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Impact of Vegetable Treatment on Human Health: A Cross Sectional Study in Togo

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Abstract
Purpose: *This study examined the effects of pollution on vegetable crops and the best methods of treatment to arrest the deleterious outcomes of these pollutants.*
Method: *A cross-sectional survey of 500 respondents; 200 farmers and 300 consumers with age ranging from 15 to 55 years was conducted in Togo. Questionnaires were administered to get information about irrigation water used to produce vegetable crops and the common methods used to treat vegetables. Data were analyzed using logistic regression analysis models.*
Results: *Findings from this study showed that vegetables treated with only potable water had a significant protective factor against diarrhoea (OR= 0.398, 95%CI= 0.251-0.632; p=0.000) and against cholera (OR= 0.536, 95%CI= 0.329-0.873; p=0.012), but not against typhoid fever and abdominal pain. Those who treated the vegetables with salt solution were 0.5 times less likely to report diarrhoea after consumption (OR= 0.514, 95%CI= 0.328-0.893; p=0.016). However, vegetables treated with salt solution were not associated with cholera, typhoid fever and abdominal pain. Potassium permanganate as a treatment method had no significant association with type of sickness.*
Conclusion: *Whatever the method used to treat vegetable crops before any consumption, it protects human health against some diseases. But vinegar and potassium permanganate, is recommended to effectively remove pathogenic microorganisms and ultimately prevent illness.*
Keywords*: polluted irrigation water; vegetable crops; water treatment; farmers'; consumers; pathogenic microorganisms; Health.*

I. Introduction

Vegetables are a vital dietary component for health and well-being. In addition to being a rich source of important nutrients, they constitute important functional food components by contributing protein, vitamins, iron, and calcium which have marked health effects [1].

Farming in many parts of the world is made highly efficient for producing and delivering high-quality products to consumers. However, when agricultural activities are not well-monitored and managed, certain practices can negatively affect the quality of the produce, and in turn affect the health of those who consume them. Agricultural water can become contaminated in several ways and can potentially spread bacteria, viruses, and parasites to crops and animals. A study conducted by Scott et al, showed that irrigation of vegetables with polluted water and untreated wastewater is practiced worldwide where urban areas with low-income, have no capacity to effectively treat wastewater while facing increasing demands for fresh vegetables [2]. High levels of faecal contamination and pathogens have been reported in irrigation water and on vegetables grown in cities in Ghana [3, 4]

Health risks associated with contaminated water include acute or chronic chemical toxicity, carcinogenicity, and infectious diseases, among which are gastroenteritis, amoebiasis, salmonellosis, dysentery, cholera, typhoid fever, hepatitis A and diarrhea are most common [5]. Recent research indicated that people who consume fruit or vegetables that have been exposed to contaminants are at risk of developing a food borne illness [6]. In Pakistan for example, more than 80% of all illnesses have been attributed to the consumption of poor quality water [7]. It is estimated that water related diseases cause an annual national income loss of Rs. 25–58 billion and over 250,000 children in Pakistan die every year due to diarrheal diseases alone and 20–40% of the hospital beds are occupied by patients suffering from water-related diseases, which are responsible for one third of all deaths [8, 9].

A previous study conducted by Mazari-Hiriart et al, indicated that poor quality water could represent an important vehicle for H. pylori transmission [10]. According to Quaglia's et al, and Mazari-Hiriart's et al, the association of the infection with consumption of raw vegetables is an additional indirect evidence for the presence of H. pylori in water used for irrigation of these vegetables [11, 12].

Methods of vegetable treatment

Several studies revealed that higher concentrations of lead in irrigation water are more likely to be found on surfaces of leafy vegetables (e.g., lettuce and spinach) from lead–laden dust and on the surface of root and tuber crops (e.g., carrots, horseradish, potato) if soils are contaminated. Therefore, to eliminate lead dust, remove outer leaves of leafy vegetable crops, peel roots, tuber and some fruits of vegetable crops as well as wash vegetables in water or water containing 1 % vinegar [13, 14, 15, 16]. In addition, Dr. Floyd Woods and Dr. Joe Kemble demonstrated that using water vinegar or acetic acid to clean, sanitize, or surface sterilize a variety of fresh fruits and vegetables can effectively remove fungi and bacteria, but the effectiveness depends on the nature of the suspected disease causing agent [17]. On other hand, washing produce in a mixture of water and vinegar appears also to help remove certain pesticides [18].

Moreover, a study conducted by Feleafel and Mirdad, showed that washing of leafy vegetables or peeling roots, tubers and vegetable crops before consumption may be an important factor in reducing the lead concentration [19]. A recent study by Shahrzad et al, highlighted polluted water, feces, animal manure and even soil as the main sources for contamination of vegetables with H. pylori, which had higher presence in un-washed vegetables and traditional salads. Therefore, pasteurization, sterilization and accurate washing can reduce the microbial load of vegetables [20]

In Sub-Saharan Africa, waters used to produce vegetables are polluted and can cause a potential risk to human health via the consumption of or exposure to pathogenic microorganisms and heavy metals .In addition, in most cities of sub-Saharan Africa, grey water is channeled into drains where it often gets mixed with storm water, solid waste and excreta from open defecation before it enters natural water bodies as these drains or streams are often used for irrigation [21, 22, 23]. Togo, a country located in West Africa has also been implicated in the production of contaminated vegetables [24]. Kara River, Kpondjo, Kpangalam and Kpandi Rivers in Sokodé are the most important rivers used to produce various vegetables in the north of Togo. However, all these rivers are contaminated by huge quantities of industrial effluents, domestic sewage discharges, municipal sewage, and urban waste carried by drains and canals which worsens and broadens their pollution. It's in this situation that both farmers and consumers in Togo, try to minimize contamination by treating vegetables with potable water, salt water, water vinegar and water potassium permanganate before consumption. The objective of the present study was to examine the pollution effects on vegetable crops and to find out the best methods of treatment to arrest the deleterious outcomes of these pollutants.

II. Materials And Method

2.1 Study area.

This study was conducted in Kara and Sokodé; two metropolitan cities located in the north of Togo. Data collection was carried out in three weeks from 19 March to 17 April, 2009. A cross-sectional design was used to get a snap-shot of the sample size by selected farmers and consumers. A multistage cluster sampling was used to generate a representative sample.

The present study was conducted at two sites. The first site of our fieldwork was performed along the river Kara, in Kara and rivers Kpondjo, Kpangalam, and Kpandi located in Sokodé, where farmers can easily access irrigation water. The irrigation is done manually with watering cans. Lettuce, cabbage, green pepper, tomatoes, spring onions and carrot are the most common vegetables produced. The second site was at the markets of these two cities among consumers. The study population in this study consisted of 500 respondents; 200 farmers and 300 consumers. The study protocol was approved by the ethics committee of the University of Lomé, Mayors of these two cities, Health Ministry and Higher Education and Research Ministry.

The data was collected by a group of well-trained investigators. Questionnaires were administered during regular work/sale hours and were expected to be filled in approximately 30 minutes. Before farmers and consumers filled the questionnaires, they were told that the questionnaire was not a test and there were no correct or incorrect answers, and were assured of confidentiality. Written informed consent was obtained from participants.

2.2 Measures

Socio-demographic characteristics of farmers and consumers were measured in this study.

2.2.1 Section I: Farmers

Knowledge of water source: Farmers were asked to indicate the source of water used by the question: "Do you have any knowledge about the source of this water?" ''yes or no''. If they answered ''yes'', then further questions focusing on the nature of the water (i.e. freshwater, dirty water, wastewater…) were asked.
Knowledge about water pollution: Farmers were also asked about the quality of water used for irrigation. "Do think the water you used for irrigation is good?" yes or no"

2.2.2 Section II: Consumers

Questionnaires were given to consumers to ascertain their knowledge and consequences of vegetable treatment. Types of vegetable treatment: Consumers were asked about various ways of vegetable treatments. "What do you use to wash the vegetables after getting them from the market?" a) only water; b) salty water; c) potassium permanganate in water; d) water vinegar.

Experience discomfort after consumption. "Did you get uneasy after you had eaten one?" "Yes or no" If answered "yes" then follow up with the next question.

Types of sickness experienced after consumption: What kind of illness did you suffer? a) diarrhoea; b) cholera; c) typhoid fever; d) abdominal pain

2.3 Statistical analysis

All analyses were performed with SPSS. Firstly, the distribution of farmers was assessed based on gender, age-group, knowledge of water source, knowledge of water pollution (see Table 1). Also, the distribution of consumers was assessed based on gender, age-group, type of vegetable treatment, becoming sick after consumption and types of sickness (see Table 2). Location differences were examined with Chi square tests of independence. Secondly, multivariate logistic regression analyses were conducted to find out the odds of types of vegetable treatments and types of sicknesses (see Table 3). Odds ratios (ORs) and their 95% confidence intervals (CIs) are presented to show the strength of association. A p-value of 0.05 was set as the level of significance for all tests.

III. Result

3.1 Socio-demographic characteristics

In total, 200 vegetables farmers, 120 from Kara and 80 from Sokodé with an age range of 15 to 55 years participated in this study. The distribution of the study participants by selected socio-demographic variables is presented in Table 1. Due to the fact that farming requires a lot of physical energy, more males than females (96.7% vs 3.3% in Kara and 88.8% vs 11.2% in Sokodé) cultivated vegetables in the past year. Most of the farmers had knowledge about the water source and were conscious that the water used was polluted. Statistically significant location differences were found in gender (χ^2=4.95, df=1, p-value=0.026), age-group (χ^2=21.742, df=2, p-value=0.000), and knowledge about water pollution (χ^2=6.883, df=1, p-value=0.009). However, there was no statistical significance with regard to water source knowledge.

Table 1: Socio-demographic characteristics

Variables	Kara (n %)	Sokodé (n %)	Chi-square	P-value
Gender			4.95	0.026*
Male	116 (96.7)	73 (88.8)		
Female	4 (3.3)	7 (11.2)		
Age-group			21.742	0.000***
<18	2 (1.7)	11(13.8)		
18-50	109 (90.8)	52(65.0)		
>50	9 (7.5)	17(21.2)		
Knowledge of water source			2.083	0.149
Yes	119 (99.2)	77 (96.2)		
No	1 (0.8)	3 (3.8)		
Knowledge about that water pollution			6.883	0.009**
Yes	109 (90.8)	62 (77.5)		
No	11 (9.2)	18 (22.5)		

Note: *p< 0.05, **p< 0.01, ***p<0.001

3.2 Consumers' demographic characteristics.

Overall, 300 consumers (180 in Kara and 120 in Sokodé) with age 15-55 years participated in the survey. Most consumers treated vegetables with water (51.7% in Kara vs 67.5% in Sokodé). Table 2 shows that consumer location was significantly associated with type of vegetable treatment (χ^2=10.935, df=3, p-value=0.012) and type of sickness (χ^2=9.348, df=3, p-value=0.025). Diarrhoea and cholera were the most commonly reported sicknesses in both locations. On the other hand, no significant difference was recorded for gender, age-group and sickness after consumption.

Table 2: Consumer characteristics

Variables	Kara, (%n)	Sokodé, (%n)	Chi-square	P-value
Gender			0.02	0.887
Male	45.0(81)	44.2(53)		
Female	55.0(99)	55.8(67)		
Age-group			1.956	0.376
<18	22.8(41)	19.2(23)		
18-50	66.1(119)	73.3(88)		
>50	11.1(20	7.5(9)		
Type of vegetable treatment			10.935	0.012*
Potable water	51.7(93)	67.5(81)		
Water salt	24.4(44)	22.5(27)		
Potassium permanganate	15.6(28)	5.8(7)		
Water Vinegar	8.3(15)	4.2(5)		
Becoming sick after consumption			1.176	0.278
Yes	46.1(83)	52.5(63)		
No	53.9(87)	47.5(57)		
Type of sickness			9.348	0.025*
Diarrhoea	50.6(42)	55.6(35)		
Cholera	27.7(23)	30.2(19)		
Typhoid fever	19.3(16)	4.8(3)		
Abdomen pain	2.4(2)	9.5(6)		

Note: *p< 0.05

3.3 Relationship between types of vegetable treatments and type of sickness.

Using multivariate logistic regression models (Table 3), our results revealed that the consumers who treated the vegetables with water were 0.4 times less likely to report having diarrhoea after consumption (OR= 0.398, 95%CI= 0.251-0.632; p=0.000).

The result also showed that cholera was significantly associated with treating vegetables with water, with consumers who treated vegetables with water being 0.5 times less likely to report having cholera after consumption (OR= 0.536, 95%CI= 0.329-0.873; p=0.012).

Similar result was found among the consumers who treated the vegetables with salt solution before consumption. Those who treated the vegetables with salt solution were 0.5 times less likely to report diarrhoea after consumption (OR= 0.514, 95%CI= 0.328-0.893; p=0.016).

However, no significant association was observed between vegetables treated with water and typhoid fever/ abdominal pain. In addition, vegetables treated with salt solution were not associated with cholera, typhoid fever and abdominal pain. Potassium permanganate as a treatment method had no significant association with type of sickness

Table 3: Logistic regression for relationship between types of vegetable treatments and types of sickness

Variables	Types of sickness		
	OR	(95% CI)	p-value
Potable water			
Diarrhoea	0.398	0.251-0.632	0.000***
Cholera	0.536	0.329-0.873	0.012*
Typhoid fever	0.761	0.45-1.288	0.31
Abdomen pain	0^b	.	.
Water salt			
Diarrhoea	0.514	0.328-0.893	0.016*
Cholera	0.646	0.38-1.098	0.107
Typhoid fever	0.818	0.462-1.449	0.491
Abdomen pain	0^b	.	.
Potassium permanganate			
Diarrhoea	0.752	0.435-1.301	0.308
Cholera	0.809	0.452-1.447	0.474
Typhoid fever	0.902	0.480-1.692	0.747
Abdomen pain	0^b	.	.

Note: *p<0.05, ***p<0.001
Reference: water vinegar

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IV. Discussion

In this study, we examined the pollution effects of contaminated irrigation water on vegetable crops and to find out the best methods of treatments to arrest the deleterious outcomes of these pollutants. The purpose of this present study was supported by Shahrzad et al study, which showed that pasteurization, sterilization and accurate washing can reduce the microbial load of vegetables and traditional salads as compared to un-washed [20]

Results from our study revealed that method of vegetable treatment was significantly associated with type of sickness after consumption. This may have important implication for methods of vegetable treatments to eliminate or reduce the pathogenic microorganisms which are more likely to cause some diseases. Consistent with our findings, a study conducted by U.S Food and Drug Administration indicated that pathogenic microorganisms were associated with whole or fresh-cut produce and can cause disease outbreaks [25].

Among the methods used to wash vegetable crops before any consumption, each method has distinct advantages and disadvantages. Previous studies [26, 27] revealed that 10% vinegar mixture reduced the numbers of bacteria by 90% and viruses by about 95%, thereby identifying it as one of the best vegetable treatment methods. Based on these findings; we chose vinegar as a reference. Findings from this study showed that vegetables treated with only potable water had a significant protective factor against diarrhoea (OR= 0.398, 95%CI= 0.251-0.632; p=0.000) and against cholera (OR= 0.536, 95%CI= 0.329-0.873; p=0.012), but not against typhoid fever and abdominal pain. We suggest that using only potable water to treat vegetables irrigated with polluted water may remove only the dust but not eliminate pathogenic microorganisms. Similarly, a study by Kilonzo et al supports our findings, where brushing or rubbing fresh produce under cold running tap water significantly reduced some bacteria [28]. Furthermore, previous studies showed that washing vegetables in water or water containing 1% vinegar eliminated lead dust, as well as removing outer leaves of leafy vegetable crops, peeling root, tuber and some fruits of vegetable crops [13, 14, 15, 16, 19].

It is also interesting to note that consumers who treated vegetable crops with water salt were found to be positively associated against diarrhoea after consumption (OR= 0.514, 95%CI= 0.328-0.893; p=0.016), but were not protected against cholera, typhoid fever and abdominal pain. The possible explanation of this finding is that salinity and nutrient concentrations may influence the growth and viability of V. cholera. A study by

Matthew et al, reported that cholera is mostly found in coastal and estuarine environment, where it is exposed to severe periodic changes in salinity and pH [29]

This finding is consistent with previous research results indicating that water salt preserves vegetable crops by inhibiting microorganisms, but not very effective [30]. However, washing fresh produce in water vinegar completely eliminated cypermethrin residue. On the other hand, water vinegar showed a very effective reduction of cypermethrin residue [31]

Surprisingly, with regard to consumers who treated vegetable with potassium permanganate solution, there were no associations between types of sickness and potassium permanganate as method of treatment. We suggest that this finding may be related to lack of knowledge about the efficacy of using potassium permanganate as one of the best methods of treatments. Inconsistent to our findings, a study conducted by Churdchai et al revealed that, potassium permanganate; vinegar and bio-surfactant are more effective in reducing some pollutants or bacterial contaminants on vegetable crops [31].

Considering the methods of vegetable treatment, we recommend mixing water vinegar and solution of potassium permanganate to eliminate maximum pathogenic microorganism on fresh vegetables. More research needs to be done to identify the predominant microorganisms and their pathogenic load in polluted irrigation water. Future studies should consider the presence of heavy metals and persistent organic pollutants in irrigation water and streams used. Laboratory testing should also be conducted to ascertain the chemical and biological components of irrigation water.

Nevertheless, our study was not without limitations. The study only considered contamination from irrigation water, but contamination may occur from other sources, including during harvesting, transportation, processing, distribution and marketing, as well as preparation in the home.

V. Conclusion

This study provides evidence that untreated vegetables constitute a great health hazard especially in areas with polluted water sources. Vegetable treatment, particularly with vinegar and potassium permanganate, is recommended to effectively remove pathogenic microorganisms and ultimately prevent illness.

Conflicts of interest

All the authors declare that they have no conflicts of interest.

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