Consumer risk perception towards pesticide stained tomatoes in Uganda.

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Abstract

Background: Tomatoes are consumed daily. Unfortunately, abuse of pesticides application by vegetable growers in Uganda increases risks of exposing consumers through the pesticide residues, as it may be above European Union Maximum Residue Limits (used as a standard in Uganda). This study is aimed to determine consumer attitudes and risk perception towards pesticide stained tomatoes available on the Ugandan local markets.

Methods: A cross-sectional study sampled 468 household consumers in four districts one from each region of Uganda. In each district, 60 household members from three randomly selected Sub Counties were interviewed. In addition, in each district 9 tomato handlers (3 tomato farmers, 3 tomato retailers and 3 tomato wholesalers) participated in Focus Group Discussion (FGDs) per district. Collected data was entered into MS-Excel 13 and exported into STATA SE 14.0 for cleaning and analysis at below a 5% level of significance and 95% Confidence Intervals (CI). Proportion of risk perceptions and attitudes were computed and presented as percentages while factors associated with risk perception were determined using Fisher exact test. Qualitative data was analyzed using deductive and inductive approaches under thematic content analysis.

Results: More than half, 54.2% (253/468), of the respondents were females, mean age was 37 years (SD=13.13, ranging from 18 to 88 years). Half of the respondents, 50.9% (238/467), were farmers by occupation and 40.3%

(188/468) had completed upper primary education. Only 5.0% (20/396) of consumers reported a high risk perception towards tomatoes stained with pesticide residues, the rest, 95.0% (376/396), were buying pesticide stained tomatoes despite their awareness about the possible health effects. The main reason for buying the pesticide stained tomatoes was that a majority, 59.0% (230/390), lacked an alternative to stained tomatoes. However, consumers generally had a negative attitude towards pesticide stained tomatoes, with 67.0% (313/468) of the consumers disagreeing to a statement that tomatoes sold on the market are safe. Consumer risk perception was significantly associated with consumer awareness about residues in the tomatoes; where the proportion of consumers who were aware of the risk of pesticide stained tomatoes were 42.8 times more likely not to buy stained tomatoes compared to the proportion of those who were not aware. OR, 42.8 (95% CI: 10.76-170.28). However, level of education P(0.975), gender P(0.581) and age-group P(0.680) were not associated with consumer risk perception after Fisher-Exact tests analysis. (95% CI and 5% level of significance).

Conclusion: Consumer risk perception on pesticide stained tomatoes among Ugandan consumers ranked low with a majority of consumers buying tomatoes stained with pesticide residues due to lack of an alternative, except for a few who had a high risk perception about the pesticide health effects.

Key words: Consumer Risk Perception, Food Safety, Pesticide Residues.

Introduction:

Globally, there has been an increase in the inquiry on the knowledge of dangers of chemicals in food which has aroused consumer concerns on food safety(1, 2). This follows from consumer reports on health effects of pesticides from their inappropriate use, exposing consumers to high amounts of pesticide residues in harvested foods (3-5). Pesticide residues in food are directly related to the irrational application of pesticides on growing crops and to a lesser extent from residues remaining in the soil. Accumulated pesticide residues in food products are associated with human health hazards ranging from acute to chronic toxic effects (4, 6-8).

In the developing countries, most of the fruits and vegetables grown on a commercial scale are sprayed with pesticides to combat pests and diseases. A study done in 2014 at the two largest horticultural produce markets in Africa showed that 91% of the fruit and vegetable samples collected between 2012 and 2014 had pesticide residues although these were compliant with the Maximum Residue Limits (MRLs) (9).

The use of pesticides has intensified globally for numerous decades in agriculture, homes and industries for increasing productivity and reducing on the losses (4, 10-12) yet also proved to be an important cost of production(13). In the Sub Saharan Africa with tropical climate that favors the growth and rapid multiplication of pests, pesticides are usually used at all levels of agricultural production including on farms to shield plants from pest

attack and damage, to control weeds and parasites in livestock as well as in post-harvest control measures. It is now nearly impossible to produce food in tropical regions without using agro-chemicals although this is considered to be among the climate change mitigation strategies (14).

In most low-income countries, fresh produce sold at local markets is usually not analyzed for agricultural chemical residues unlike export products. This raises concerns about the perceived safety levels of local food supplies in contrast to exported products (9). For instance, a study in Uganda showed that 24.5% of farmers were not aware of any health risks of spraying tomatoes close to harvest time, almost 50% of farmers (45.8%) sprayed their tomatoes less than a week up to harvest time, 29.2% sprayed their tomatoes at harvest with intentions to extend the shelf-life while 50% did so to attract consumers (15, 16).

Another study in 2015 shows how famers spray tomatoes 6 times the manufacturer recommended dosage, but also harvesting these tomatoes 2-3 days after last spraying session compared to recommended 4-7days (16). These phyto-sanitary practices increase pesticide residues in tomatoes with no control measures in place since Uganda lacks a pesticide residue monitoring plan for conventionally grown food, but also the health sector has not prioritized prevention and control measures for pesticides poisoning (17).

Although developed countries use 75% of global pesticides; these countries apply them with strict regulations compared to developing countries which

lack the enforcement or the regulations. Though developing countries use the least quantities of pesticides, they use the most toxic ones (18, 19) resulting in increased risks of acute poisoning. The inappropriate use of pesticides in developing countries increases pesticide exposure and health risks to the consumers. Approximately 25% of developing countries lack regulations and 50% of the WHO-region countries lack sufficient resources to enforce their pesticide-related regulations (20-22). Also, under existing international laws, highly toxic, banned or unregulated pesticides are always exported to developing countries (23-26), posing health risks to consumers.

Although Uganda is in its transition of establishing a pesticide residue monitoring program, this is moving on a slow pace and protecting public health may take time to be realized. This study aimed at understanding the attitudes and risk perception of consumers towards pesticide stained tomatoes with a plan of establishing evidence for the need of a pesticide residue monitoring program for Uganda.

Methods

Study area and population

This study was conducted in the 4 districts, from each of the four regions of Uganda namely; Northern (Nebbi), Western (Masindi), Eastern (Bugiri) and Central (Ssembabule). From each district, three sub counties were randomly selected and consumers selected systematically at household level for

interviews. The above districts were Pesticide Use, Health and Environment (PHE) Project intervention areas where tomatoes are commonly grown and intensively sprayed with pesticides with agriculture as their first priority day to day business.

The Uganda National census 2014 estimates average population for the above districts as follows; Nebbi (385,220), Masindi (94,622), Bugiri (426,000) and Ssembabule (219,600).

Study design

A cross-sectional study design conducted in June 2019 employed both qualitative and quantitative methods of data gathering. Working through already existing branches of the District Farmers Association (DFA) in each of the four districts, three sub counties were randomly sampled clustered into urban, peri-urban and rural. In each of the districts, at household level, on average 117 participants were randomly selected and interviewed making an overall total of 468 participants in the four districts. In addition, purposive sampling for Focus Group Discussions (FGDs) was done by the DFA focal person, forming a total of 9 participants per group per district. Each FGD was composed of three tomato farmers, three tomato retail vendors and three tomato wholesalers totaling to 36 participants in the four districts.

Materials

Pretested and standardized structured questionnaires adopted from a survey "*A monitor on consumer confidence in food safety*" developed (by Janneke de Jorge, 2008) for monitoring consumer safety in a Canadian population were modified and used for data collection (details provided in the S5 File). All questionnaires were translated into the local languages of participants and translated back into English for quality assurance purposes. Focus Group Discussion Guides were used to collect the qualitative data and also administered in the local language by trained Research Assistants (RAs).(details of the guides are provided in S6 File).

Consumer risk perception was assessed using a series of three questions in the order; 1) Are pesticide residues harmful to human health? 2) Are you aware that tomatoes sold on local markets contain pesticide residues? 3) Do you buy pesticide stained tomatoes? Attitudes were measured on a three-Likert scale (responses ranging from agree, not sure and disagree) with questions on optimism, pessimism and trust. On the side of optimism, questions assessed the safety, confidence and satisfaction about the pesticide residues on tomatoes while pessimism assessed the worrisomeness, suspicion and discomfort caused by the pesticides residues on the tomatoes (Assessment results provided in S2 File).

Data collection and analysis

Research Assistants (RAs) were trained on the objective of the study in a one day training per district, questionnaire pretested with the RAs and supervision done on a daily basis, every filled-in questionnaire was reviewed to ensure that they were fully filled in and ethical considerations were not bleached.

Trained RAs from the respective District Farmer Associations were enumerated to gather quantitative data in each of the 3 sub counties per district, but also where necessary used as translators during FGDs for qualitative data collection. A total of 36 respondents were involved in the FGD, 9 per district, all their responses recorded on audio and data gathered on tapes. Sample size for the FGDs was based on the level of saturation of the responses.

Quantitative Collected data was gathered and entered into Microsoft Excel Version 2013 and exported into Stata SE.14 for cleaning and analysis. A total of 468 entries were achieved. Categorical variables like Risk Perception (measured as a binary outcome) and Attitude, age group, occupation, gender, and level of education were presented as frequencies with their respective percentages while continuous variable such as age presented as mean with respective (SD) and ranges.

Bivariable analysis for risk perception (measured as a binary outcome), was computed by gender, level of education, age categories, residence (rural, urban and peri-urban) and the chi-square plus the respective p-values under (95% CI, 5% Level of significance) reported. Awareness about the pesticide

residues was computed by level of education and by the practice of buying tomatoes and their Chi-square, p-values under (95% CI and 5% Level of significance) reported. Fisher exact test was used to determine the factors associated with consumer risk perception and the factors for buying of pesticide stained tomatoes under (95% CI, 5% Level of significance), details provided in the S3 File. Finally, simple logistic regression was used to compute the odds of high risk perception by consumers who were aware of pesticide residues on the tomatoes and the respective Odds Ratio with the p-values reported under (95% CI and 5% Level of significance.

Qualitative data collected among the 36 participants in the four districts was transcribed and analysis done thematically based on the study objectives using deductive approach of reasoning, making conclusions based on participant responses. These conclusions were later used to support a discussion with quantitative data findings.

Ethical consideration

This study sought ethical approval from Makerere University School of Public Health, Higher Degree Research and Ethics Committee (MakSPH HDREC) with an approval reference registration number 686. Informed consent was sought from all participants before the interviews, for anonymity, participants initials were used instead of their names on the questionnaire and they were free to withdraw from the study at any point when they felt like not continuing with the interviews.

Results

Demographic characteristics of consumers

The study registered 100% response from consumers equally sampled by residence (rural, urban and peri-urban), interviewed from three sub counties in each of the four districts (Northern region: Nebbi district, Eastern Region: Bugiri District, Central Region: Sembabule district and Western region: Masindi district).

As indicated in Table 1, Slightly more than half, 54.1% (253/468), of respondents were females, a majority, ≈51.0% (238/468) practiced farming as an occupation (*refer to S1* File), a majority, 84.4% (273/468), had attained lower level of education. The mean age of participants was 37.7years (SD±13.1, ranging from 18-88) and 54.7% (256/468) were falling into the age group below the mean age. From the qualitative results, interviews involved tomato farmers 33.3% (12/36), tomato retail vendors 33.3% (12/36), and tomato wholesalers 33.3% (12/36) sampled in equal proportions in the 4 districts. i.e. three persons per category per district.

Table 1: Demographic characteristics of consumers

Variable	Category	Frequency (%)
Gender	Male	214 (45.8)

(n=468)	Female	253 (54.2)
Age group	Below mean Age Above mean Age	256 (54.7) 212 (45.3)
	Mean Age	37.7 (SD±13.1)
Level of education (n=468)	No formal education Lower level upper level	39 (8.3) 395 (84.4) 34 (7.3)

General consumer attitudes towards pesticide stained tomatoes

Consumer negative attitude (pessimism) towards pesticide stained tomatoes.

Basing on the computed percentages of pessimism, measured on a 3-Likert scale, a majority, 74.3%(347/467) of the consumers had a negative attitude (on the agreement side) towards the stains on the tomatoes compared to 2.4%(11/467) who were not sure and 23.5% (109.6/467) who felt positive about the stains on the tomatoes in terms of worrisomeness, discomfort and suspicion that the residues cause (details provided in S2 File and Fig1*)*.

Fig 1. Average negative perceptions of consumers on pesticide stained tomatoes in percentage.

Consumer positive attitude (optimism) towards pesticide stained tomatoes.

Basing on the computed percentages of optimism, measured on a 3-Likert scale, Consumer positive attitude towards the pesticide stains was low. On average, only 33.2% (155.3/468) of the consumers agreed to the statement that tomatoes sold on the Ugandan market are safe, compared to a majority 61.1%(285.6/468) who disagreed with the statement while 5.7% (26.7/468) were not sure as provided in Fig2. and indicated S2 File.

Fig 2: Average positive perceptions of consumers on pesticide stained tomatoes in percentages.

Consumer level of trust in pesticide stained tomatoes

In terms of trust, based on the 3-scale resized computed averages for trust, about 77.7 % (362/466) of consumers lacked trust and disagreed that tomato vendors have the characters of trust such as the competence to control safety of tomatoes, the knowledge to guarantee tomato safety, honesty about the safety of the tomatoes, sufficiently open about tomato safety and giving special attention to control the safety of tomatoes compared to 8.1% (37.6/466) who were not sure and 14.1%(65.4/466) who trusted tomato vendors (details provided in the S2 File).

Consumer risk perception level towards pesticide stained tomatoes

Consumer risk perception was measured using a model with questions as provided in Fig 3.

Fig 3. Model for determining consumer risk perception

Consumer risk perception

Among consumers who were aware and knowledgeable about sold tomatoes containing pesticide residues, ≈95.0% (376/396) of them bought these pesticide stained tomatoes (i.e. had a low risk perception) compared to only 5.0% (20/396) who perceived tomatoes to be of high risk to their health and withdrew from buying them (i.e. had a high risk perception) as provided in Fig 4.

Fig 4. level of consumer risk perception towards pesticide stained tomatoes

Reasons for buying pesticide stained tomatoes.

The main reasons for buying pesticide stained tomatoes was that 59.0% (230/390) of the consumers had no alternative choice to buying pesticide stained tomatoes, followed by 27.2% (106/390) who had to prepare these

tomatoes to reduce on the residues, 9.2% (36/390) who perceived no health risks of buying stained tomatoes and 4.6% (18/390) falling in the other categories which included the attributes of the tomatoes like size, ripeness among other.

Consumer confidence on the safety of tomatoes sold on Ugandan Market.

On a general scale, more than half, 66.9% (313/468), of the consumers disagreed to the fact that tomatoes sold on the Ugandan markets are safe, consumers' general confidence on the safety of tomatoes sold on Ugandan Markets outweighed their counterparts with nearly half, 49.6%(231/466), of the consumers being confident about the safety of tomatoes sold on the Ugandan markets while only 14.4%(168/466) were not confident and 14.4% (167/466) were not sure.

Factors associated with consumer risk perception and buying of stained tomatoes.

From the Fisher-exact tests, Consumer risk perception was not associated with the level of education P(0.975), Residence P(0.462), gender P(0.581), age-group P(0.680) and marital status P(0.581), as indicated in the S3 File. Further simple logistic regression analysis revealed that consumer risk perception was significantly associated with consumer awareness about residues in the sold tomatoes; where the proportion of consumers who were aware that tomatoes contain pesticide residues being 42.8 fold more of a high risk

perception compared to the proportion of those who were not aware of the residues as provided in the S4 File.

In table 2, the consumer awareness about Pesticide residues was not associated with age-group and level of education but significantly associated with gender, where male consumers were 1.77 time more likely to be aware of the pesticide residues in the tomatoes compared to counter parts; the second factor was whether consumers ever obtained pesticide safety information where consumers who had never obtained pesticide safety information being 61% less likely to be aware of the pesticide residues compared to consumers who had obtained information on pesticide safety, OR 0.39 (95% CI: 0.24-0.64)

Table 2: Logistic Regression for Consumer awareness about pesticide residues on tomatoes and some consumer demographics (crude Odds ratio)

	Aware of pesticide residues No (%) Yes (%)	**Odds Ratio**	**Std. Err.**	**P>|z|**	**[95% CI]**	
Gender						
Female	54(21.3) 200(78.7)	1.0				
Male	28(13.2) 184(86.8)	1.77	.451	**0.024**	1.078	2.921
Age category						
Below mean age	46(18.0) 210(82.0)	1.0				

above mean age	36(17.1) 174(82.9)	1.06	.259	0.816	.655	1.711
Education category						
None	10(25.6) 29(74.4)	1.0				
Lower level Education	69(17.6) 324(82.4)	1.62	.631	0.217	.754	3.477
Upper level Education	3(8.8) 31(91.2)	3.56	2.52	0.072	.891	14.249
Ever obtained information about pesticide safety						
Yes	34(12.1) 247(87.9)	1.0				
No	48(25.9) 137(74.1)	0.39	.098	**0.000**	.244	.639

Consumer awareness about the pesticide stained tomatoes was not associated with consumer level of education P(>0.05) but significantly associated with consumer risk perception P(<0.05) and the practice of buying stained tomatoes P(<0.05) as indicated in table 3 below.

Table 3: showing associations between awareness about pesticide residues in tomatoes with the consumer level of education and practice of buying stained tomatoes.

	Aware of pesticide residues in the tomatoes Freq (%)			**Fishers-exact p-values**
Buy stained tomatoes	**Yes**	**No**	Not sure	**0.000**

No	14/20(70.0)	6/20(30.0)	0 /20(0.0)	
Yes	370/376(98.4)	4/376(1.1)	2/376(0.5)	
Consumer risk perception				**0.000**
High risk perception	13/19(68.4)	6/19(31.6)	0/19(0.0)	
Low risk perception	371/377(98.4)	4/377(1.1)	2/377(0.5)	
Education level				0.095
None	29/39(74.4)	7/39(17.9)	3/39(7.7)	
primary	216/272(79.4)	35/272(12.9)	21/272(7.7)	
secondary	108/121(89.3)	7/121(5.8)	6/121(5.0)	
tertiary	31/34(91.2)	1/34(2.9)	2/34(5.9)	

Qualitative findings

Pesticide effects on human health

Main claim

From our qualitative findings, most participants, 41.2% (7/17) claimed that pesticide stained tomatoes are poisonous, harmful to human health and create fear for the consumer's health.

"To me it is real poison because even on the pesticide label the manufacturer cautions the users to put on protective gears. This puts me at

risk as a farmer and puts fears to the final consumer that is not safe'', one of the Farmers from Masindi district said.

These residues are harmfull to our health because from the time of planting to harvesting a farmer uses over 10 chemical types in order to bring out good results meaning that these chemicals get dissolved inside the tomato juice", one the wholesaler from Sembabule district said.

Underlying Issues

Some participants claimed that spraying tomatoes with pesticides was fine as long as they are washed before eating. However, some claimed that spraying high dosages leads to more residues/stains on tomatoes which may affect the consumers.

Some participants were of the opinion that residues indicate high doses of pesticide spraying before sale to the market rendering tomatoes unsafe for consumption.

Proposition:

Participants mainly suggested that tomatoes need to be washed before sale in the market and consumption to ensure safety, while other participants argued that tomatoes can be soaked in water for one (1) hour before consumption or the outer cover peeled off in order to reduce exposure in consumed food.

Argument /disagreement:

However, there was a diversion in perception about the harmfulness of pesticides, Some Participants argued that Pesticides are only harmful to pests on plants and not humans, they protect tomatoes from damage, keep them safe and ready for consumption, "*Since the pesticides are used to kill pests, the chemical is only harmful to the pests affecting tomatoes.*" narrated by a farmer from Olyeko village, Nebbi municipality.

Some participants were more interested in the appearance of pesticide residues/stains on tomatoes claiming it assured them of the market since customers preferred such tomatoes.

Participants discussed that the residues are both on top and inside, preserve the tomatoes and reduce losses and customers had to wash the tomatoes clean of pesticides.

Participants also mentioned that they spray because of environmental related issues claiming that the environment can no longer support proper tomato growth without use of pesticides and Pesticides are used to increase yields.

Unfortunately, participants were aware that farmers don't follow instructions on labels and rarely use any protective equipment as these are not easily accessible and affordable.

Perception on impact of stains/pesticide residues on consumer health

Underlying issues

Main claim

Most of the Participants 47.1% (8/17) said that pesticides negatively affect consumer health. This is mainly because most of them had experienced a sign of pesticide poisoning, for instance some claimed itching, irritations, stomachaches, and restlessness. Some participants were aware of the effects from the pesticide labels while some claimed that the smell of pesticides indicates that they have a negative effect on health.

Proposition

Some participants proposed that Consumers need to be sensitized on pesticide dangers, including the effects of the residues.

Argument

Despite the impact, some participants argued that Farmers overdose tomatoes with pesticides to meet of customers' demand of storing tomatoes for a longer time. Customers in market shun pesticides without pesticide residues; they demand those with residues because they believe they are healthy and last longer.

Some attributed this practice to the tomato varieties on market which require a lot of spraying throughout the growth stages to maximize yields.

Participants argued that farmers can't interpret the labels on pesticide containers because most of them are not educated and therefore may overdose or underdose the tomatoes with pesticides.

In addition, some participants claimed that pesticides are not very bad if used properly but farmers don't observe pre-harvest interval.

Perceived danger of stains

Main claim

Most participants 70.6% (12/17) claimed pesticides were harmful due to the health problems they cause whereas some, 29.4% (5/17) were somehow optimistic and argued that pesticide residues are not very harmful because the effects are observed after a very long time.

Underlying issues

Some participants argued that due to the low market prices and limited resources, farmers tend to delay harvesting tomatoes by spraying them to keep them longer until there is a better market price.

Proposition

Some participants recommended that the government plays its role to obliterate some pesticides including counterfeits from the market, while others recognized that farmers also have a role to play by following the prescription made by the manufacturer from the labels.

Perception on considerations before buying tomatoes

Main claim

Some participants claimed they don't consider pesticide residues and buy tomatoes with pesticides because they last longer. Some participants consider tomato size (prefer big to small), tomato ripeness (prefer not so ripe tomatoes), freshness and customer needs.

"*We look for general appearance of tomato but at sight I look at the pesticide residue on tomato not the size. I would better go with small tomato with pesticide than a big one.*" answered a farmer from Masindi district.

However, a few wholesalers consider Place of tomato selling. They say that usually tomatoes from non-mulched gardens spoil faster especially during rainy seasons. So they would like to make loses by discarding most of the damaged tomatoes. *"Sure deal, traders consider the pesticide residues on the tomato, and the quality of the tomatoes is determined by the life expectancy of that tomato. A good tomato turns red not yellow in appearance and doesn't have disease spots when ready. Traders consider the glittering cover, and size. For tomatoes sprayed from the store, the residue is just on top and can easily be rubbed off with your mere hands but a tomato which has been sprayed earlier can't rub off the residues even if they are being seen."* explained a tomato whole seller from Masindi district.

"When the buyers are many in his garden they don't consider or mind anything they just collect all except the damaged ones" said a farmer from Nebbi district.

Proposition

Participants recommend that Researchers share information with local people to understand the health impact of pesticides and how to reduce exposure.

Argument

Some participants claimed that tomatoes are sprayed shortly before harvesting to stores, because some buyers may book the tomatoes and fail to pick up on the exact promised day.

All Participants however, claimed no further spraying is done at the stalls because they are already sprayed well and need to preserve quality and harden skin.

Discussion

Very little information is available about the pesticide residue in tomatoes in Uganda and consequently the risk of exposures to this. The focus of this study is to determine the consumer risk perception towards pesticide stained tomatoes and residues, and the attitudes (pessimism vs optimism) towards the safety of the pesticide stained tomatoes. It employed a cross-sectional study design with a total of 468 consumers as respondents equally sampled by residence and interviewed from each of the four districts (Northern region:

Nebbi district, Eastern Region: Bugiri District, Central Region: Sembabule district and Western region: Masindi district), thus a good representation of Ugandan consumers.

Characteristics of the respondents show that slightly more than half of respondents were females as expected since the majority of these stay home to take care of home chores, similar to findings by (27) where 58% of women were involved in the purchase of meat, more than three quarters were married women as interviews were conducted at homesteads and consent sought from adults making it more likely for the married women to be interviewed. Half of the respondents were farmers given that Uganda as a country has more than three quarters of its population engaged in farming and given that this study was carried out in a rural setting, involving vendors, buyers and tomato growers. A majority had completed lower level of Education and a majority belonged to age group <30 years as the Ugandan population is composed of 75% youths as the majority(28), 80% of these residing in rural areas. From these characteristics we can definitely report that the consumers interviewed in this study were a good representation of tomato consumers in Uganda(28). Respondents of this study represent adult consumers experienced with tomato farming and with adequate level of education to well express their risk perception towards pesticide stained tomatoes.

On a general note, consumer risk perception ranked low with a majority of consumers (95%) buying tomatoes well known to be stained with pesticide residues, a majority giving reasons that they have no alternative. Results from this study highly deviate from similar studies conducted in developed countries such as among Californian consumers where 80% were safety cautious and checked the food items to see if they were opened or damaged (29). While in Georgia, 89% considered testing of pesticide residues in food to be very important or somewhat important(30) and in Boston, consumers had a high risk perception of conventionally grown produce compared to public health hazards(31), most of these were mainly triggered by the health effects of the contaminants such as pesticide residues in the sold produce.

From the Turkish perspective, consumers' willingness to pay for reduced pesticide residues in tomatoes was mainly determined by their risk perception about the residues which is explained by the label on the purchased apples(32). In this case due to the different situations, in Uganda unfortunately tomatoes are not labeled with the residual contents and benefits of low pesticide residual levels. This could be the reason why a majority of the consumers in this study bought the tomatoes due to lack of such information which could have triggered them to make their choices. This is a gap to be closed by authorities in charge of food safety. Uganda lacking a food safety policy puts public health at stake for the pesticide exposures. Results from this study are a vivid evidence to be used as part of the

advocacy statements in finding ways of establishing a National Food Safety Policy.

A study on consumers' willingness to pay for pesticide-free vegetables indicated how consumer awareness about the residues in vegetables and the residual effects on human health greatly influenced their willingness to pay for these vegetables. Consumers in this study were willing to pay 50% more for the pesticide-free vegetables (33). In the Ugandan context, the consumer's low risk perception on pesticide-stained tomatoes indicates a risk of increasing exposures to pesticide residues if these lack an alternative. As reported in other findings (34) our qualitative results by vendors and tomato farmers from the FGDs, indicate that the highly stained tomatoes are due to poor hybrid tomato seeds that need frequent spraying, vendors' demand from tomato growers to spray tomatoes before they sell but also a low level of literacy to understand the pesticide label information coupled with a wrong perception of tomato farmers that Mancozeb pesticide can harden the outer skin and increase tomato shelf life. It is from this misconception that tomato vendors only buy stained tomatoes presuming that these tomatoes will stay long on shelf, are healthy & free from the microbial contaminants.

Unlike other studies(30) from Georgia, where consumers prioritize microbial contamination followed by pesticide residues as the first consideration before making a choice to buy vegetables, tomato consumers in Uganda partly have a feeling that pesticide stained tomatoes are free from pathogens and thus healthy, giving not much priority to pesticide residues. As reported some

think that pesticides are selective and only meant to kill plant pests and cure plant diseases. However, our logistic regression analysis indicates how consumer awareness about pesticide residues increases chances of a high risk perception, protecting consumers from residue exposure, but this is just to a few individuals.

From our focus group discussion of vendors and farmers, all farmers claimed that vendors would only buy tomatoes with pesticide residues as these are thought healthy. On the other hand, vendors attest that stained tomatoes are healthy, look good, take long to go stale and have a high resale value on the market.

From these findings, Ministry of Agriculture Animal Industry and Fisheries needs to sensitize farmers as well as improve coordination and regulations on the sale and use of agro-inputs. Agro-input dealers who are the immediate information providers to the farmers need to be trained in Pesticide safe-use training. A recent unpublished survey done by UNACOH in 2020, reports only 6% of the agro-input dealers in 12 districts to have obtained the safe-use training, a training required to be undertaken by all agro-input distributors before starting their business.

Tomato residues are given less attention by the consumers probably because consumers lack knowledge of the dangers that the residues may impact on their health which in most cases takes time. From a model by Huang Chung (35) estimating the relationship between consumer perceptions, attitudes

and behavioral intentions (S7 File), choices (behavioral intentions) on buying food is influenced by perceptions and attitudes, which influence each other in addition to knowledge (information) from personal experience, evaluative criteria and social demographics. All based on the consumer awareness about the pesticide's potential ill effects but also on a larger extent the social economic status of the consumer. Consumers of a higher social economic status are most likely to have a high educational level and consequently easily access all the necessary information about the effects of pesticide residues. These will tend to have a high risk perception about the pesticide stained tomatoes and not likely to buy tomatoes which are stained with pesticides. However, this was not so with our finding. Consumer risk perception was not directly associated with level of education although associated with awareness about pesticide residues where consumers who were aware of pesticide residues were 42.8 times more likely to be of high risk perception compared to those who were not aware. From our results the low proportions (5%) of high risk perception consumers may be largely attributed to our sample containing low percentages of highly educated consumers (upper level education, table 1).

On the other hand, pesticide residue knowledge among the general public in Uganda is a new topic and studies conducted along these lines are few, most of the time not intended for creating awareness among the public on the potential ill effects of residues in food. From other related findings in this study, consumers have no access to sources of information on pesticide

residues in food with most of the information on pesticide residues acquired through radio and television media, followed by health professionals, depicting a big gap in information accessibility, but also its availability.

Conclusion

Consumer risk perception among Ugandan consumers was ranked low with a majority of tomato consumers buying tomatoes stained with pesticides regardless of their level of education, age and gender, this all linked to lack of alternative organic tomatoes on the market. However awareness that tomatoes contain pesticide residues was associated with consumer risk perception where the proportion of consumers who were aware of tomatoes containing pesticide residues was 42.8 fold more of high risk perception than consumers who were not aware.

There is a need by the government through its line of Ministry of Agriculture Animal Industry and Fisheries (MAAIF) and other health information dissemination Civil Society Organization to sensitize the Ugandan population on the effects of pesticide residues, the farmers on the dosage and the pre-harvest intervals as well as train Agro-input Dealers from which farmers buy pesticides.

MAAIF should also hasten the establishment of the National Pesticide Residue Monitoring Program to protect Public Health from this chronic exposure to pesticide residues in agricultural produce.

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Supportive information

Data-set used to yield the above results is available upon request from the author. However, separate supportive information has been attached as highlighted below.

S1 File. Other Demographic characteristics of consumers. PDF

S2 File. Consumer attitudes towards pesticide stained tomatoes. PDF

S3 File. Fisher-exact tests for the factors associated with consumer risk perception. PDF

S4 File. Simple logistic regression of consumer risk perception vs awareness about pesticide residues. PDF

S5 File. Questionnaire: Consumers risk perception towards pesticide stained tomatoes in Uganda. PDF

S6 File. Focus Group Discussion guide for Consumers risk perception towards Pesticides stained tomatoes in Uganda. PDF

S7 File. A model for estimating the relationship between consumer perceptions, attitudes and behavioral intentions. PDF

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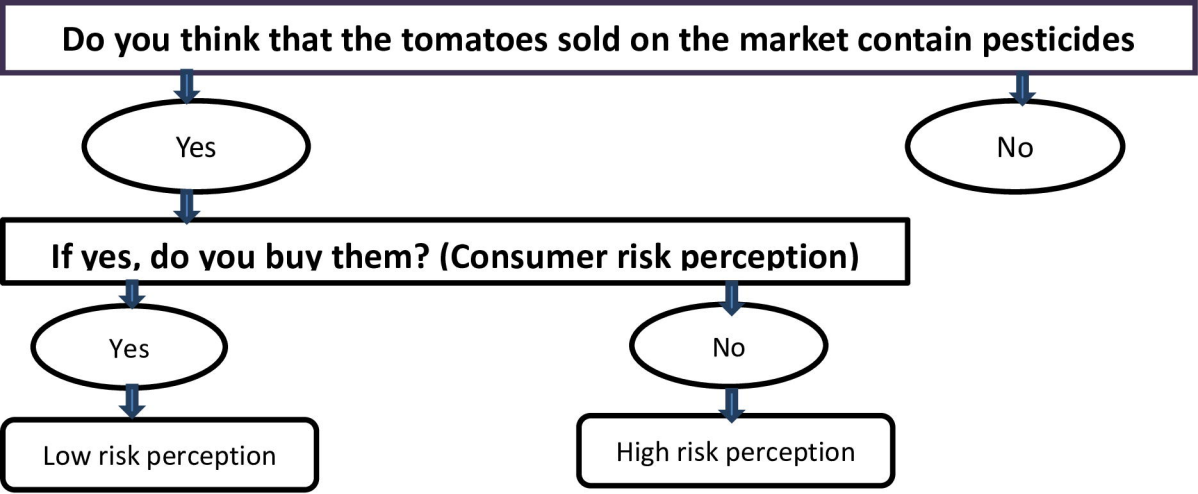

Fig 1. Model for determining consumer risk perception

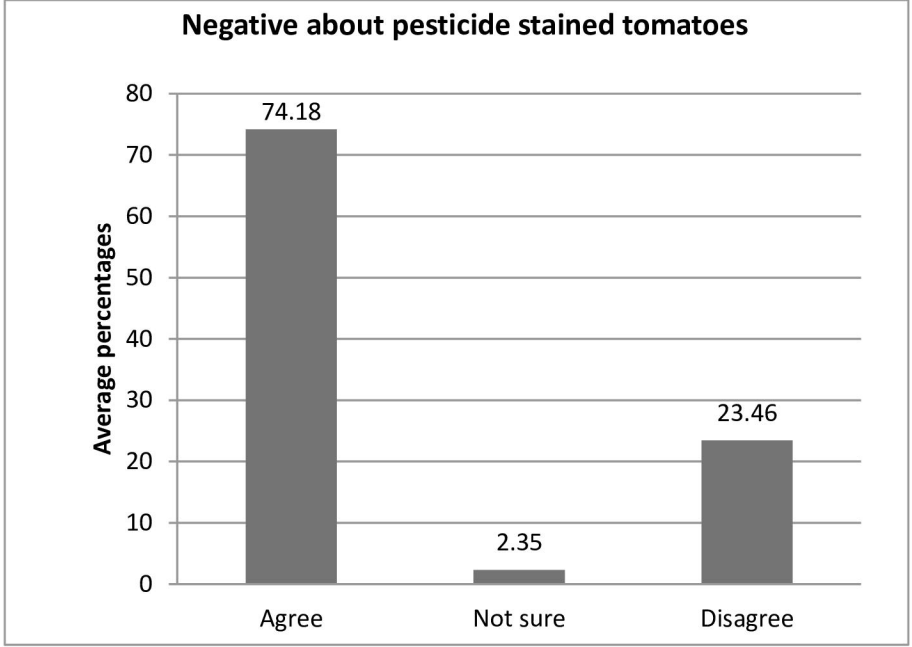

Fig 1. Average negative perceptions of consumers about pesticide stained tomatoes.

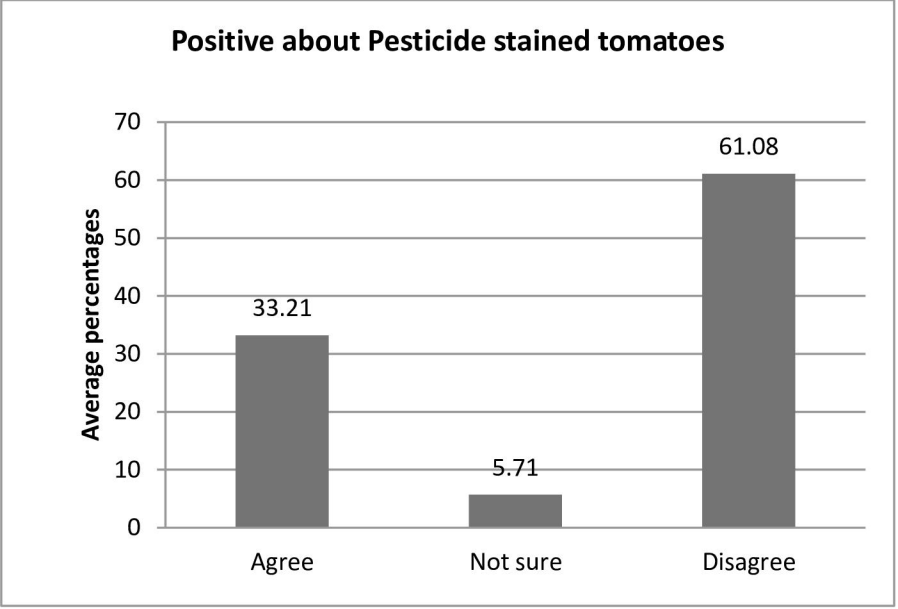

Fig 2. Average positive perceptions of consumers on pesticide stained tomatoes in percentages.

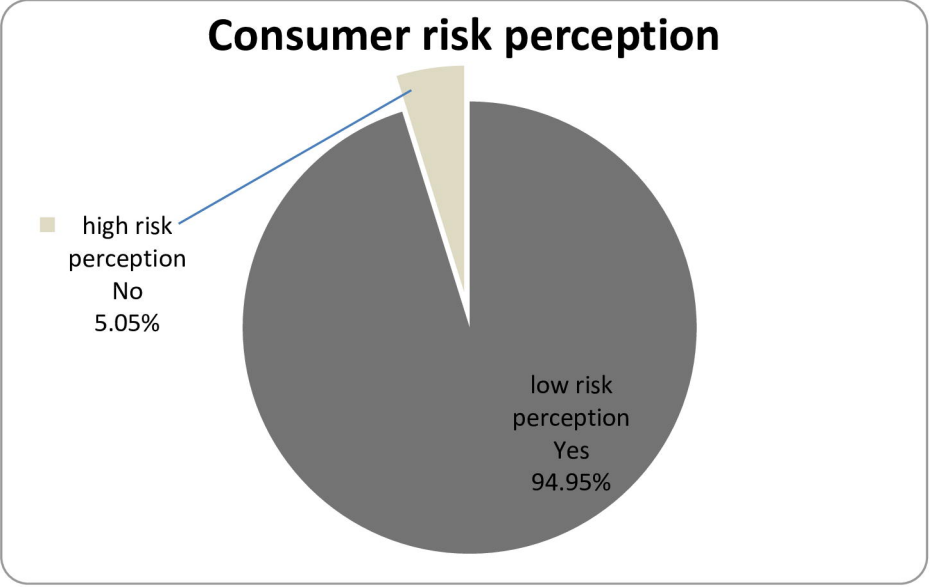

Fig 4. Level of consumer risk perception towards pesticide stained tomatoes