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ABSTRACT: Consumer awareness of the presence of pesticides in fruits and vegetables and associated health risks influences the actions they undertake to reduce their exposure. This study was carried out to explore consumers' awareness of pesticide residues in fruits and vegetables and perceptions towards associated health effects in Kampala Metropolitan Area (KMA) in Uganda. Eight focus group discussions (FGDs) were done with fruit and vegetables consumers in KMA. The FGDs consisted of females and males living in urban and rural areas. Discussions were recorded and transcribed. The transcripts were coded inductively and analysed using conventional content analysis. Consumers were aware of the presence of pesticide residues in fruits and vegetables. Non-compliance to good agricultural practices, desire to produce good quality fruits and vegetables, and conflict of interest were thought to be the underlying reasons for the contamination. Consumers thought that their health is at risk of chronic and acute health effects, and that this risk is unavoidable. They emphasized that long term exposure to the pesticide residues puts them at risk of conditions like reproductive defects and noncommunicable diseases like cancer, hypertension, obesity, kidney and heart diseases among others. To reduce the risk, consumers were aware of and relied on mitigation measures including washing, peeling, drying and cooking or applied them in combination. Consumers were aware of the presence of pesticide residues on fruits and vegetables, potential short and long term health risks due to exposure, and domestic processing methods to reduce health risks. There is need for authorities to ensure adherence to good agricultural practices and ensure that farmers and consumers understand that pesticide are used to control pests and disease but not to primarily increase shelf life of fruits and vegetables.

KEYWORDS: Focus group discussions, handling and processing practices, risk mitigation measures, contaminants, Uganda

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Introduction

Use of pesticides in fruits and vegetables production may result in their accumulation on produce. Pesticides are applied to protect fruits and vegetables from pests and diseases to improve their produce.[1] Uncontrolled use of pesticides on fruits and vegetables to protect them from damage and loss by pests may result in increased residues levels in–or-on them,[2] to levels above the maximum residue limits (MRLs) that might be toxic to human health. Irrational use is often as a result of farmers not following Good Agricultural Practices (GAPs) and pesticide management[3,4] including observing the pesticide mixing concentrations on the labels and the pre-harvest intervals.[5] Farmers in many low- and middle-income countries (LMICs) do not comply with the GAPs given their circumstances.[6] Similarly, in Uganda many farmers do not follow the GAPs (Kaye et al). This implies that fruits and vegetables in the market may have high concentrations of pesticide residues that puts consumers at risk of their associated effects. However, consumers are often not aware of the existence of pesticide residues in the fruits and vegetables they consume.[7]

Consumer awareness of the possible presence of pesticide residues, and of associated health risks in fruits and vegetables they consume is important in reducing exposure. Awareness of the presence of pesticides influences consumers' actions towards reduction of exposure.[8,9] Some consumers are willing to pay more money to buy vegetables that are produced using organic pesticides.[9,10] While fruits and vegetables produced using organic pesticides might be available in high-income countries, most of those available on the Ugandan market and other under-resourced setting are grown using conventional methods. In addition to relying on products produced using organic pesticides, consumers are also willing to purchase products

with food traceable systems like the blockchain.[11] So, other consumers might opt for food preparation methods like washing, peeling and cooking or boiling that are effective in reducing pesticide residue concentration in fruit and vegetables.[12,13] Despite the paucity of literature on consumers' health risk perceptions towards pesticide residues in food especially in LMICs, a Ghanaian study showed a low perception towards health risks associated with consumption of pesticide residue contaminated fruits and vegetables.[7]

Most literature points to pesticide residue exposure reduction towards farmers, but consumers also have a role to play and be protected from pesticide associated health hazard, as emphasized by the farm to fork strategy.[14] Awareness of the possible presence of pesticide residues in fruits and vegetables and associated effects will motivate them to adopt better food preparation methods like washing, peeling and boiling that have been shown to be effective in reducing the risks.[15,16] This study explored consumers' awareness of the possible presence of pesticide residues in fruits and vegetables and associated health effects in Kampala Metropolitan Area (KMA) in Uganda.

Methods

Study design

We collected qualitative data in KMA in the districts of Kampala, Wakiso and Mukono (Figure 1). Kampala, Wakiso and Mukono were selected out of the 6 districts that make up KMA because they have a mix of urban and rural areas, with an approximated total population of 10 812 700; which is 15% of Uganda's population,[17] and covers an area of 1000 km^2.[18] KMA has the largest market for fresh produce by population including restaurants and many middle-income homes that consume fruits and vegetables grown within and in other parts of Uganda. We conducted focus group discussions (FGDs) with consumers who purchase fruits and vegetable to determine their perceived vulnerability to pesticide residues and associated health risks. For data triangulation purposes, we enrolled 4 types of participants in the FGDs including: females, males, and urban and rural residents. The study was approved by the Makerere University School of Public Health Higher Degrees, Research and Ethics Committee and by the Uganda National Council for Science and Technology (SS 5203). FGD participants provided written informed consent prior to the discussions. Participant privacy was protected through anonymous and voluntary participation.

Selection of participants

The FGD participants were selected from the pool of fruits and vegetable consumers that participated in a food frequency questionnaire (FFQ) survey.[19] During the FFQ survey, participants phone contacts were collected for purposes of recruitment into the FGDs. On completion of the survey, participants that were involved in the FGD were selected based on contribution in the FFQ, sex and geographical location. Participants who agreed to participate in the FGDs were given the date, time and venue for the meeting. One-day prior the date of the FGD, participants were reminded about the date, time and venue. Each FGD was composed of 8 to 12 participants. The FGDs were divided into sub-groups based on location (urban and rural), and gender (females and males) to enable variability and comparison of perspectives among groups. Saturation was reached at 3 FGDs in each of the urban and rural geographical locations but undertook 2 more discussions making a total of 8 FGDs.

Data collection

The FGD were carried out using a guide developed from existing literature[8,9] and knowledge of the subject and local practices. The guide consisted of questions that explored perspectives on the presence of pesticide residues in fruits and vegetables, perspectives on potential for pesticide residues to affect consumers' health and perspectives on consumers' vulnerability to pesticides residues. The guide was translated to the local language (Luganda) and pretested with community members who had not participated in the FFQ survey and the feedback was incorporated prior to data collection. The FGDs were moderated in the local language (Luganda) by a Masters of Public Health graduate SN and PK a mass communication graduate with 3 years of experience in qualitative data collection was taking notes and helping with the recording. The moderator and note taker were trained on the subject, interviewing skills and consent process. All the FGDs were conducted under the supervision of CS, the Principal Investigator. A memo was also maintained by the moderator and note taker pre and post FGDs while reflecting and documenting their experiences. The FGDs were homogenous with regards to sex and geographical location to avoid possible bias and ensure equal participation. The FGDs were carried out either at church or school within the community and lasted approximately 1 hour and 30 minutes. All the proceedings of the FGDs were audio recorded after receiving permission from the participants. The audio recordings of the FGDs were labelled and stored on a secured server. They were transcribed verbatim and translated to English by moderator and note taker who are fluent in both English and Luganda.

Data analysis

The transcripts were read by CS and the Master of Public Health graduate SN who moderated the FGDs to generate text fragments containing some information from the discussion – meaning units. The meaning units were then grouped into codes. The FGDs were imported into NVivo software version 21.0, and coded deductively and inductively. Data was analysed using conventional content analysis. Several emerging ideas were identified from the narratives based on the words

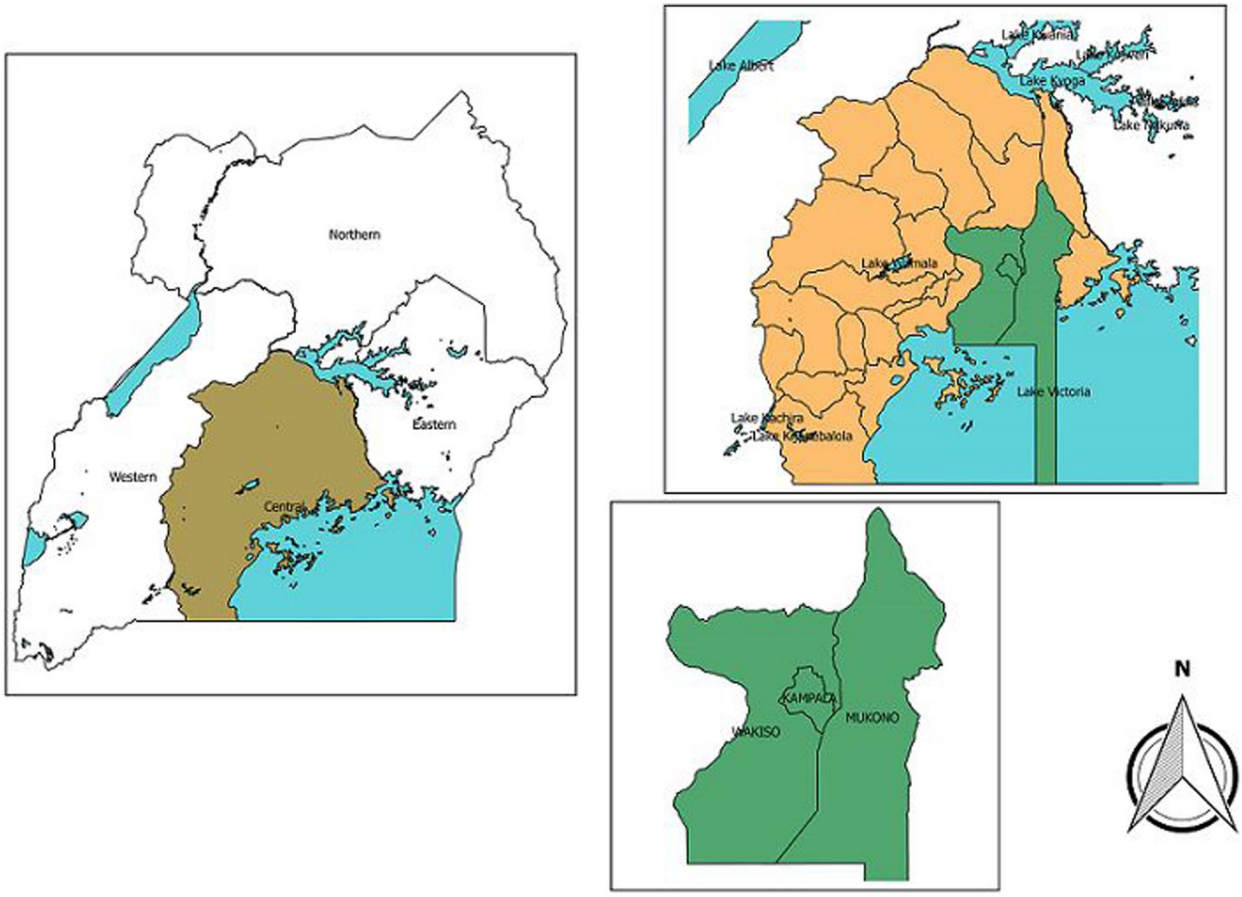

Figure 1. Map of Uganda showing Kampala Metropolitan Area – the study area.

and phrases that appear more often as organized by codes in NVivo software. The emerging ideas were organized into meaningful categories based on recurring ideas to form sub-themes. The sub-themes were merged to come-up with themes. The themes are described extensively and supported with quotes from the discussions in tables.

Results

A total of 75 people participated in 8 FGDs. Most of the participants had attained secondary education (56) and were either involved in business (31) or in farming (29). The mean age of participants was 38 with a standard deviation of ±14.5 (Table 1). Saturation was observed at 6 FGDs with fruits and vegetable consumers (n = 56, 74% participants). Each FGD lasted between 50 and 90 minutes.

After data analysis 4 main themes regarding consumer's awareness and health risk perceptions of pesticides residues in fruits and vegetables were identified: (1) consumer awareness of pesticide contaminants in fruits and vegetables; (2) underlying reasons for contamination of fruits and vegetables with pesticides; (3) consumers' health risk perceptions to pesticides in fruits and vegetables; and (4) risk mitigation measures employed by consumers. Further descriptions of each theme and subtheme, as well as informative quotes in support of the results are shown in Table 1.

Consumer awareness of pesticide contaminants in fruits and vegetables

Participants stated that fruits and vegetables contain pesticide residues. It was agreed by all participants that pesticides are used on the farm for controlling pests and disease as well as in weeding in order to improve the quality of the harvest, and thus accumulate in the fruits and vegetables. Participants noted that fruits and vegetables especially tomatoes and cabbages are sprayed from the planting to harvesting stage and thus contain high concentrations of pesticides. In fact, participants mentioned that vegetables like tomatoes have visible pesticides in form of a whitish colouring.

> "*All farmers spray their crops with pesticides. If a pesticide is used to kill weeds, how sure are we that it will not persists in the crops and produce we buy in the market*" (FGD, urban, male)

FGD participants said that fruits and vegetables contain multiple pesticide residues, as they are sprayed at different stages of their development with different types of pesticides. Thus, all these accumulate in and/or on the fruit and vegetable. They also hinted that farmers often mix pesticides before spraying. Participants did not know the pesticide types that are on the fruits and vegetables but knew them by the trade names. They mentioned Indofil, Duducyper, Dudu acelamectin, Rocket,

Table 1. Socio-demographic of FGD participants.

VARIABLE	FREQUENCY (N=75)	PERCENTAGE (%)
Age in years Mean(±SD)	38 ± 14.5	
Education		
None	4	5.4
Primary	22	29.3
Secondary	42	56.0
Tertiary	7	9.3
Occupation		
Business	31	41.3
Civil servant	8	10.7
Farmer	29	38.8
House Wife	7	9.3
Location		
Rural	38	50.7
Urban	37	49.3
Sex		
Male	37	49.3
Female	38	50.7

Weedmaster, Round up and 2,4-D as the common pesticides used in the fruit and vegetable growing.

> "*Tomatoes are sprayed with three types of pesticides, while in the nursery bed, after transplanting and during fruiting. So, we eat multiple pesticides in one tomato*" (FGD, rural, male)

Underlying reasons for contamination of fruits and vegetables with pesticides

The accumulation of pesticides in fruits and vegetables raises utilization questions. FGD participants revealed that farmers do not follow the manufacturers guidelines. Consumers said that farmers often mix high concentration of pesticides than those recommended on the pesticide labels. Participants also said that many farmers harvest the fruits and vegetables immediately after spraying and thus do not observe the recommended pre-harvest intervals. So, they attribute the pesticide residues contamination in fruits and vegetables to non-compliance to GAPs.

> "*. . .. . if crops are harvested immediately after spraying, it is very hazardous. Ample time should be left between the last spraying and harvesting to allow for dilution of pesticides*" (FGD, rural, male)

Comments that indicate the desire to have quality fruits and vegetables and the role of pesticides in achieving it manifested during the FGDs. consumers said that farmers spray just enough pesticides to ensure that the fruits and vegetables grow optimally. They emphasize that the pests may become resistant and affect the growth of the fruits and vegetables. It was also noted that sprayed fruits and vegetables look succulent on the market but also tasty and thus the need for the farmers to use pesticides.

> "*If farmers do not use the recommended amount of pesticide, the pests may not die completely or might return shortly after spraying. Yet, farmers grow crops for profit and thus need high yields*" (FGD, urban, female)

The consumers also cited conflict of interest from all stakeholders (manufacturers, farmers and consumers) along the chain as the reason for continued unsafe use of pesticides for fruit and vegetable production. Consumers said that the manufacturers want profits, the farmers need quality yields that will give them huge profits. Consumers hinted that they prefer succulent and big fruits and vegetables regardless of whether they have applied pesticides in their production.

Consumers' health risk perceptions to pesticides in fruits and vegetables

FGD participants agreed that their health is at risk due to exposure to pesticide residues. They mentioned that long term exposure results in accumulation of pesticide residues in their bodies and eventually accelerate disease conditions in old age. Participants mentioned reproductive and birth defects, cancers, hypertension, obesity, kidney and heart disease as the chronic health effects due to consumption of pesticide residues in fruits and vegetables.

> "*Our health is at a high risk because we eat fruits and vegetables that are contaminated with pesticide residues. The pesticides accumulate in our bodies and can be passed on to our children during pregnancy*" (FGD, urban, male).

Most consumers thought that they are at risk of acute health risks from consuming pesticide residues. Acute health risks like allergies, skin irritation, nausea and sneezing were mentioned by consumers as risks associated with consumption of pesticide residues in fruits and vegetables.

> "*If you have allergies, pesticide residues on fruits and vegetable may trigger the allergies such as skin irritations*" (FGD, urban, female).

Consumers attributed the surge in non-communicable disease in their communities to exposure to pesticide residues in fruits and vegetables. They said that NCDs were gradually increasing even among children. On the other hand, consumers thought that NCDs are due to the general diet components especially sugar and unsaturated fat. Consumers also perceived risks due to exposure to pesticide residues in the fruits and vegetables they consume as unavoidable. They said that pesticides play a key role in the production of fruits and vegetables but also leach into their inner layers.

"*Pesticide residues in fruits and vegetables have caused a lot of harm to peoples' health. I gave birth to twins but when they got health complications, the doctor said they were caused by the different chemicals in the food they eat, which may be harmful to health*" (FGD, urban, male).

Risk mitigation measures employed by consumers

Participants stated that washing, peeling, drying and cooking or a mix of methods are handling and processing methods they employ to reduce the concentration of pesticide residues in the fruits and vegetables they consume. Consumers agreed that washing fruits and vegetables is the sufficient and ultimate method of reducing the concentration of pesticides. Washing with warm or boiled water and application of vinegar after washing were cited as the most effective way of reducing the pesticide concentration. Soaking the fruits and vegetables before washing was mentioned by consumers to reduce pesticides. However, consumers cited lack of access to water and time as key challenges to washing as a mitigation measure. On the contrary, consumers believe that pesticide residue leach inside the fruit or vegetable and thus washing does not reduce their concentrations.

"*. . .. . we have to wash and reduce the concentration. Although some residues may be within the fruit or vegetable, let us at least try to wash away those on the surface*" (FGD, urban, female)

Peeling of fruits and vegetables was mentioned by many consumers as a means of reducing the concentration of pesticide residues. Consumers said that peeling if very effective especially if the pesticides are lodged on the pericarp, but might not if the pesticides leaches and accumulate into the fruits and vegetables. Lack of time to peel off the outer layer of fruits and vegetables was viewed as a challenge to peeling. Consumers also reflected about the facts that some of the outer layers of fruits and vegetables contain nutrients that might be lost with peeling. However, consumers thought that peeling is not effective in vegetables like cabbages that are sprayed throughout their growth and thus pesticides are encapsulated inside.

"*Peeling may reduce the concentration of pesticide residues in fruits and vegetables but sometimes the pesticide residues are encapsulated internally*" (FGD, rural, female)

Most of the consumers agreed that cooking reduces the concentration of pesticide residues in fruits and vegetables and thus advised colleagues against eating them raw. However, consumers thought that cooking might increase the intensity or potency of pesticide residues. Although it was said to reduce the nutrient content in fruits and vegetables, consumers relied on drying to disintegrate pesticide residues.

"*Cooking reduces the concentration of pesticide residues in fruits and vegetables but may only increase the potency of the pesticides*" (FGD, urban, male)

Participants mentioned applying multiple handling and processing measures to reduce pesticide residue before eating their fruits and vegetables. Participants washed and peeled the fruits and vegetables. Others combined 3 methods including washing, peeling and cooking.

"*I first wash the fruit and vegetables then peel off the outer layer*" (FGD, urban, female)

Discussion

This qualitative exploration was aimed at understanding consumers' awareness of pesticide residues and potential health effects in fruits and vegetables. Generally, participants were aware of the presence of pesticide residues in fruits and vegetables, and that these can put their health at risk. Participants agreed that long term exposure puts them at risk of developing chronic conditions including NCDs like cancer, kidney and liver disease among others. Consumers see the need to protect themselves and thus apply domestic handling and processing measures including washing, peeling, drying and cooking to reduce the uptake amounts of pesticide residues.

A consensus emerged that fruits and vegetables contain pesticide residues. Our findings are similar to other socio-cultural studies that have been carried out among consumers,[7-9] which indeed demonstrated that they were aware that their fruits and vegetables were contaminated with pesticides. Consumers perceptions in our study also align well with laboratory studies carried out within the study area which found that fruits and vegetables contain pesticide residues.[20-22] Consumers also reported that fruits and vegetables contain multiple pesticides. This could be explained by the fact that farmers use cocktails of pesticides or application of different chemicals over different stages of development of the fruits and vegetables.

The FGDs revealed that consumers understand the underlying reasons for the presence of pesticides residues in fruits and vegetables. Non-compliance to good agricultural practices like the mixing concentrations and pre-harvest intervals in the bid to improve the quality of their fruits and vegetables and conflict of interest by pesticide manufacturers, farmers and consumers were said to explain the overreliances on these chemicals in agriculture. This view has also been expressed by Andersson and Isgren, that while farmers are aware of the risks involved they lack alternatives for pest control.[23] There is need to apply strategies to reduce use of pesticides for food productions such as promotion of low-efficiency pesticides, use of traceability labels, reliance on other crop protection services like GAPs and mechanical sowing / transplanting.[24,25]

Consumer expressed that their health is at risk citing chronic exposure to pesticide residues and consequent health effects like reproductive defects, NCDs like cancer, hypertension, diabetes, obesity, kidney and liver disease were the major effects. Our findings correlate with findings from previous studies in Africa and German which found that consumers rated pesticide residue contaminants as a serious threat to their health,[8,9,26-28] in fact, Kher and colleagues found that consumers were specifically concerned about health risks that

were likely to result from their long term exposure to these chemicals.[8] Indeed, risk assessment studies have shown that long term exposure to pesticide residues poses health effects to consumers,[29-32] to many organ systems.[33] Contrary to our findings, a study carried out in similar settings in Ghana showed that consumers of urban grown vegetables had a low health risk perception.[7] The high health risk perception implies that consumers need to devise measures to reduce their exposure to pesticide residues.

Although some questioned how effective they are, consumers either washed, or peeled, or dried or cooked or applied a combination of these aforementioned methods to reduce their exposure to pesticide residues as well as resultant health effects. Our findings are contrary to a study which found that consumers did not know any pesticide decontamination methods.[34] Existing literature indeed shows that domestic processing methods such as washing, peeling, drying and cooking reduce or increase some pesticide residues on/in fruits and vegetables.[13,35-43] In terms of effectiveness, some studies have shown that peeling is effective in reducing pesticide contamination[15,16,43,44] but not for all active ingredients.[44] Washing and/or soaking with water[41,43,45,46] and increasing cooking time have also been shown to reduce the risk of exposure.[41] Indeed cooking reduces chronic exposure risk, a study that compared different cooking methods showed that salad preserved almost all the pesticide residues while other methods greatly lowered all types, contents and exposure risks.[47] Generally, literature suggests that effectiveness of processing methods increases with increase in the time for which the method is applied.[41,43,48] Although quite old, some literature has shown that a combination of washing and peeling was also found to be very effective and removes up to 99%.[49] Among the processing methods used by consumers to reduce pesticide residues in our study, drying and cooking have been found to increase concentration of some chemicals.[13,37,38,43,46]

Our results have policy, practices and research implications. Underlying reasons for fruit and vegetable contamination with pesticide residues such as non-compliance to GAPs require government initiative to adopt to enforce implementation of these guidelines among farmers. Pesticide use in fruits and vegetables production is aimed at controlling pests and diseases as well as weeds but not to give taste, increase size of the produce or prolong shelf life, therefore, there is need to change farmers and consumers' perceptions towards their role in horticulture. Our findings also demonstrate the need to develop post-harvest pesticide residues reduction guidelines that address processing conditions such as time, solubility and temperature and disseminate especially at consumption stage in order to protect the consumer. While consumers were aware of potential health risks, we are not certain of what influences these perceptions. Future research should assess the factors that influence risk perceptions among consumers. There is also need to assess whether risk perceptions and preference are significantly correlated with the mitigation (processing) behaviours or practices.

Whilst this paper identified clear themes, our research is limited by general qualitative study limitations including the fact that we decided on the questions to be asked and how responses are interpreted. The fact that FGD participants had participated in an earlier fruit and vegetable consumption survey[19] could have influenced their responses in this study. The study population was also limited to KMA which is fairly educated compared to other regions in Uganda. The balance the number of the FGDs between men and women might have influenced opinions about the mitigation measures used especially that women are often involved in the handling and processing of fruits and vegetables in the study setting.

Conclusion

Overall, our findings show that consumers are aware of the presence of pesticide residues and potential health risks in the fruits and vegetables they consume. Consumers are awareness of the acute health effects due to pesticide residues but stressed that long term exposure aggravates the risk especially to chronic conditions like NCDs. While there is widespread agreement that pesticides are part the fruit and vegetable production ecosystem, consumers appreciate the fact that they have a role to play in reducing their levels of exposure to the residues. To reduce the risks due to pesticide residue exposure, consumers apply a combination or individual domestic processing methods such as washing, peeling, drying and cooking. The government of Uganda through the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) should ensure that fruit and vegetable farmers are adhering to good agricultural practices including mixing pesticides and pre-harvest intervals. In addition, there is need to change farmers and consumers' perceptions towards the role of pesticide in the production of fruits and vegetables. There is also need to develop and disseminate post-harvest pesticide residue decontamination guidelines for consumers.

Authors' Note

This manuscript is exploring consumers' awareness of the presence of pesticide residues in fruits and vegetable. It also describes consumers' perspectives on their vulnerability to pesticide associated long and short term health risks and potential mitigation measures. There are similar papers from Uganda that have been published in the Environmental Health Insights.

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Authors' Contribution

Conceived and designed the experiments: CS, AB, JCS and DG. Analysed the data: CS. Wrote the first draft of the manuscript: CS. Contributed to the writing of the manuscript: CS, AB, JCS and DG. Agree with manuscript results and conclusions: CS, AB, JCS and DG. Jointly developed the structure and arguments for the paper: CS, AB, JCS and DG. Made critical revisions and approved final version: CS, AB, JCS and DG. All authors reviewed and approved of the final manuscript.

Disclosure and Ethics

Ethical approval was granted by the Makerere University School of Public Health Higher Degrees, Research and Ethics Committee (HDREC); and registered by Uganda National Council for Science and Technology (SS 5203). All participants provided written informed consent before their involvement in the study.

Supplemental Material

Supplemental material for this article is available online.

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