Journal homepage: www.fia.usv.ro/fiajournal
Journal of Faculty of Food Engineering,
Ştefan cel Mare University of Suceava, Romania
Volume XXIII, Issue 4 - 2024, pag. 21 - 33

SAFETY OF FRESH VEGETABLES IN MARKET VALUE CHAIN: A CASE STUDY IN THREE VEGETABLE PACKING COMPANIES AND THREE URBAN VEGETABLE GROWERS VALUE CHAIN IN GREATER ACCRA REGION

Ruth Fosu[1], Kwaku Tano-Debrah[2], Kofi Wisdom Amoa-Awua[3]
Food Research Institute, P.O Box M20, CSIR ACCRA Ghana[1], University of Ghana[2], Food Research Institute, CSIR ACCRA Ghana, College of Science and Technology (Affiliated to University of Cape Coast) [3]
*Corresponding author: r.fosu24@yahoo.co.uk
Received 26 June 2024, accepted 29 November 2024

Abstract: *The objectives of the study were to map out, to document the value chains of vegetable production and marketing in the Greater Accra Region, and to determine the microbiological quality of selected non-traditional vegetables, carrot, cabbage, lettuce, and cucumber, along different value chains in the Greater Accra Region, and also to determine pesticide residue levels in the selected vegetables along the different value chains. A survey was conducted to seek views from key actors along the value chains on the treatment and handling of the selected vegetables that show Urban Vegetable Growers used streams, dugouts, water from gutters, and drains. In contrast, Pack House companies use treated water or connected irrigation pumps. It was also revealed that Urban Growers used organic fertilizer more than the Pack Companies' Farms that used inorganic fertilizer. The vegetables were sampled along their respective value chains to test for the presence of aerobic mesophiles, Escherichia coli, coliforms, yeast and molds, Staphylococcus aureus, Salmonella, Clostridium perfringens, and Listeria monocytogenes. Generally, the study revealed that samples from Vegetable Packed Companies' value chains had a lower microbial population than vegetables from Urban Vegetable Growers. Seven pesticide residues were found in vegetables from Urban Growers while four were found in vegetables from the Packed Companies in trace amounts. The concentrations found in the vegetables for both value chains were within the acceptable limits for consumption. Therefore, Urban Vegetable Growers should be educated on agricultural practices and awareness should be created about the risk of consuming vegetables that are not contaminated.*

Keywords: *actors, value chain, Vegetable Packed Companies, Urban Vegetable Growers.*

1. Introduction

Vegetables are the second most essential food group consumed after grains and cereal products in Ghana. A recent study found that 11.4% and 5.4%, respectively of the total household food budget and annual household cash are spent on vegetables [1]. Vegetables are excellent sources of minerals, vitamins, and dietary fiber, and thus, play major roles in a human diet. Vegetable intake is found to be associated with a reduced risk of heart disease, obesity, diabetes, and cancer [2]. Vegetables have been used in the preparation of soups to enhance their thickness and in stews to increase their bulkiness [3]. In Africa, vegetables are preferentially eaten as the main dish or as a side dish with starchy foods. Presently, the use of non-traditional vegetables such as lettuce, cabbage, and carrots in the preparation of some Western delicacies such as salads is on the ascendency in many urban households in Ghana. There is a high demand for such vegetables, which is mainly influenced by increasing consumer affluence, urbanization changes in consumer lifestyles, and preferences as well as population growth [4,5].

Ghana's population has tripled a little over half (54.04%) of the population residing in urban areas. Increased urbanization and population growth, coupled with changing lifestyles due to increased affluence, fueled a parallel increase in the demand for non-indigenous or non-traditional vegetables.

DOI: https://doi.org/10.4316/fens.2024.019

Much of the vegetable supply in urban Ghana is cultivated on unused parchments of land in the cities by small-scale farmers. These farmers overcome the challenges of water supply and soil fertility by employing irrigation and animal waste manure from both households and industries that are mostly released into the environment untreated and eventually end up in major streams or water bodies used in vegetable irrigation [6]. Adetunde et al. [7] and Cobbina et al. [8] analyzed the microbial quality of irrigation water and irrigated leafy-green-vegetables and found a strong positive correlation between the microbial counts on vegetables and in irrigation water. While this practice is cost-effective and provides a means of utilizing urban sewage, it also poses serious public health concerns from the risk associated with untreated waste.

This problem garners even more concern when coupled with the fact that most of these vegetables are consumed raw or with minimal processing. Consumption of fresh vegetable products is known as a risk factor for infection with enteric pathogens such as *Salmonella* spp. and *Escherichia coli* O157:H7 [9]. Consumption of fresh produce is associated with a growing number of foodborne outbreaks due to bacterial contamination of these products [10].

Generally, the food supply for Ghanaians has continually been exposed to frequent incidents of foodborne diseases, which raises questions about the credibility and safety of the food supply [10]. The number of foodborne illnesses is likely to increase in Ghana if the consumption of fresh produce increases, a trend that has been observed in other countries [10]. A study by Quansah et al. [11] found that up to 84% of vegetables from small-scale farms in the Accra metropolis tested positive for fecal coliform contamination, with a corresponding high prevalence of *Salmonella*, a potentially life-threatening human pathogen. Poor vegetable quality constitutes public health concerns for consumers but also an economic loss for the country.

This study sought to assess the microbiological and chemical hazards associated with vegetables (carrot, cucumber, cabbage, and lettuce) in value chains in Accra.

2. Materials and methods

2.1. Study design

The study was carried out in two stages. The first stage was carried out to seek information from consumers to assist in mapping out the value chains. The information gathered was used in identifying the actors along with the two-value chain Vegetable Packed House Companies and Urban Vegetable Growers. Persons involved in the Vegetable Packed House value chain were farmers, pack houses, supermarkets, and restaurants, Urban Growers' lines of production include farmers, middle women/distributors, retailers/open markets, and food vendors. In the second stage, the selected vegetables were sampled to determine the microbial contamination and levels of pesticide residues as indicators of quality.

2.2. A survey on the treatment and handling of vegetables

A survey was conducted to seek views from key actors along the value chains on the treatment and handling of the selected vegetables. Focus group discussions were used with random sampling. A total of 186 respondents consisting of 64 vegetable growers, 107 vegetable sellers, and 15 users were interviewed to seek information on the source of irrigation water, source of fertilizers or manure used, quality of water used, and postharvest handling and treatment of vegetables.

The oral interview was used to seek information from consumers on the source of their vegetables, and a snowball method was followed to get all actors from farms to consumers. This information was used to map out two value chains that were traced from consumers to farms.

2.3. Samplings for microbial analysis

Samples of vegetables, soil, manure, and water were collected from the two lines of production (Urban Vegetable Growers and Vegetable Packing Companies).

2.3.1. Sampling of vegetables from Urban Vegetable Growers

Samples were taken from the actors along with the Urban Growers' value chain. The vegetable was taken from farms, middle women/distributors, open markets, and street food vendors. Four cabbage heads were taken per plot, making a total of 16 cabbage samples from a farm and 48 cabbage samples from three farms. 48 cabbage heads were also purchased from middle women/distributors, open markets, and food vendors. The same approach was used to sample lettuce, carrot, and cucumber, making a total of 192 samples from Urban Vegetable Growers' lines of production and Vegetable Packing Companies.

The samples were collected in polypropylene sampling bags, labeled, and transported to the laboratory in an ice chest with an ice pack for microbial and pesticide analyses.

2.3.2. Samplings of vegetables from Vegetable Packed House Companies

The same sampling procedure for Urban Growers' lines of production was used for the Vegetable Packed Houses value chain. Samples were taken from the following actors: farmers, Pack Houses, supermarkets, and restaurants. A total of 192 samples of equal quantities of cabbage, carrot, lettuce, and cucumber were collected. A total of 48 vegetable samples were obtained from 3 farms, 3 pack houses, 3 supermarkets, and 3 restaurants. The samples were collected in polypropylene sampling bags, labeled, and transported to the laboratory in an ice chest with an ice pack for microbial and pesticide analyses.

2.3.3. Sampling of irrigation water and water used to wash vegetables in the value chains

Water used for irrigation was collected (250 mL) from each farm three times, as well as cleaning water used at the pack houses and restaurants for washing the vegetables.

2.3.4. Sampling of soil and manure from both farms

The soil was scooped (to a depth of 10-15 cm) from the bed which is the best soil depth on which the vegetables were grown using a sterile polypropylene spoon into acid-cleaned polypropylene sampling bags. Manure samples from the same site were also taken at a depth of 10 cm from the piles. These samples were air-dried by spreading each sample on paper or aluminum foil at room temperature, sealed in containers, and transported to the laboratory for microbiological analysis.

3. Results and Discussion

The results from the survey revealed most Urban Vegetable Growers used water from streams, rivers, and dugouts, while Vegetable Packed Company Farmers mostly used treated water and the Urban Growers used untreated water for irrigation. The Urban Growers mostly used organic fertilizers while Vegetable Packed Farmers used mostly inorganic fertilizers (Fig. 3.1, 3.2, 3.3, and 3.4).

3.1. Water used by both Urban Vegetable farmers and Vegetable Packed Company Farmers

Vegetable farming largely depends on irrigation. The results from the survey Fig 3.1 showed that most of the Urban

Vegetable Growers draw water from streams 40% /rivers 40% and /dugouts 20% to irrigate their vegetables.

During the rainy season, they depend on streams and rivers most of which dry up during long dry seasons [12]. Nurudeen [13] established that, vegetable farmers in Accra metropolis used polluted water that runs through drains and big gutters in some parts of the metropolis to irrigate their vegetables.

Most irrigation water sources are contaminated with untreated domestic wastewater originating from poor urban sanitation. About 47% of households dispose of their liquid waste mostly graywater through street gutters [14].

For black water, most houses in low-density areas have on-plot pit latrines or septic tanks, but usually without drains fields. The excess of septage from septic tanks into soils, stormwater drains, and water courses is common and contaminates the urban environment.

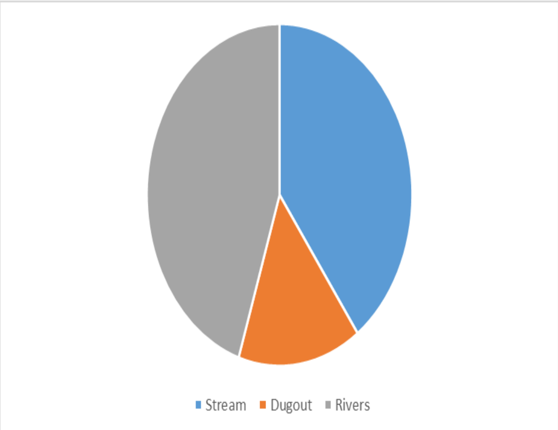

Fig. 3.1. Irrigation water used by Urban Vegetable Growers' Farmers

Subsequently, most street drains, which cover about 60% of Accra and were meant for stormwater (and graywater) passage, also show high coliform levels [15].

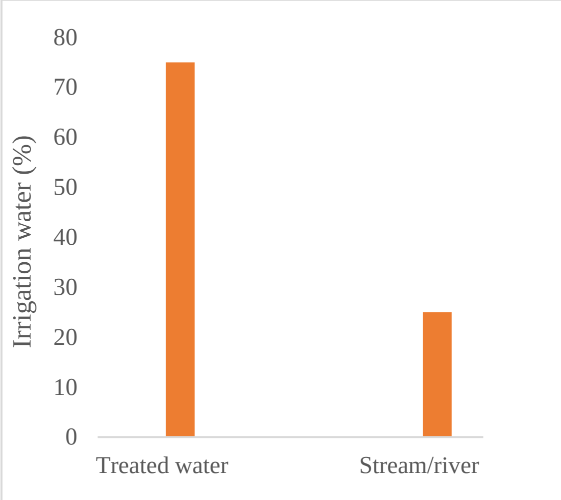

Fig. 3.2. Irrigation water used by Vegetable Packed Company Farmers

The study above Fig 3.2 revealed that most of the Vegetable Packed Company Farmers treat their water (treated water 75%) and also used stream/river (25%) for irrigation. This practice could be attributed to the reduction in the risk of contaminating the vegetables. Drechsel & Seidu [16] agreed with the idea that most of the functional and semi-functional plants for the treatment of wastewater were small-capacity, plants owned by hotels and private companies

.

3.2. Type of fertilizer used by Urban Vegetable Growers

From the result of Fig. 3.3, 75% of the farmers use compost, while 25% use poultry dropping. The application of plant nutrients is a practice that helps farmers to maximize yield. However, there are certain basic factors that one must consider when applying fertilizer. The result of this study revealed that organic manure is the most used fertilizer for the cultivation of vegetables for Urban Vegetable Growers. The commonest organic manure used is poultry droppings. This might be due to the abundance of organic fertilizer (poultry dropping) in the study area and could account for the presence of fecal coliform and *Escherichia coli* in vegetables because organic manure is the main source of fecal contamination. Allen [17] stated that manure and improperly managed compost act as reservoirs for pathogenic bacteria like *Escherichia coli*. It also confirms a statement by Amoah et al. [18] that vegetables cultivated with manure are highly infested by bacteria, indicating contamination from fecal sources.

3.3. Types of fertilizers used by Packed House Company farmers

From the results of Fig 3.4, 75% of the farmers use inorganic fertilizers while 25% use compost. The low microbial population of vegetables along the chain could be attributed to the use of inorganic fertilizer which does not have any fecal contamination unlike the poultry droppings used by the Urban Vegetable Growers.

3.4. Microbiological quality of water used to grow the vegetables

All the vegetable farms visited during this study depended on irrigation for cultivation. Most Urban Vegetable farmers draw water from streams rivers or dugouts to water their vegetables and do not have irrigation facilities as such.

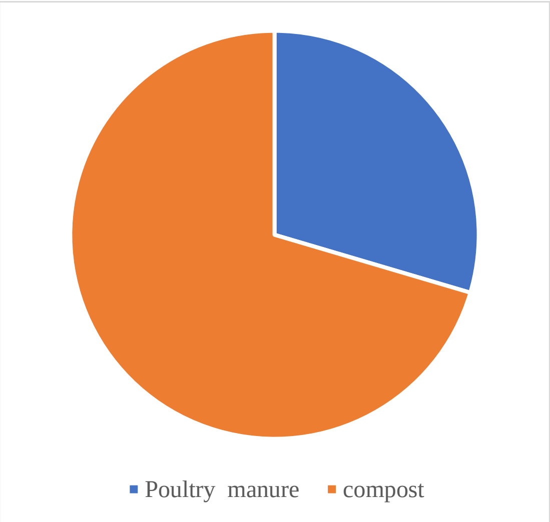

Fig. 3.3. Type of fertilizer used by Urban Vegetable Growers

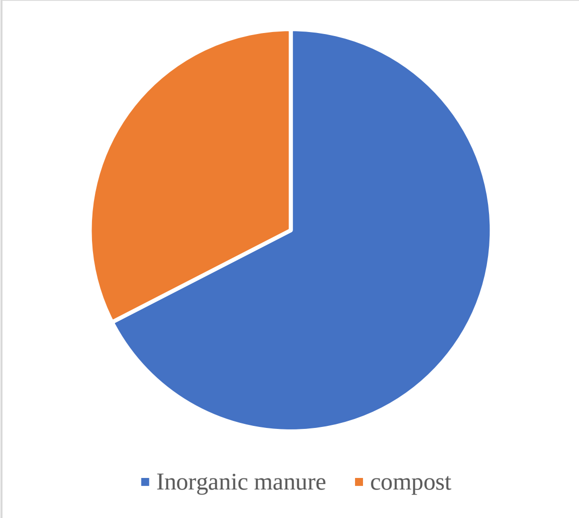

Fig. 3.4. Type of fertilizer used by Vegetable Packing Companies

The vegetable growers depend on streams and rivers; however, during long dry seasons, most of the streams dry up. According to Keraita et al. [6], streams, shallow wells, and waste drains are common sources of irrigation water used in vegetable cultivation in Ghana. The Pack House Farms visited in this study used mostly treated pipe-borne water for their vegetables. They have irrigation facilities and pump the water to irrigate the beds. One of the companies adds pesticides to tap water before it is used to irrigate the farm. Results of microbial analysis of water samples used by Urban Growers and Pack House Farms are presented in Fig 3.5.

The water samples were analyzed for aerobic mesophiles, coliforms, and *Escherichia coli*, and for each group or type of bacteria, higher counts were recorded in water used by the Urban Vegetable Growers than in the Pack House water samples. For aerobic mesophiles, the difference between counts was 2.05 log CFU/g, coliforms 1.32 log CFU/g, and *Escherichia coli* 0.43 log CFU/g. The higher contamination of the water used on the Urban Growers' Farms contributed to the higher microbial counts in their harvested vegetable samples.

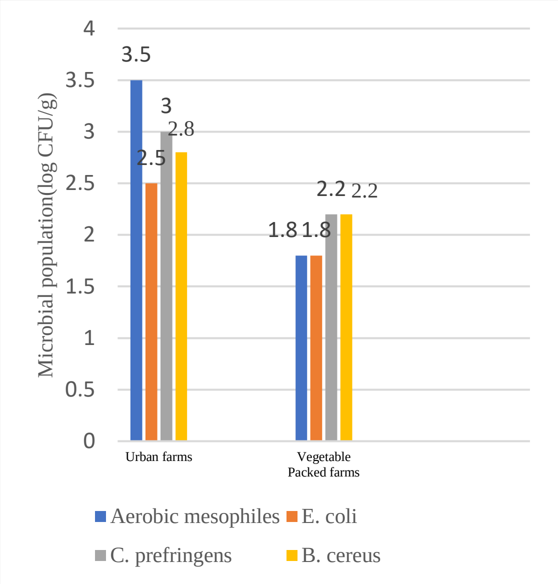

Fig. 3.5. Mean microbial loads of water used in both value chains in log CFU/g

According to Sagoo et al. [19] wastewater from both households and industries is mostly released into the environment untreated and eventually ends up in major streams or water bodies used in vegetable irrigation. Ghana Statistical Service [14] noted that some vegetable farmers in the Accra metropolis use polluted water that runs through drains and big gutters in some parts of the metropolis to irrigate their vegetables. Adetunde et al. [7] and Cobbina et al. [8] assessed the microbiological quality of irrigation water and irrigated leafy green vegetables and reported a strong linkage between the microbial count on the vegetables and irrigation water. Adetunde et al. [7] has also reported that wild and domestic animals could be a source of irrigation water contamination and this could also have contributed to the high microbial population on vegetables produced by the Urban Growers. The use of less contaminated water on the Pack House Farms contributed to the lower microbial counts on their harvested vegetables in comparison to the Urban Growers Farms.

3.5. Microbial contamination along the two-vegetable value-chain

Table 3.1 shows that each figure represents the mean population of all four vegetables monitored (cabbage, carrots, lettuce, and cucumber) at each step in the chain. While operations along the Urban Vegetable Growers' value chain may be described as informal, operations along the Pack House value chain are formal and involve activities of well-structured companies with trained personnel supervising or carrying out the operations. At the production/farm stage, the difference in counts of the various microorganisms between the two value chains ranged from 0.42 log CFU/g for *Escherichia coli* to 1.08 log CFU/g for aerobic mesophiles. At the processing/distribution stage, the differences in the counts ranged from 0.94 log CFU/g for *Escherichia coli* to 2.68 log CFU/g for aerobic mesophiles. At the retailing stage, the differences ranged from 0.27 log CFU/g for *Escherichia coli* to 1.43 log CFU/g for aerobic mesophiles while for the consumers the differences ranged from 0.50 log CFU/g for *Escherichia coli* to 1.31 log CFU/g for *Staphylococcus aureus*. Various sources of the contamination of the vegetables include poor farming practices such as the use of polluted irrigation water, use of poultry litter without adequate composting, poor handling of vegetables during loading and offloading from transporting vehicles, lack of proper storage facilities, poor hygienic practices of market women, etc. [19,11]. In the Pack House value chain, there is less exposure to vegetables directly to the outside atmosphere. Packaging of the vegetables in cling polypropylene film or bags created modified atmosphere conditions that retarded microbial growth. Refrigeration and cooler in the supermarkets also retarded microbial growth. The use of salt or vinegar solution to wash vegetables in restaurants reduced the microbial loads on the vegetables before consumption. This study revealed that samples from Urban Growers had a higher microbial population compared to the Packed House Companies Farm.

3.6. Microbiological quality of water used to wash harvested vegetables

The harvested vegetables were washed before they were sold to consumers. In the Urban Growers value chain, though the distributors who are the middle women do not usually wash the vegetables, the market women who purchase the vegetables from the middle women wash the vegetables before they are sold to consumers. In the Pack House value chain, after the vegetables are conveyed from the farm to the Pack House, the vegetables are washed before they are cut up for the packaging. Where the vegetables are not cut up, they are washed and packed in polyethylene bags for distribution.

The purpose of washing the vegetables is to remove the dirt and other particles, and also reduce the microbial load. In the present study, samples of water used to wash vegetables before retailing i.e., by market women and Pack Houses, and also for food preparation for consumption, were assessed for the population of aerobic mesophiles, coliforms, and *Escherichia coli*, and the results are given in Fig. 3.6. The water used to wash vegetables in the Pack Houses was of better microbiological quality compared to water used by market women to wash the vegetables they display for sale. The counts of aerobic mesophiles, coliforms, and *Escherichia coli* were lower by log 1 to 2 CFU/g in the Pack Houses. Apart from the use of sanitizing agents in the Pack Houses, another key factor that was observed in the study was that the market women usually wash a whole lot of vegetables with a bowl of water without changing the water regularly, leading to higher counts in the wash water. One of the visited Pack Houses, washed the vegetables first in clean water, then in water containing food-grade chlorine or sodium hypochlorite, and then rinse the vegetables in clean water before they cut them up for the packaging.

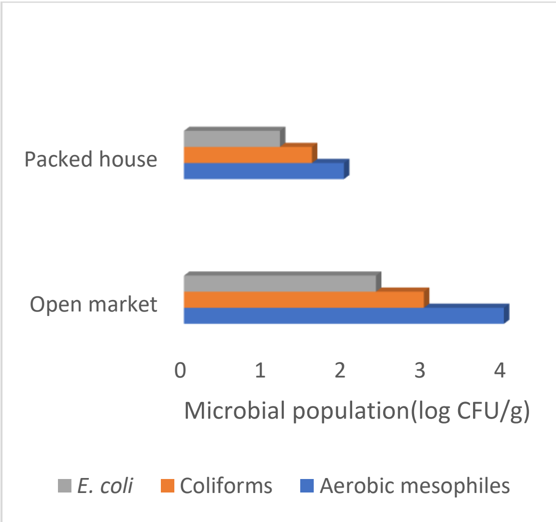

Fig. 3.6. Microbiological quality of water used to wash harvested vegetables before retailing. *Mean of three samples each taken from three different open markets and three different packed houses

3.7. Pesticide residue of vegetables from Urban Vegetable Growers' value chain

As many as nine pesticide residues were found in the vegetables from three cultivation locations, even though not all were in each vegetable sample. Nonetheless, the levels detected were below the recommended maximum residual levels. All the same, consuming these vegetables still poses a menace to the health of consumers since most consumers eat them in their raw state or lightly cooked. More pesticides were detected in cabbage and lettuce from the three urban farms compared to cucumber and carrot. Vegetables from these three areas of Urban

Growers showed no detectable level of fenitrothion and profenofos. Pirimiphos-methyl was not found in all vegetables from the first farm (Table 3.2). Less than 0.01 mg/kg of bifenthrin was found in carrots, but not in the cabbage, cucumber, and lettuce. A low level of chlorpyrifos was found in carrots and cucumbers, but not in lettuce and cabbage. A concentration of 0.01 mg/kg of lambda-cyhalothrin was found in lettuce, but not in the carrot, cucumber, and cabbage. Less than 0.02 mg/kg of permethrin was found in cabbage, but was not in the lettuce, carrot, and cucumber. Moreover, a concentration of 0.01 mg/kg and 0.03mg/kg of cyfluthrin was found in lettuce and cabbage receptively, while carrots and cucumber had no cyfluthrin. Less than 0.01 mg/kg of cypermethrin was found in all vegetables except cucumber.

The last farm recorded less than 0.01 mg/kg concentration of chlorpyrifos and lambda-cyhalothrin in carrots and lettuce, but not in the cucumber and cabbage. While less than 0.04 mg/kg of cyfluthrin was found in lettuce but was not in carrots, cabbage, and cucumber. However, there was no concentration of pirimiphos-methyl, fenitrothion, profenofos, bifenthrin, and cypermethrin in all vegetables. Small amounts of lambda-cyhalothrin and cypermethrin were detected in lettuce with less than 0.01 mg/kg, respectively. Less than 0.02, 0.03, and 0.01 mg/kg residual levels were also detected in cabbage for permethrin, cyfluthrin, and cypermethrin, respectively. However, generally, seven residual levels were found in vegetables from Urban Growers' lines of production with concentrations from 0.01-0.04 mg/kg (Table 3.2).

3.8. Pesticide residue of vegetables from Packed House Company

Fenitrothion, profenofos, bifenthrin, permethrin, and cypermethrin were not detected in all vegetables obtained from three farms. A concentration of 0.01 mg/kg of pirimiphos-methyl was found in lettuce and cabbage, but no concentration was found in carrot and cucumber in the Packed House chain. Less than 0.01 mg/kg concentration of chlorpyrifos was found in cabbage and carrot, but not in the cucumber and lettuce. A small amount of lambda-cyhalothrin was found in lettuce and carrot with 0.01 mg/kg concentration, but was not found in the cabbage and cucumber. Cyfluthrin was found in cabbage with 0.01 mg/kg concentration, but was not found in the lettuce, carrot, and cucumber (Table 3.3). Chlorpyrifos and cyfluthrin were not found in all vegetables from the first farm. Moreover, there was no detection of pirimiphos-methyl, fenitrothion, profenofos, bifenthrin, permethrin, cypermethrin, and lambda-cyhalothrin in all vegetables on the next farm. Likewise, vegetables from the last farm recorded no concentration of fenitrothion, profenofos, bifenthrin, permethrin, and cypermethrin for all vegetables. In general, four residual levels (pirimiphos-methyl, lambda-cyhalothrin, chlorpyrifos, and cyfluthrin) were found in the Vegetable-Packed Company line of production with less than 0.01 mg/kg concentration. The occurrence of pesticides in the vegetables could be attributed to direct contact with crops during spraying or by engagement from the soil. Usually, after spraying farmers would not wait for a suggested date before harvesting, and that could be a cause of residues in the vegetable. This could be attributed to the fact that leafy vegetable attracts a lot of insects and therefore, cabbage and lettuce are sprayed with more pesticides, and also more frequently, than carrot and cucumber. Pesticides are more frequently used in the cultivation of vegetables to control pests and diseases due to their high economic value or profits.

Table 3.1.

Mean microbial counts in log CFU/g of all vegetables along the two value-chains

Actor or stage in the value chain	Aerobic mesophiles	Yeasts and molds	Coliforms	*E. coli*	*B. cereus*	*S. aureus*	*L. monocytogenes*	*Salmonella*
Stage 1: Production								
(A) Urban Farm	5.23 ± 1.04	4.83 ± 0.48	3.51 ± 0.40	2.19 ± 0.39	4.04 ± 0.68	4.48 ± 0.51	Detected	Detected
(B) Pack House Farm	4.15 ± 0.25	4.11 ± 0.66	2.79 ± 0.25	1.77 ± 0.12	3.53 ± 0.55	3.93 ± 0.95	Nd	Nd
Difference in counts	1.08	0.72	0.72	0.42	0.51	0.59		
Stage 2: Marketing								
(A) Middle women	6.24 ± 0.75	5.53 ± 0.84	3.75 ± 0.20	2.24 ± 0.58	4.41 ± 0.64	4.91 ± 0.53	Detected	Detected
(B) Pack House	3.56 ± 0.22	3.34 ± 0.62	2.56 ± 0.25	1.30 ± 0.24	2.66 ± 0.36	3.29 ± 1.01	Nd	Nd
Difference in counts	2.68	2.19	1.19	0.94	1.75	1.62		
Stage 3: Retailing								
(A) Open market	5.13 ± 0.55	4.42 ± 0.38	3.48 ± 0.36	1.77 ± 0.18	3.15 ± 0.19	4.29 ± 0.59	Nd	Detected
(B) Supermarket	3.70 ± 0.60	3.40 ± 0.51	2.96 ±0.54	1.50 ± 0.07	2.61 ± 0.41	3.35 ± 0.43	Nd	Nd
Difference in counts	1.43	1.02	0.52	0.27	0.54	0.95		
Stage 4: Consumption								
(A) Street food	3.83 ± 0.51	3.61 ± 0.30	2.67 ± 0.18	1.50 ± 0.15	2.82 ± 0.29	4.04 ± 0.52	Nd	Nd
(B) Restaurant	3.18 ± 0.31	2.86 ± 0.50	2.15 ± 0.50	1.00 ± 0.65	2.31 ± 0.07	2.73 ± 0.19	Nd	Nd
Difference in counts	0.65	0.75	0.52	0.5	0.50	1.31		

*Mean of four vegetable samples each taken from three different farms, distributors, and consumers along the value chain. Nd means not detected.

Table 3.2.

Pesticide residue in mg/kg in vegetables obtained from three different Urban Vegetable Growers' Farms

Farm	Pirimiphos-methyl	Fenitrothion	Chlorpyrifos	Profenofos	Bifenthrin	Lambda-cyhalothrin	Permethrin	Cyfluthrin	Cypermethrin
Farm A									
Carrot	Nd	Nd	<0.02	Nd	<0.01	Nd	Nd	Nd	<0.01
Lettuce	Nd	Nd	Nd	Nd	Nd	<0.01	Nd	<0.01	<0.01
Cabbage	Nd	Nd	Nd	Nd	Nd	Nd	<0.02	<0.03	<0.01
Cucumber	Nd	Nd	0.01	Nd	Nd	Nd	Nd	Nd	Nd
Farm B									
Cabbage	<0.01	Nd	Nd	Nd	Nd	Nd	<0.01	<0.01	Nd
Carrot	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Lettuce	Nd	Nd	Nd	Nd	Nd	<0.01	Nd	<0.02	Nd
Cucumber	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Farm C									
Cabbage	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Lettuce	Nd	Nd	Nd	Nd	Nd	<0.01	Nd	<0.04	Nd
Carrot	Nd	Nd	<0.01	Nd	Nd	Nd	Nd	Nd	Nd
Cucumber	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd

Pesticides residue levels from three urban farms and their respective vegetables; Nd – not detected.

Table 3.3.

Pesticide residue in mg/kg in vegetables obtained from three different Vegetables Packed Companies' Farm

Farm	Pirimiphos-methyl	Fenitrothion	Chlorpyrifos	Profenofos	Bifenthrin	Lambda-cyhalothrin	Permethrin	Cyfluthrin	Cypermethrin
Farm 1									
Carrot	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Lettuce	<0.01	Nd	Nd	Nd	Nd	<0.01	Nd	Nd	Nd
Cabbage	<0.01	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Cucumber	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Farm 2									
Cabbage	Nd	Nd	<0.01	Nd	Nd	Nd	Nd	<0.01	Nd
Carrot	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Lettuce	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Cucumber	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Farm 3									
Cabbage	<0.01	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Lettuce	<0.01	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Carrot	Nd	Nd	<0.01	Nd	Nd	<0.01	Nd	Nd	Nd
Cucumber	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd

Pesticides residue levels from three Vegetable-Packed farms and their respective vegetables; Nd – not detected.

The use of pesticides, especially high concentrations has been shown to kill soil microorganisms [20,21]. Pest and insect attack is one major problem that threatens farmers in Ghana, especially in Accra metropolis. To reduce costs and losses due to pest attacks, vegetable farmers in the Accra Metropolis uses a lot of pesticides, especially in vegetable-packed farms. This research showed that most farmers use lambda-cyhalothrin which was detected in the vegetables. This study found that a low level of formal education among the farmers in the study area makes it difficult for them to understand the instructions on the chemicals. It is concluded that farmers may not use the correct dosage.

4. Conclusions

Vegetables are gradually becoming an important product obtaining for local and export markets. They have a great potential to improve the nutrition and thereby the health of consumers as most are good sources of vitamins, minerals, and proteins needed for proper functioning and development of the human body. This study maps out two value chains (Urban Vegetable Growers and Vegetable Packed Companies) for these vegetables (carrot cabbage, cucumber, and lettuce) grown in the Accra metropolis based on the oral interview obtained from consumers. The microbial population of aerobic mesophiles, yeasts and molds, coliforms, *Escherichia coli, Bacillus cereus,* and *Staphylococcus aureus* was enumerated in vegetables obtained from these value chains. However, this study revealed, urban vegetable growers' line of production had high microbial loads compared to vegetable Packing House Company. *Salmonella* and *Listeria monocytogens* were detected in most urban growers' production line compares to vegetables Packing House Company. However, *Salmonella* was detected in vegetables from the farms, middle women/distributors, and in open markets, for Urban Vegetable Growers, while vegetables from supermarkets and restaurants from vegetable-packed companies were not detected. Vegetable Packed Companies recorded no *Listeria monocytogens* along the value chain for all vegetables. However, the microbial population was higher at the Urban Vegetable Growers' line of production except for food vendors. Both chains recorded low microbial loads in street food vendors and restaurants (consumers). Generally, urban vegetable growers had a high microbial population compare to Vegetable Packing Companies. Out of nine pesticide residues detected, seven were found in urban growers while four were found in Vegetable Packed House Companies. The residual levels were within the EU acceptable maximum residual levels.

4.1. Recommendations

1. There should be proper education, and monitoring of the cultivation and post-harvest handling of vegetables to reduce the contamination of vegetables in the supply chain and ensure quality in consuming vegetables cultivated in Accra metropolis.
2. Urban Vegetable Growers' stakeholders should be educated on good agricultural practices.

Conflict of interest

There was no conflict of interest.

5. References

[1]. Population and Housing Census. District Analytical Report. Tamale Metropolis. Ghana Statistical Service, GSS, (2014).
[2]. AUNE, D., GIOVANNUCCI, E., BOFFETTA P., FADNES, L.T., KEUM, N., NORAT, T., GREENWOOD, D. C., RIBOLI, E., VATTEN, L. J., TONSTAD, S., Fruit and vegetable

intake and the risk of cardiovascular disease, total cancer and all-cause mortality – A systematic review and dose-response meta-analysis of prospective studies, *International Journal of Epidemiology*, 46(3): 1029–1056, (2017).
[3]. DARKWA S., DARKWA, A. A., The use of indigenous green leafy vegetables in the preparation of Ghanaian dishes, *Journal of Food Processing & Technology*, 4(12): 286, (2013).
[4]. PARROT, L., DONGMO, C., NDOUMBE, M., POUBOM, C., Horticulture, livelihoods, and urban transition in Africa: evidence from South-West Cameroon, *Journal of Agricultural Economics*, 39(2): 245–256, (2008).
[5]. SATTERTHWAITE, D., MCGRANAHAN, G., TACOLI, C., Urbanization and its implications for food and farming, *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554): 2809–2820, (2010).
[6]. KERAITA, B., SILVERMAN, A., AMOAH, P., ASEM-HIA, S., Quality of irrigation water used for urban vegetable production. In P. -Drechsel, & B. Keraita (Eds.), Irrigated urban vegetable production in Ghana (2nd ed., pp. 62e63), (2014).
[7]. ADETUNDE, L., SACKEY, I., DOMBIRL, D., MARIANMA, Z., Potential links between irrigation water microbiological quality and fresh vegetables quality in Upper East region of Ghana subsistence farming, *Annual Research & Review in Biology*, 6(6): 347–354, (2015).
[8]. COBBINA, S. J., KOTOCHI, M. C., KORESE, J. K., AKRONG, M. O., Microbial contamination in vegetables at the farm gate due to irrigation with wastewater in the Tamale metropolis of Northern Ghana, *Journal of Environmental Protection*, 4(7): 676–682, (2013).
[9]. LUNA-GUEVARA, ARENAS-HERNANDEZ M. M. P., MARTINEZ, C., de la Peña, JUNA, L. SILVA, The role of pathogenic *E. coli* in fresh vegetables: Behavior, contamination factors, and preventive measures, *International Journal of Microbiology*, 2019(1): 2894328, (2019).
[10]. CALLEJON, R. M., RODRIGUEZ-NARANGO, M. I., UBEDA C., HORONEDO-ORTEGA, R., GARCIA-PARRILLA, M. C., TRONCOSO, A. M., Reported foodborne outbreaks due to fresh produce in the United States and European Union: Trends and causes, *Foodborne Pathogens and Disease*, 12(1): 32–38, (2015).
[11]. QUANSAH, J. K., KUNADU, A. P.-H., SAALUIA, F. K., DIAZ-PEREZ, J., CHEN, J., Microbial quality of leafy green vegetables grown or sold in Accra metropolis, Ghana, *Food Control*, 86: 302–309, (2018).
[12]. KERAITA, B., DRECHSEL P, HUIBER F, RASCHID-SALLY, L., Wastewater use in informal irrigation in urban and peri-urban areas of Kumasi, Ghana, *Urban Agriculture Magazine*, 8: 11–13, (2002).
[13]. NURUDEEN, S., Vegetable farmers use polluted water to irrigate crops, *Daily Graphic*, (2010).
[14]. Population and Housing Census, summary, report of final results. Accra, Ghana: Ghana Statistical Service (GSS), (2012).
[15]. DRECHSEL, P., ADAM-BRADFORD, A., RASCHID-SALLY, L. Irrigated urban vegetable production in Ghana. In P. Drechsel, & B. Keraita (Eds.), Irrigated urban vegetable production in Ghana: Characteristics, benefits and risks (2nd ed., pp. 2e4). Sri Lanka: International water Management Institute, (2014).
[16]. DRECHSEL, P., SEIDU, R., Cost-effectiveness of options for consumer health risk reduction from wastewater irrigated crops, *Water International*, 36(4): 535–548, (2011).
[17]. ALLEN, J., Vegetable crop specialist: Sandra Jones - On farm food safety programme lead/OMAFRA, (2006).
[18]. AMOAH, P., DRECHSEL, P., ABAIDOO, R. C., NTOW, W. J., Pesticides and pathogen contamination of vegetables in Ghana's urban markets, *Archives of environmental contamination and toxicology*, 50: 1–6, (2006).
[19]. SAGOO, S. K., LITTLE, C. L., GRIFFITH, C. J., MITCHELL, R. T., Study of cleaning standards and practices in food premises in the United Kingdom, *Communicable Disease and Public Health*, 6(1): 6–17, (2003).
[20]. AYANSIN, A. D. V., OSO, B. A., Effect of two commonly used herbicides on soil microflora at two different concentrations. *African Journal of Biotechnology*, 5(2): 129–132, (2006).
[21]. KALIA, A., GUPTA, R. P., *Handbook of Fruit and Fruit Processing*. Blackwell publishing. Pp 3-28, (2006).