abel Walekhwa	:Data curation
Africa One Health University Network (AFROHUN) at Makerere University, Angella Musewa	:Funding and resources
Suzan Nakayiza	:Investigation
Suzan Nakayiza, Abel Walekhwa	:Methodology
Suzan Nakayiza, Abel Walekhwa	:Project administration
Abel Walekhwa, Gabriel Tumwine, James Muleme	:Supervision
Abel Walekhwa, AFROHUN	:Validation
Suzan Nakayiza, Abel Walekhwa	:Writing – original draft
Suzan Nakayiza , Abel Walekhwa, Gabriel Tumwine,	:Writing – review & editing

List Of Abbreviations

KCCA	Kampala Capital City Authority
CoVAB	College of Veterinary Medicine, Animal Resources and Bio-Security
AFROHUN	Africa One Health University Network
WASH	Poor water, sanitation and hygiene
SWOT	Strengths, Weakness, Opportunity, Threats
FAO	Food and Agriculture Organization of the United Nations
WHO	World Health Organization
UN	United Nations
FBD	Food borne diseases

References

1. Food and Agriculture Organization of the United Nations. One Health [Internet]. [cited 2021 Dec 30]. Available from: <https://www.fao.org/one-health/en/>
2. King LJ. One health and food safety. In Improving food safety through a One Health approach: Workshop Summary. Washington (DC): National Academies Press; 2012. 218 p.

3. Mehlhorn H. WHO estimates of the global burden of foodborne diseases: foodborne disease burden epidemiology reference group 2007-2015. *Encycl Parasitol*. 2015;1–1.
4. Jaffee S, Henson S, Unnevehr L, Grace D, Cassou E. The safe food imperative: Accelerating progress in low-and middle-income countries [Internet]. World Bank Publications; 2018 [cited 2021 Dec 30]. Available from: <https://books.google.co.ug/>
5. Alsanius BW, Von Essen E, Hartmann R, Vagsholm I, Doyle O, Schmutz U, et al. The “one health”-concept and organic production of vegetables and fruits. *Acta Hortic*. 2019;1242:1–13.
6. Judit M. The Role of Vitamins and their Dietary Sources: Salad Variations for Global Health Promotion. 2021;3(2):4–7.
7. Gill SK, Rossi M, Bajka B, Whelan K. Dietary fibre in gastrointestinal health and disease. *Nat Rev Gastroenterol Hepatol* 2020 182 [Internet]. 2020 Nov 18 [cited 2021 Dec 30];18(2):101–16. Available from: <https://www.nature.com/articles/s41575-020-00375-4>
8. Deis L, Quiroga AM, De Rosas MI. Coloured Compounds in Fruits and Vegetables and Health. *Psychiatry Neurosci Updat* [Internet]. 2021 [cited 2021 Dec 30];343–58. Available from: https://link.springer.com/chapter/10.1007/978-3-030-61721-9_25
9. Mahajan P V, Caleb OJ, Singh Z, Watkins CB, Geyer M. Postharvest treatments of fresh produce. *Philos Trans R Soc A Math Phys Eng Sci*. 2014;372(2017).
10. Watson JA, Treadwell D, Sargent SA, Brecht JK, Pelletier W. Postharvest Storage, Packaging and Handling of Specialty Crops: A Guide for Florida Small Farm Producers. *EDIS Publ Syst* [Internet]. 2020;2016(1):18. Available from: <https://edis.ifas.ufl.edu/hs1270>
11. Paltrinieri G. Handling of Fresh Fruits, Vegetables and Root Crops: A training manual for Grenada. *Food Agric Organ United Nations* [Internet]. 2014;35–9. Available from: <http://www.fao.org/3/a-au186e.pdf>
12. Dijkxhoorn Y, Galen M van, Barungi J, Okiira J, Gema J, Janssen V. The vegetables and fruit sector in Uganda: Competitiveness, investment and trade options. 2019 [cited 2021 Dec 30];79. Available from: <https://research.wur.nl/en/publications/the-vegetables-and-fruit-sector-in-uganda-competitiveness-investm>
13. Wakholi C, Cho B-K, Mo C, Kim MS. Current State of Postharvest Fruit and Vegetable Management in East Africa. *J Biosyst Eng*. 2015;40(3):238–49.
14. Kereth G a, Lyimo M, Mbwana H a, Mongi RJ, Ruhembe CC. Assessment of post-harvest handling practices: knowledge and losses of fruits in Bagamoyo district of Tanzania. *Food Sci Qual Manag*. 2013;11.

15. Blakeney M. Global Food Losses and Food Waste: Extent, Causes and Prevention. Food and Agriculture Organization of the United Nations. Rome, Italy; 2011. 1–204 p.
16. Abesiga R. The Effects of Privatisation Policy on Markets Performance in Uganda : A Case Study of St. Balikuddembe Market. Masters Thesis, Int Inst Soc Stud. 2014;(December):1–41.
17. Government of Uganda. Local Governments (Kampala City Council Markets) Ordinance 15. UPPC, Entebbe. 2006;XCVIX(74):1–8.
18. Naguib MM, Li R, Ling J, Grace D, Nguyen-Viet H, Lindahl JF. Live and Wet Markets: Food Access versus the Risk of Disease Emergence. Trends Microbiol. 2021 Jul 1;29(7):573–81.
19. World Health Organization. A Guide to healthy food markets. WHO Press. 2006;
20. Ministry of Health. The weekly epidemiological Bulletin week 28: 12th – 18th July 2021. Public Health Emergencies MoH. 2021;(July):1–6.
21. Al-kharousi ZS, Guizani N, Al-sadi AM, Al-bulushi IM, Shaharoona B. Hiding in Fresh Fruits and Vegetables : Opportunistic Pathogens May Cross Geographical Barriers. Int J Microbiol [Internet]. 2016;2016(May 2008):14. Available from: <http://dx.doi.org/10.1155/2016/4292417>
22. Bron IU, Jacomino AP. Ripening and quality of Golden ' papaya fruit harvested at different maturity stages. Brazilian J Plant Physiol. 2006;18(3):389–96.
23. Kikulwe EM, Okurut S, Ajambo S, Stoian D, Naziri D. Postharvest Losses and their Determinants : A Challenge to Creating a Sustainable Cooking Banana Value Chain in Uganda. Sustainability. 2018;10(7):2381.
24. Haile A. Shelf life and quality of tomato (*Lycopersicon esculentum* Mill.) fruits as affected by different Packaging Materials. African J Food Sci. 2018;12(2):21–7.
25. Kaur K, Dhillon WS, Mahajan BVC. Effect of different packaging materials and storage intervals on physical and biochemical characteristics of pear. J Food Sci Technol. 2013;50(1):147–52.
26. Tröger K, Amy M, Hensel O, Kaufmann B. Geoforum Re-framing post-harvest losses through a situated analysis of the pineapple value chain in Uganda. Geoforum [Internet]. 2020;111:48–61. Available from: <https://doi.org/10.1016/j.geoforum.2020.02.017>
27. Dzepe D, Magatsing O, Kuietche HM, Meutchieye F, Nana P, Tchuinkam T, et al. Recycling Organic Wastes Using Black Soldier Fly and House Fly Larvae as Broiler Feed Recycling Organic Wastes Using Black Soldier Fly and House Fly Larvae as Broiler Feed. Circ Econ Sustain. 2021;(April):1–12.
28. Lake RJ, Devleesschauwer B, Nasinyama G, Havelaar AH, Kuchenmüller T, Haagsma JA, et al. National studies as a component of the World Health Organization initiative to estimate the global and

regional burden of foodborne disease. PLoS One. 2015;10(12):1–10.

29. Strand TM, Lundkvist Å. Rat-borne diseases at the horizon. A systematic review on infectious agents carried by rats in Europe 1995–2016. Infect Ecol Epidemiol [Internet]. 2019;9(1):2000–8686. Available from: <https://doi.org/10.1080/20008686.2018.1553461>%0A©

Figures

Figure 1

Market infrastructure in Nateete market as suggested by fruit traders (n = 20)

Figure 2

A shows traders selling fruits on a dirty market floor with open waste disposal site inside the market (yellow arrow), B shows oranges and tomatoes sold on a dirty plastic on the floor, C shows open section of sewage channel that runs in inside the market

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Appendix1.png](#)
- [Appendix2MapofKampalashowinglocationofNateetemarket.png](#)