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Consumers' awareness of the presence of pathogenic bacteria and pesticide residues on tomatoes sold in Nairobi

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Tomato consumed worldwide for its vitamins and bioactive elements can harbor postharvest bacteria and pesticide residues. A cross-sectional survey using a semi-structured questionnaire was done in 101 households in Kangemi assessing consumers' awareness on pesticide residues and bacterial presence on tomatoes sold in Nairobi. Questionnaire was administered in Kangemi during weekends, systematic random sampling was applied during household recruitment. Data analyses used SPSS; analytical tools included means, standard deviation, binomial test and bivariate correlation. Male (64.86±0.48) had better awareness on pesticides on tomato (p=0.037) and consumers of 36 to 53 years old were more knowledgeable (58.29±0.34) than others. Awareness with education level was significant at 95% level of confidence (p=0.044); 86% respondents were more conversant with pathogens than with pesticides and 97% knew that pesticides were used in farms (p= 0.0001). About 91% indicated that pesticides are dangerous for health and 74% related pesticides in farms to their presence on tomatoes in markets (p= 0.0001). However, 74% believed that washing provides tomatoes without pesticides (p= 0.0001) while 65% mentioned that pesticides can be present on tomato eaten as salad (p= 0.004). Consumers' knowledge was insufficient on tomato with pesticides; this can be improved through information, communication and education.

Key words: Health, household, farms, knowledge, marital status, vegetable

INTRODUCTION

Tomato is widely cultivated and consumed worldwide for its peculiar virtues providing vitamins and bioactive elements (Kariathi et al., 2017). Dias (2012) encourage quotidian intake of vegetables and state that, tomatoes

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can provide phenolic acid, ascorbic acid and phytochemical compounds protecting against free radical and tumor cells in human body. Viuda-Martos et al. (2014) noticed that, the daily intake of 25 g of the processed tomato is hypolipidemic (decreases the level of lipids in blood). Dias (2012) reported that low consumption of vegetables such as tomato contributes to 11% of stroke and 31% of ischemia heart diseases in the world. Oguntibeju et al. (2013) on the other hand state that frequent consumption of vegetables helps to manage glucose in blood and reduces the incidence of diabetes type-2 and cancers (oropharynx, oesophagus, stomach, colon, rectum, lung cancer, prostate cancer). With such value, the vegetable is currently much diversified phenotypically and genotypically (Vijee et al., 2016). Its efficacy for health protection is being reinforced and the purple tomato or "Indigo Rose" for instance is a new variety with high concentration of lycopene (Scott, 2012). Other improvements are targeting the quality and taste of the crop (Ric et al., 2011).

It has been found that in spite of all these health benefits fresh tomatoes can harbor pesticide residues (Hammad et al., 2017) and pathogens (Liu et al., 2018). Pesticides can be found on tomatoes (Elpiniki and Amvrazi, 2011; Kariathi et al., 2016) as they are even misused in farms (Mutai et al., 2015; Kumari and Basavaraja, 2018). Similarly, potential bacterial pathogens can find themselves on tomatoes through diverse routes including running polluted water from rains, adulterated water from showers, wrongly treated and untreated manure, soil reservoir, wounds from pests and pesticides, irrigation with unprocessed sewage (Sheppard, 1998; Heaton and Jones, 2007; Orozco et al., 2008; Gu et al., 2013; Farakos and Frank, 2014). Kithure et al. (2014) studied the seasonal levels of vegetables with pesticide residues in Makuyu-Kenya and detected higher contamination of deltamethrin in dry period than in wet season. Pierangeli et al. (2014) analyzed bacterial contamination of fresh produce from open air markets and supermarkets in the Philippines and found presence of *Escherichia coli* and *Salmonella* species.

It is in light of the aforementioned that a study was conducted to assess consumers' awareness on the quality of fresh tomato consumed in Nairobi. Specifically, the study aimed to assess consumers' awareness on potential contamination of fresh tomatoes with pathogenic bacteria and pesticide residues.

METHODOLOGY

Study design

A cross sectional study assessing consumers' awareness on exposure to foodborne bacteria and pesticide residues on tomato was done in Kangemi suburb of Nairobi. A total of 101 households were randomly selected and interviewed. A semi-structured questionnaire on fresh tomatoes sold in Nairobi was designed for the collection of data from households. The questionnaire was pretested in Kawangware to confirm precision, appropriate answers and was reviewed after observations of the first interview.

Study setting

The study was undertaken in Nairobi region, the capital city of Kenya located in the South-East end of the Kenyan's heartland agriculture. It is the regional headquarters for international organizations and the city produces more than half of the GDP of the country. Kangemi slum located in the outskirt of the city and in a small valley on Waiyaki way was purposively selected and covered by the survey.

Kangemi is neighboring in the south with Kawangware and four middle class areas, Loresho and Kibagare in the north; Mountain View in east and Westlands in west. The low-income settlement is within coordinates' 1°16'17.4" S 36°44'36.4"; covers an area of 0.87 km^2 and is located at around 10 km from the central business of the metropolis. The population of the area is more than 100,000 inhabitants with a density of 22,243 dwellers/km^2 (Cherunya et al., 2015). Kangemi is a multi-ethnic area with a strong informal activity including street food ready-to-eat as "Kachumbari" reflecting the need to feed the growing population (Mwau, 2009; Oyunga-Ogubi et al., 2009).

Study tool

A semi-structured questionnaire was designed for data collection from tomato consumers

Target population

The lower class population was targeted assuming that, they are less informed on pesticide residues and bacteria presences in fresh tomatoes sold in markets compared to the middle and high classes.

Sampling procedure

A preliminary field visit of reconnaissance was done in Kangemi on both side of Wayaki way to decide on how to cover the area during data collection. Six enumerators, all Master's students were recruited and trained to administer the questionnaire in a face to face interview. They were divided in two groups to cover Kangemi on both side of Wayaki Way. The questionnaire was administered during weekends as described by Okello et al. (2015). A systematic random sampling was applied during household recruitment for interview. The head of the household was always requested to be the respondent. In case of absence of the head of the house, the wife was requested for interview or an appointed person by the household was responding to the questions. Consent and voluntary participation were always obtained from the respondents after introduction of the aim of study. The enumerators collected data from 101 elders of each household or from the person appointed by the household.

Data collection

The questionnaire targeted the sociodemographic (gender, age, level of education and marital status) characteristics of respondents. The socio demographic helped to know whether households were mostly males or females; if they were mostly old people, middle age or young; if awareness of tomato contamination is known by old, middle age or young people. As well, it was also to know the contribution of education on the issue and whether marital status

Table 1. The percentage of various demographic characteristics on gender, age, marital status and education.

Demographic characteristics	Variable	Frequency (N)	Percentage
Gender	Male	32	31.7
	Female	69	68.3
Age	18 to 25	19	18.8
	26 to 35	54	53.5
	36 to 53	28	27.7
Marital status	Married	61	60.4
	Single	37	36.6
Level of education	Never attended school	4	4
	Primary school	23	22.8
	Secondary school	43	42.6
	Tertiary level	17	16.8
	University level	9	8.9

was an important factor enhancing the awareness of respondents. The questionnaire also sought to get the overall knowledge of respondents on specific questions on enteric bacteria and pesticide residues. Some correlations on pesticide residues were assessed in order to measure the level of the perception of consumers on potential diseases able to be obtained by fresh tomato consumption.

Data analysis

The Statistical Package of Social Sciences (IBM SPSS Statistics 20) software was used for data analysis. Answers of each questionnaire were entered into the software. Descriptive statistics were used to generate the sociodemographic characteristics of household for their awareness on exposure to pathogens and pesticides residues in fresh tomato marketed in Nairobi. Respondents' knowledge on pesticide residues and pathogens were coded and differentiated as right or wrong answer and scores one for good answer and nil for wrong ones was allocated. Same procedure was applied on knowledge of potential diseases related to pathogens and pesticides contamination of tomato. Right answers were calculated and converted into percentages. As well, the standard deviation to measure the dispersion was also obtained. The binomial test was applied to assess frequencies of respondent on some specific questions of tomatoes contamination. The bivariate correlation using the Pearson coefficient two-tailed test was used to measure the degree of linkages between pesticide variables. The mean differences were calculated at 95% level of significance. Fisher's exact test was used to examine the significance of pesticides variables' association.

RESULTS

Socio demographic characteristics of the population studied

The survey conducted in Nairobi among 101 respondents showed more females (69/101) participation and majority of respondents (59/101) were between 26 and 35 years old. Very few participants (4/101) had not attended any school and more than half of interviewees were married. This participation has allowed measuring the reasons why some households have designated people or why some people stood by themselves to take the interview by gender, education and marital status. During the interviews, some participants were silent on some demographic characteristics as marital status and level of education. The percentage of the sociodemographic characteristic was obtained as shown in Table 1.

Consumers' general awareness on pesticides and bacteria on tomato and relations with other findings around contaminated crops

The overall assessment of enteric bacteria and pesticides residues on tomatoes showed levels of significance. About 74% of consumers knew that, pesticides use in farms can be present in tomato sold in markets, but majority (74%) believed that it is safe to eat fresh tomato from markets after washing. As well, 95% supported that, washing tomato before eating in salad prevents from any diseases. For some consumers, washing stands as the critical control point preventing from any disease infection. An overall knowledge of consumers reflecting pesticides and bacteria knowledge was designed as shown in Table 2

Expected awareness of consumers on pesticide residues using correlations between variables

Some variables of pesticide were correlated to measure their levels of linkages as shown in Table 3. In order to

Table 2. Percentage or frequency of food safety knowledge among respondents.

Food safety questions	Responses	N	Frequencies (%)	p-value
Pesticides				
1. Can fresh tomato cause any disease to someone?	Yes	47	49	1
	No	48	51	
2. Do you know pesticides?	Yes	79	78	0
	No	22	22	
3. Pests and diseases of tomatoes in the farms?	Yes	95	94	0
	No	6	6	
4. Pesticides are made to protect tomatoes in farms?	Yes	96	97	0
	No	3	3	
5. Farmers use pesticides to protect tomatoes in farms?	Yes	99	98	0
	No	2	2	
6. Pesticides are dangerous for humans' health?	Yes	87	91	0
	No	9	9	
7. Pesticides can cause diseases to consumers?	Yes	48	49	0.92
	No	50	51	
8. Pesticides used in tomato farms can be present on tomato sold in markets?	Yes	73	74	0
	No	25	26	
9. Pesticides used in tomato farms can be present on tomato eaten in salad?	Yes	65	65	0.004
	No	35	35	
10. Pesticides used in tomato farms can be present in tomato cooked at home?	Yes	46	47	0.641
	No	52	53	
11. Pesticides used in tomato farms can be dangerous for consumers' health?	Yes	81	82	0
	No	18	18	
Enteric bacteria				
12. Do you know pathogens?	Yes	80	79	0
	No	21	21	
13. Pathogens can be found on the surface of tomato?	Yes	77	86	0
	No	13	14	
14. Pathogens can be found inside tomato?	Yes	53	58	0.142
	No	38	42	
15. It is safe to eat raw tomato from farms or markets after simple washing?	Yes	73	74	0
	No	25	25	
16. Tomato eaten in salad can affect human health?	Yes	50	51	1
	No	49	49	
17. Tomato cooked in food can affect human health?	Yes	35	35	0.005

Table 2. Contd.

	No	64	65	
18. Tomato washing before eating in salad prevents from any disease?	Yes	95	95	0
	No	5	5	

understand the validity and evidence of reliability (Goodwin and Leech, 2006), a correlation among pesticide variables was applied. The aim was to see whether variables used to assess knowledge on pesticides in this survey were adequate for evaluating consumers. As well, it was to see whether, a holder of a knowledge may also possess the understanding of the correlating other knowledge and thus, be able to respond adequately to the one with which it correlates.

Consumers' awareness on potential diseases related to pathogens and pesticide residues in tomato

About 49% of respondents knew that fresh tomato can cause any diseases to consumers. They pointed that raw tomato can cause diseases as cancers, stomachache and amebiasis. However, for illnesses related to pathogens, 24% pointed stomachache, diarrhea 19% and amebiasis 4%. For sicknesses related to pesticide residues, they indicated stomachache (32%) and cancer (11%) (Table 4).

Influence of sociodemographic characteristics on awareness of pesticide residues and bacterial organisms in tomato

Knowledge on pesticide residues and pathogens presences was assessed based on socio demographic characteristics as shown in Table 4. Males (64.86±0.48) had better knowledge than female (50.77±0.36); married people (60.16±0.31) had better understanding than single (39.75±0.43) and the level of education was an important factor among the respondents ($p < 0.05$) (Table 5).

DISCUSSION

Consumers' awareness by sociodemographic characteristics participation

Consumers awareness by gender

The study had a participation of 68.3% females and 31.7% males. Strong participation of females in this study holds on the fact that, cooking in Africa is naturally a duty destined to women. They were more expected to provide best answers due to the natural social rank given by the society between men and women in households. Pambo (2013) accordingly reminds that, females are mostly implicated because they are the designers of nutrition schedule and are responsible of food preparation in homes. Although this natural set up, socioeconomic development and its challenges have raised the matter of gender equality. From this reality, participation of men in this study may be justified by number of reasons obliging them to be fully or partially implicated in cooking. The reasons might include unavailability of the female committed to duties generating income, gender equality or good relationship in a couple and obligation to help or contribute in cooking at any time when the need arises. For such reasons, it was useful to have them in the survey.

The present observation is in concurrence with the work of Maschkowski et al. (2010) in Germany who reported 82% female participants in the study of parents' contribution in fruits and vegetables consumption in families. This finding also agrees with the study of Pambo (2013) in Kenya who reported 54.9% of female participation against 45.1% of male in his study of consumers' awareness on fortified sugar.

Consumers' awareness by marital status

About 60% respondents were married and 37% were single. Marital status can contribute to understand the awareness of vegetables' contamination and can improve the couples' knowledge through worries as wellbeing, diseases' prevention and family protection. Ambrožič et al. (2016) in Slovenia observed that, women have strong knowledge on viral presence on food than men because they care for their homes and families. Similar report came from Tomaszewska et al. (2018) in a survey that covered Poland and Thailand. Another study from Thailand by Kanang (2012) stated that, men in Bangkok care a lot compared to women on the quality of food purchase for family consumption. Both studies pointed food quality desired by parents in households no matter the sex when it comes to food provision for families. This behavior is mostly found among married people with children. They request for organic diet to avoid contaminated food with pesticide residues (Davies and Titterington, 1995; Kanang, 2012) to prevent foodborne infections and related disabilities adjusted life years (DALYs). It may be under such consideration that,

Table 1. Correlations between variables of pesticides.

Correlation	Can fresh tomato transmit any disease to someone?	Pesticides are dangerous for humans' health	Pesticides use in tomatoes farms can be dangerous for consumers' health	Pesticides use in tomatoes farms can be present on tomato in markets	Pesticides used in tomatoes farms can be present on tomato eaten in salad	Pesticides can transmit diseases to tomatoes consumers
Can fresh tomato transmit any disease to someone?	1	0.328** 0.002	0.487** (0.000)	0.331** (0.001)	0.399** (0.000)	0.217** (0.037)
Pesticides are dangerous for humans' health	0.328** (0.02)	1	0.394** (0.000)	0.257** (0.013)	0.208** (0.43)	0.185 (0.075)
Pesticides use in tomatoes farms can be dangerous for consumers' health	0.487** (0.000)	0.394** (0.000)	1	0.410** (0.000)	0.364** (0.000)	0.260* (0.010)
Pesticides use in tomatoes farms can be present on tomato in markets	0.331** (0.001)	0.257** (0.013)	0.410** (0.000)	1	0.705** (0.000)	0.094 (0.362)
Pesticides used in tomatoes farms can be present on tomato eaten in salad	0.399** (0.000)	0.208* (0.043)	0.364** (0.000)	0.705** (0.000)	1	0.091 (0.371)
Pesticides can transmit diseases to tomato's consumers	0.217* (0.037)	0.185 (0.075)	0.260* (0.010)	0.094 (0.362)	0.091 (0.371)	1

**Correlation is significant at the 0.01level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

studies point anxiety and worry of parents generated by their psychological attachment to families while looking for food of houses in markets (Maschkowski et al., 2010; Srinivasan et al., 2015). This attitude was also illustrated by Tanja (2015) in Finland who stated the structural dynamism of consumers and decision making when it comes to buying food. He stressed that, parents buy goods for the family to satisfy the needs as good health under personal, social and psychological factors. Pambo (2013) in Kenya supported the idea especially when he argues that, married people are more aware of food quality and that, households with children care more about the quality of food consumed. This finding also corroborates the work done in Turkey by Erdem et al. (2015) who found that, marital status had an influence on awareness of Halal among respondents.

Consumers' awareness by education

About 96% respondents had been to school including primary education, secondary, tertiary and university level. Studies showed that, understanding the worries of food safety requires a great level of education. Respondents with high level of education might be more curious, sensitive, more informed, open minded and interested on such topics. That is probably why Kanang (2012) in Thailand insists that, learned consumers in markets go for organic food for instance. It may be under such thought that, Hassan and Dimassi (2014) in Lebanon decided to assess knowledge on food safety among universities' students. They found that, knowledge grows with the level of education and showed that, the higher the level of education, better the awareness. Kimenju et al. (2005) in Kenya got similar finding in their study of Genetically Modified (GM) foods and said that, consumers' awareness increases with education.

This survey relates with the study in Turkey by Erdem et al. (2015) on consumers' perception and awareness in consumption of Halal. They got respondents with similar education (5% never attended school, 18% primary level and 47% secondary school) and affirmed that, consumers' knowledge is bound to education. The study also concurs with the survey done in Poland and Thailand by Tomaszewska et al. (2018) who observed that correct answers in their study were frequently given by educated participants.

Table 4. Safety perception of tomato consumption.

Variable	Answer	Frequency (N)	Proportion (%)
Diseases related to pathogens contamination			
Can fresh tomato transmit any diseases?	Yes	47	49
	No	48	51
Dysentery	Yes	4	4
	No	97	96
Diarrhea	Yes	19	18.8
	No	82	81.2
Stomachache	Yes	24	23.8
	No	77	76.2
Cancer	Yes	2	2
	No	99	98
Diseases related to pesticide residues contamination			
Can fresh tomato transmit any diseases?	Yes	48	49
	No	50	51
Stomachache	Yes	32	31.7
	No	69	68.3
Cancer	Yes	11	10.9
	No	90	89.1
Headache	Yes	4	4
	No	97	96
Nausea	Yes	2	2
	No	99	98

Consumers' general awareness of pesticides and pathogens on tomato and the need of consensus on vegetables harboring pesticide residues

Consumers have good notions on pesticides use n tomato farms and its potential presence on tomatoes sold in markets. Through this knowledge, they are somewhat alerted by the potential threat of pesticide residues on fresh tomatoes. This might help them to observe adequate practice of washing before cooking to reduce the levels of presence during consumption. Though little is known in Kenya on vegetables domestically consumed; some results are available. Mutai et al. (2015) reported that, vegetables in Kenyan markets contain organophosphates and pyrethroids at 42%.

The level of knowledge of pesticides found in this study corroborates the work of Bempah et al. (2010) in Ghana. He assessed consumers' knowledge and found that, 70% knew fruits and vegetables contamination with pesticide residues. The finding also agrees with the study of Kumari and Basavaraja (2018) in India who realized that, 55% of consumers were aware of pesticides use in vegetables farming.

Regarding consumers' knowledge and the safety of tomato ready to eat, 65% say that, pesticides used in tomato farms can be present on tomato eaten in salad ($p = 0.004$). Also, 74% indicated washing as a practice providing safe tomatoes for consumption ($p = 0.0001$). As well, 95% of participants disclosed that, washing fresh tomato before eating in salad prevents from disease transmission ($p = 0.0001$). This stand point can neither be accepted nor rejected. It is believable that, right information can be given if only pesticides' levels compared to MRLs are given in fresh tomatoes ready-to-eat.

This finding is contrary to that of Kumari and Basavaraja (2018) in India who found that, consumers have no trust on washing practices as a mean providing safe vegetable for consumption and they are restrained on vegetables to buy in markets. They argue that, consumers look for vegetables free of pesticides residues and are willing to spend more on organic crops for health

Table 5. Awareness of pesticides residue and bacterial pathogen contamination of tomatoes among various demographic variables.

Demographic variable		n	Knowledge of tomato with pesticides		Knowledge of tomato with pathogens	
			Mean (scores ± SD)	P-value	Mean (scores ± SD)	P-value
Gender	Male	32	64.86±0.48	0.037*	55.78±0.43	0.083
	Female	69	50.77±0.36		42.01±0.39	
Age	18-25	19	49.58±0.45	0.707	32.03±0.25	0.646
	26-35	54	57.89±0.23		47.79±0.34	
	36-53	28	58.29±0.34		49.67±0.54	
Marital status	Married	56	60.16±0.31	0.005*	67.16±0.39	0.26
	Single	37	39.75±0.43		45.58±0.41	
Level of education	Never attended school	2	24.17±0.26	0.044*	28.60±0.45	0.068
	Primary	28	35.88±0.65		34.83±0.74	
	Secondary	47	58.67±0.23		55.72±0.35	
	Tertiary	15	71.58±0.45		68.49±0.25	
	University	9	72.19±0.43		71.50±0.33	
Grand Mean			53.64±0.38		49.93±0.40	

*****Percentage difference significant at 0.05 level.

protection. Even their study pointed that, 30% of respondents mentioned long term infection due to consumption of vegetables with chemical residues regardless of levels. This view is supported by Kanang (2012) in Thailand who reported that, consumers in Thailand have adopted consumption of sustainable food and are more attached to green diet or produces free of pesticide residues.

Consumers' awareness seems influenced by the knowledge of washing raw produce for pathogens' reduction to acceptable levels of consumption (Sumonsiri and Barringer, 2014). In fact, of the 26% (25/101) stating that washing cannot provide safe crop to eat, only 3% (3/101) believe the crop can still contain pesticides residues, 2% (2/101) pointed that it can contain heavy metals and 15% (15/101) designated the presence of pathogens and 5% (5/101) remained silent on the question. Even, respondents with tertiary (16.8%) and university (8.9%) levels of education were not able to cover properly the point of chemical residues on raw tomatoes. This shows that, consumers mostly think of pathogens when cleaning tomatoes from markets and have less understanding on potential pesticide residues presence on the surface of tomato. It is believable that, knowledge on pathogens is well rooted among tomato consumers compared to pesticide residues from farms.

Consumers might have gained knowledge on pathogens through formal education, episodes of sicknesses related to pathogens, information received during diagnoses in health centers, costs of burden (expenditures for treatment for instance), DAILYs and cooking practices transferred by parents from childhood to adulthood. Consumers could not do better than this when studies on pesticides in Kenya focus on vegetables for export (Mutuku et al., 2014; Mutai et al., 2015) neglecting those consumed locally. It can be assumed that, knowledge on pathogens has been built with progress in science assorted by ways of preventing microbial infection.

Consumers might have either chosen these answers out of any knowledge or, they might be influenced by studies surrounding pesticides use in farms and related critics on side effects. By pointing pesticides as dangerous for human health and that they can be found in tomatoes marketed, they have probably learned from surveys on farmers and pesticides use in Kenya (Nyakundi et al., 2010; Mutuku et al., 2014) and worldwide (Nunifant, 2011; Huynh, 2014; Jamali et al., 2014; Paiboon and Tikampom, 2014; Kariathi et al., 2016). Similarly, respondents might be aware of pesticide multiple residues presence on vegetables demonstrated in South Africa, Sudan, Kuwait and in the European Union (Mutengwe et al., 2016, Hammad et al., 2017; Jallow et al., 2017; EFSA, 2017). Some interviewees might be aware of reports on chemical misuse in tomatoes farms (Latif et al., 2011; Firas, 2015; Mutai et al., 2015; Kamuri and Basavaraja, 2018). By indicating pesticides presence on tomato eaten in salad, they probably knew debates on MRLs adopted for chemical control in farms (FAO, 2009; Elpiniki and Amvrazi, 2011; Latif et al., 2011; Hammad et al., 2017) as well as the EU audit and evaluation outcomes on pesticide residues in Kenyans' fresh crops held in 2013 (European Commission, 2014). In the meantime, establishment of

both Pest Control Products Board (PCPB, 2010) and Kenya Plant Health Inspectorate Service (KEPHIS, 2013) by the Kenyan government are some indicators or indices of consumers' knowledge. Lastly, when consumers indicate the safeness of tomatoes after washing, they might be influenced by studies depicting multiple residues on tomatoes ready to eat but pointing them as harmless for human health (Mohammed and Boateng, 2016). Though these probabilities, consumers need updates.

Consumers cannot imagine infiltration of synthetic chemicals in tissues of fresh vegetables (Kariathi et al., 2016). They could not also imagine that, pesticides residues on surface cannot be easily removed after washing. From these points, their knowledge is limited and their awareness insufficient. They think pesticide residues are like pathogens which can be reduced to acceptable levels for consumption through washing (Sumonsiri and Barringer, 2014). Washing chemical residues on surfaces of tomatoes seems ineffective. Studies depict surfactants or adjuvants in agrochemicals as containing oil and other water insoluble agents (Castro et al., 2013). Such oily and water insoluble components reduce the value of simple washing for the reduction of pesticide residues to acceptable levels. Thus, this increases exposure and potential health risks of consumers. This point corroborates the work of Bempah et al. (2010) in Ghana who analyzed health risk of chemical residues on tomato and recommended consumers' health protection through constant investigation. Analyses surrounding pesticides use for crops protection and potential contamination of consumers seem to have generated two thoughts; those rejecting potential human's infection versus those arguing human exposure and infection. One of the main argument standing between both is washing the crop before consumption.

Washing fresh tomato and its inability to transmit diseases to consumers has been demonstrated by number of studies as providing safe vegetables for consumption. Perez et al. (2016) in Mexico agreed with washing of vegetable as a practice preventing any human health infection with pesticides residues because those on the surface are usually removed. Their finding concurs with Akomea-Frempong et al. (2017) in Ghana who found multiple pesticide residues and molecules above MRLs in vegetables ready to eat and concluded that, consumers are not at risk of pesticides related diseases if they wash their crops with running water.

Studies supporting positive effects of washing contaminated vegetables with pesticides residues have been contradicted by a number of researches. Andersson et al. (2014) in France argued that, illnesses generated by pesticides do not manifest instantly after few hours or few days; they appear at long term. This view found support from Kamuri and Basavaraja (2018) in India who analyzed consumers' awareness of pesticides contamination in vegetables. They found respondents pointing health infection by pesticide residues on long term when consuming contaminated vegetables. This implies that, illnesses generated by chemical residues appear long after consumption of contaminated diet. For that reason, consumers or health practitioners cannot trace back the causes of ailments as reported by Ames et al. (1993) in their mutagenesis and carcinogenesis studies. They argued specifically that, effect of synthetic chemical injury is related to human system defense which is also influenced at its turn by previous history of exposure to synthetic chemicals.

Elpiniki and Amvrazi (2011) in Greece also contradicted the safety of contaminated produce even after washing with running water. The researcher insisted that, rinsability of vegetables is not bound to solubility and removability of pesticides on crops. He even added with support from Kiriathi et al. (2016) in Tanzania that, pesticides can infiltrate the flesh of crops and washing will not change their concentrations. This position found support in Brazil by Graziela et al. (2015) who studied effects of washing on contaminated tomatoes with pesticides. They studied the rinsability of tomatoes contaminated with multi residues in households by application of 3 (three) washings on each sample. They concluded after using different solvents (water, sodium bicarbonate 10% and vinegar cleaner 10%) that, all molecules could not be removed. These findings are calling for a need of consensus on pesticide residues on vegetables.

Expected awareness of consumers on pesticides residues using correlations between variables

The bivariate correlation using Pearson coefficients two-tailed test between pesticides variables revealed positive associations at 95 and 99% levels of significance. For instance, a weak positive connection (r=0.364; p= 0.0001) was found between pesticides use in farm can be dangerous to consumers' health and the presence of these pesticides in tomatoes eaten in salad. In the same line, a moderate association (r= 0.410; p= 0.0001) exist between pesticides use in tomatoes farms can be dangerous for consumers' health and, pesticides use in tomatoes farms can be present on tomatoes sold in markets. In addition, a strong correlation (r= 0.705; p= 0.0001) was found between pesticide use in tomatoes' farms can be present in markets and their presence on tomatoes eaten in salad. These positive correlations show that, a holder of one knowledge probably has the understanding of the other. This justifies why those questions were well answered. Though this understanding, consumers might still have some missing information. No significant correlation between: pesticides residues can be on tomatoes eaten in salad and pesticides can transmit diseases to tomatoes' consumers was noted (r= 0.091; p= 0.371). Therefore, respondents could not provide better answers to this association. In this case, interviewees with one of this knowledge might

not link to the other. As such, they cannot improve washing practices inherited in households from childhood to adulthood. With this missing skill, respondents might not improve the culture of washing raw tomatoes to reduce more and more chemical residues before consumption in salad. This constitutes a gap to fill in order to increase consumers' awareness and see them starting using running tap water or its equivalent (Akomea-Frempong et al., 2017), detergent (Abou-Arab, 1999), sodium bicarbonate 10% and vinegar cleaner 10% (Graziela et al., 2015) to clean the crop before consumption. This might contribute to prevent human infection with chemical residues at the time when pesticide residues in vegetables are potential sources for systemic poisoning of consumers (Asiedu, 2013). This study corroborates the work done by Tomaszewska et al. (2018) in Thailand and Poland who found that, high positive correlation goes along with correct answers among Poland respondents.

Consumers' knowledge on potential diseases related to pathogens and pesticide residues in fresh tomatoes

With only 10% pointing cancer as a potential disease related to pesticides residues, consumers have poor knowledge. A number of studies have pointed pesticides use in farms as potential cause of cancer diseases (Ridgway et al., 1978; Pratibha et al., 2015). Perhaps, little official communication has been shared on the topic with consumers and maybe, the knowledge is not yet included in school programs at primary and secondary levels to educate young generations on the issue. Undoubtedly, information is still mostly shared within scientists' communities. Few participants responded to this question which probably was embarrassing to them. But, they seemed more conversant with diseases of pathogens. Insertion of this topic in education program will probably improve consumers' knowledge as reminded by Kanang (2012). He revealed that, educated consumers distinguish organic and potentially contaminated food and show preferences for sustainable diet due to related knowledge (avoiding high levels of chemical residues, standard and labelling, level of safety from label).

This study showed that, pathogens and pesticides are well-known by consumers. However, consumers seem to have more knowledge on pathogens compared to pesticides. This might be from the fact that, pathogens actions in humans are usually sudden, can manifest immediately after few hours or days following food consumption. On contrary, pesticide residues related action on health is not an instant or short term process rather; it is a long term procedure (Andersson et al., 2014). This might be the reason why European stakeholders rank pathogens as the priority to worry about on fresh produce compared to pesticides (Boxstael et al., 2013).

Also, consumers might be much conversant with pathogens because for a long time, capacities of African populations were built on pathogens. Their capacities were built through information, education and communications on personal hygiene and cooking of food. Pathogens have been taught in schools' programs since primary level. This strategy has been strong enough to inform and educate the populations on the threat. As well, microorganisms are always diagnosed in health centers and this has contributed to build the capacities and knowledge on the issue. Contrary to germs, pesticides use for crops' protection was recently adopted by the FAO for use in farms in the nineties to address the issue of food security (Shaw, 2007). Maybe, the topic is not yet developed enough to share its understanding with laypersons.

Influence of gender, age, education and marital status on awareness of pesticide residues in raw tomato

Gender consideration has shown a significant difference ($p= 0.037$) in knowledge of use of pesticides in tomatoes farms. Males had good knowledge on the topic compared to females. This knowledge tended to increase with age though there is no significant difference ($p= 0.707$) among age intervals. Marital status was an important factor on food safety among consumers ($p= 0.005$) at 95% level of confidence. Married people had better knowledge on both pesticide residues and pathogens compared to single who were slightly less aware of the concern. The level of education of participants in understanding the concern of tomato contamination with pesticides was an important factor and was statistically significant ($p= 0.044$). Answers of awareness came from respondents with higher level of education.

Both variables age and education relate with the work of Ambrožič et al. (2016) in Slovenia who observed that, knowledge of consumers on food safety increases with age. According to contaminants in food, their survey on foodborne viruses reveals that, consumers with higher level of education were much aware of viral food safety than those with low educated. The present study on marital status agrees with the work done by Pambo (2013) in Kenya and Erdem et al. (2015) in Turkey. These researchers found that, marital status was an important factor of food safety in food consumption in households.

Influence of gender, age, education and marital status on awareness of pathogens presence in raw tomatoes

Contrary to consumers' knowledge on pesticides use in farms, there was no significant difference on awareness

of tomato contamination with pathogenic bacteria on gender (p= 0.083), age (0.646), marital status (0.26) and level of education (0.068). However, respondent of 36 to 53 years old had better knowledge followed by respondents of 26 to 35 years old and lastly the youngest 18 to 25 years old. Consumers with university level had better understanding followed by tertiary, secondary, primary and those who have never attended school. Although the level of education seemed important, scores obtained for awareness of bacterial load in fresh tomatoes was not significant (p= 0.068). This may be justified by the usual practice of washing raw tomatoes before consumption. This does not require any experience, degree or a higher understanding because the habit is rooted within the society and is transferred through generations. High score recorded by respondents of 36 to 53 years old may hold on the fact that, many of them are responsible and probably have families and children. As such, they are used to cooking and have knowledge for providing safe food in tables to protect the house dwellers from foodborne ailments. The middle age 26 to 35 years old may be on the same track as elders (36-53 years old) and they might have started building their life experience on safe food and health. The earlier age 18 to 25 years are respondents who have just left the age of teenagers, thus they have less experience in food contamination generally and specifically, vegetables and human's health infection. At this age, some might either start living alone due to studies or job opportunities or, are still in parents' houses. Although they were taught on pathogens in schools, they are not yet concerned on vegetables contamination as their experience in diseases and potential health infection may still be low. In other meaning, they are still not much concerned of where and how they might get infected with food consumed. In one case or another, they are mostly bound to social media (Facebook, Twitter, and WhatsApp) hardly promoting scientific knowledge or raising awareness on issues as this one. From the youngest to the oldest age, the knowledge is acquired progressively and consumers become fully aware with time and experience.

This finding is consistent with the work on consumers' awareness done in Kenya by Pambo (2013) who observed that, consumers' awareness on fortified sugar comes with experience and level of education. The study also corroborates the finding of Malavi et al. (2017) who assessed the practices of food handlers in Kenya and came to similar conclusion.

Conclusion

The study established that, consumers were aware of contamination of fresh tomatoes with pathogens than with pesticides residues. Knowledge on contamination is related to age, level of education, marital status. Consumers knew that pesticides are dangerous to human health and washing reduces their presence on tomatoes. Though respondents knew that, pesticides are dangerous for humans' health and can even be present in freshly prepared salad, they were not able to realize that, pesticide residues presence in salad might be a threat to humans' health. They were convinced that, washing with plain water reduces pesticide residues in raw tomatoes and makes it safe for consumption. This deficiency should be improved through studies on washing contaminated vegetables as well as education, information and communication with consumers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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