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Effect of Vegetable Commercialization on Food Safety

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ABSTRACT---- ***The commercialization of fresh vegetables is crucial in enhancing revenues from commercial vegetable farming and ensuring reliable supply of high-quality produce for consumers. However, this is only guaranteed under ethical application of agrochemicals beyond which can lead in a more pronounced public health as well as environmental hazards. The present paper sought to examine the influence of commercialization on food safety. Vegetable samples weighing between 1 to 2 kg were purchased from randomly selected producers in two major producing counties (Kiambu and Kirinyaga) in Kenya. All samples were freeze-dried and stored in an ice chess box, to minimize contamination. Then the samples were labeled, and transported to the laboratory for processing and testing. All approved samples were subjected to the QuEChERS preparation method for pesticides and quantified using gas chromatography equipped with mass spectrometry (GC-MS). Lab results tested positive for 13 problematic pesticides including known carcinogens and highly hazardous agrochemicals such as Malathion, chlorothalonil and chlorpyrifos. The most common agrochemical was carbofuran (67%) in terms of insecticide. For the case of fungicides, the most common was mancozeb (60%) and metalaxyl (58%). Food safety issues are caused mainly by not observing preharvest intervals, excessive application of chemicals and use of illegal agrochemicals. Chemical residues in food mainly results in carcinogenic diseases (43 to 49%), stomach related problems (15 to 19%), eye related problems (10 to 15%), and skin related problems (11 to 14%) and breathing difficulties (10 to 12%). This study demonstrates that there is a problem of agrochemical use and food safety concerns and kale and tomato value chain.***

Keywords--- Commercialization, Agrochemicals, Chemical residues, Producers, Consumers

1. INTRODUCTION

In order to address the escalating food demand, global community need choose whether to expand the current agricultural area to increase total production (extensification) or to concentrate on increasing yields of the existing agricultural land (intensification). On one hand, the former option would result to encroaching and altering of vital ecosystems and injuring of community livelihoods. On the other hand, the later would warrant use of productivity enhancers which would also contribute to alteration of the ecosystem (soil structure, organism diversity among others) and safety concerns. Considering that extensification is highly detrimental over a bigger area and would eventually necessitate up-scaling to intensification over time, the latter has been favored across the world. Intensification in under-yielding nations (especially poor countries) has been further touted for lower environmental effects such as clearing of approximately 0.2 billion ha of land, CO_2-C equivalent greenhouse gas emissions and global N use compared to extensification which would require clearing of ~1 billion ha, ~3 Gt y^{-1} emissions and N use of ~250 Mt y^{-1} (Tilman *et al*., 2011).

Agricultural commercialization presents an opportunity to produce more food for the bulging population, but ethical issues associated with the use of external inputs arise thus contributing to food safety risks (Kenmore *et al*., 2004). Most often in agricultural commercialization, food safety risks arise at the production level due to improper use of external inputs in terms of quantities, formulations, type of agrochemical and time of application, resulting to chemical residues in food (Prabhakar *et al*., 2010). Researchers such as Waltner-Toews and Lang (2000) have attributed food safety risk to the technique in which resources especially substances have been utilized in production as well as distribution of food. In as much as the threat to food security is global, it is more prevalent in the developing countries due to gaps on food safety regulations and enforcement (Unnevehr, 2000). As a result, the World Health Organization (WHO, 2014) estimates 2 million deaths annually in developing world to be caused by diseases resulting from the consumption of unsafe food and water.

Recently, food safety concerns have been on the rise in international trade circles especially with regard to fresh food products such as vegetables. The concerns are interlinked with the effects emanating with the increasing use of agrochemicals commonly referred to as the "cocktail effect" which is the resultant interaction impact of various chemical residues (Mabe *et al*., 2017; Ahoudi *et al*., 2018). As a result of this trend, developed countries have increasingly revised their chemical residue standards thereby introducing stringent regulations for fresh produce exports from developing countries (Okello & Swinton, 2010) and boosted in-country monitoring systems.

In Kenya, use of banned pesticides and misuse agrochemicals have been reported in horticultural production contributing to rejections of fresh produce in export markets due to non-compliance to the set maximum residue levels (MRLs) (Nguetti *et al*., 2018; Okado, 2001). Food safety concerns are higher with the regenerative category of fresh vegetable. After they are harvested, they regenerate again and thereby necessitating use of agrochemicals to boost the development of the regenerating parts, for instance, tomato *(Solanum lycopersicum* L.) as well as kales (*Brassica oleracea* L. var. acephala). The regenerative aspect narrows down the time it takes from spraying to maturity and harvesting (closes down the harvesting-spraying-maturity-harvesting gap) thus increasing the food safety risk associated with continuous application of agrochemicals throughout its life. This category of vegetables is mainly consumed domestically where there is lack of coordinated food safety management system for fresh produce thereby leaving the local consumers' safety at the hands of profit-oriented producers.

A report by European Union (EU) shows that Kenya has been on high alert by officials who are flashing out products rejected by external markets such as Europe due to high residual levels of chemicals and heavy metals consequently unfit for humans and environment (Gitonga *et al.,* 2010). In essence, European Union has put Kenya on notice as being one of the many nations with increased maximum residual levels (MRLs). The report also indicates that a total of 11 domestic exporting firms have remained in the meantime banned for failing to meet these standards (ibid).

Kenya Plant Health Inspectorate Services (KEPHIS) have correspondingly remained active in the fight to make sure that consumers are safe. Despite their efforts, produce which are banned in the external markets are being dumped in the domestic markets where scrutiny and alerts are not as strict. As per the Consumer Federation of Kenya (COFEK), vegetables and fruits in the local markets are worryingly loaded with metals and harmful pesticides (Inonda *et al*., 2015). In other cases, counterfeit pesticides and those rejected in the external market are in use, particularly for products in the domestic market.

With the increasing levels of commercialization and differing production regimes, the export markets are keen on production practices and subject producers to rigorous pre-inspection controls from production, harvesting to post harvest handling in order to guarantee food safety and quality to their target consumers. Unlike the export markets, domestic markets are not keen on what is offloaded in the markets because the local food systems set-up have been keen on complying with export standards whereas food (fresh vegetable) safety for domestic consumers has largely been left at the mercy of profit oriented primary producers (Gitonga *et al.,* 2010). There have also been indications that fresh produce that is rejected for export is diverted into the domestic food supply chains. In addition, the country's consumer welfare watchdog has not been outspoken in order to initiate debate and policy action in relation to agribusiness ethics compliance by fresh food producers (Muriithi & Matz, 2014; Rahman *et al*., 2021).

Majority of farmers either lack the knowledge to safely use agrochemicals or deliberately abuse them towards perceived objectives. Therefore, they do not observe pre-harvest intervals. Some apply excess chemicals than recommended. This has led to rejection of fresh commodities especially for export market. High chemical residue has also led to increased carcinogenic disease incidences on consumers. Scientists have increasingly linked global mortality to consumption of unsafe fruit and vegetable (Trichopoulou *et al*., 2003; Schneider *et al*., 2007; Agudo *et al*., 2007; Nicklett *et al*., 2012). Oyebode *et al*. (2014) established an association among fruit and vegetable consumption as well as cancer and heart illness mortalities.

Tomatoes as well as kales (sukuma wiki) contain higher pesticides residues as they are more heavily treated than other fruits and vegetables (Oyugi, 2013). It is also true that there is no formally laid out mechanism in use for monitoring agrochemicals at the farm level in developing countries as well as the quality of fresh food offloaded to the domestic markets. The major question is, 'is the Kenya vegetable domestic producer keen on agribusiness ethics? Is the consumer safe? In order to answer these fundamental questions, this paper sought to evaluate the impact of vegetable commercialization on agribusiness regulatory compliance and food safety in Kenya.

2. MATERIALS AND METHODS

2.1 Location of the Study

The study was conducted in Kirinyaga, Kiambu and Nairobi counties of Kenya. According to D'Alessandro *et al.* (2019), Kirinyaga County is among the leading producers of fresh tomato in Kenya while Kiambu is a major source of kales (sukuma wiki). Nairobi is the main market for the produce and was, therefore, used for studying consumers.

2.2 Research Design

The study adopted a mixed methods approach comprising of descriptive survey design and experimental design. Mixed methods research allowed for the collection, analyses and integration of both quantitative (experiments, surveys) and qualitative (focus groups, interviews) data. The descriptive design described the state of affairs as it exists at present. Experimentation, on the other hand, provided a procedure for testing the relationship between independent and dependent variables.

2.3 Sampling Procedure and Technique

Select target markets in Nairobi and farms in Kirinyaga and Kiambu were used in the chemical residue study. A random sample was selected from the sampling frame to give each market and farm an equal probability of being selected. Vegetables were randomly purchased from the major vegetable market outlets identified in Nairobi. The target markets were Wakulima as well as major self-service stores in Westlands such as Tuskys, Carry Four, Chandarana and Naivas. Samples for chemical residue estimation and testing from producers were identified during the producer survey.

2.4 Preparation for Chemical Analysis

Each sample was a three replicate of a composite sample gathered through random sampling. All the samples (1 to 2 kg each) were freeze-dried to prevent further physiological change and stored in an ice chess box, to minimize contamination, labeled, and transported to the laboratory for processing and testing. The samples were tested for pesticide and fungicide residues.

2.5 Sample Extraction and Cleanup

The QuEChERS sample preparation method for the analysis of chemical residue was used for all the samples. A10 g ration of the standardized sample was weighed up into a 50 mL polytetrafluoroethylene (PTFE) tube added 10 mL of acetonitrile. Then, 4 g magnesium sulphate ($MgSO_4$), 1 g sodium chloride (NaCl), 1 g sodium citrate tribasic dehydrate ($Na_3C_6H_5O_7.2H_2O$) and 0.5 g sodium citrate dibasic sesquihydrate ($C_6H_5Na_2$ O7.1.5H_2O) was added, then samples were shaken thoroughly for 1 min on a vortex. Samples were centrifuged at 1100 ×g for 5 min. The supernatant (6 mL) was moved to a 15 ml PTFE tube and 900 mg $MgSO_4$, 150 mg PSA (Primary and secondary amine) and 150 mg GCB (Graphitized Carbon Black) were put. The extracts were shaken using a vortex mixer for 30 s then centrifuged at 1100 ×g again for 5 min. Aliquot, 2 mL of the supernatant placed into a graduated test tube and 20 µL of formic acid (HCOOH) were added to adjust the pH. These extracts evaporated to dryness under a stream of nitrogen then reconstructed with 2 mL of hexane : acetone (4:1) and were then transferred to 2 mL vial and sealed for quantification by way of gas chromatograph prepared with mass spectrometry (GC-MS).

2.6 Preparation of Pesticide Standard Solution

The chemicals were procured from Government Chemist (Nairobi, Kenya) where laboratory analysis of the sample was done. Standard solutions of the chemical were prepared by weighing precisely 10 mg of each chemical into 10 mL volumetric hipflask and liquefied with acetone; yielding a concentration of 1mg/ml. mixed solutions of chemical were prepared in 5 µg/mL hexane: acetone (4:1). The standard chemical solutions were prepared at 0.005, 0.1, 0.25, 0.5 and 1.0 µg/mL concentrations by serial dilution method for making the calibration curve.

2.7 Instrumental Method

Chromatographic instrumentation and quantification was done by Gas chromatograph- mass spectrometer GC-MS (Shimadzu QP2010 Ultra) with a GC column HP- 5MS 5% phenyl-95% methyl siloxane, 30 × 0.25 mm id × 0.25 film thickness. The GC conditions: split less injection, injector temperature 250 °C, helium carrier gas (99.9999 purity) at flow rate 1.20 mL min^{-1} with column head pressure 89.4 kpa, oven temperature from 100°C (1 min hold), elevated to 200 °C with a degree of 10 °C (2 min hold) then thereafter raised to 300 °C degree of 10 °C (5 min hold). The MS systems were regularly set-in careful ion monitoring (SIM) mode and each composite remained quantitated as per the peak area by use of one target and one or two qualifier ion.

2.8 Survey, interviews and focused group discussion

Sample size was determined based of on the method adopted Delice (2002). Therefore, a total of 384 households in the three counties (Nairobi, Kirinyaga and Kiambu) were interviewed. Data was collected on the socio-demographic profiles, training, popularity of the agrochemicals used, effect of the agrochemicals used and reasons resulting to the effects.

2.9 Data Analysis

Data were analyzed using SPSS (v20) for frequency distribution, percentage, mean, and standard deviation.

3. RESULTS AND DISCUSSION

3.1 Chemical residues

Results from the farm and traded vegetables indicated the presence of various agrochemicals that were either banned or whose controlled use was flouted. These were permethrin, bifenthrin, Malathion, diazinon, carbofuran, carbaryl, cypermethrin, chlorpyrifos, carbendazim, chlorothalonil, mancozeb, and metalaxyl (Table 1). However, mancozeb and metalaxyl were not present on sampled kales. This could attribute to the fact they these fungicides are not used on kales. Mancozeb and metalaxyl (ridomil) is reported to be used in tomato farming to control early and late blights (Kariathi *et al*., 2016), thus explaining its presence on tomatoes. Previous studies such as Lozowicka *et al*. (2015) detected similar residues, particularly, chlorothalonil, metalaxyl, bifenthrin and endosulfan in tomatoes. Jara & Winter (2019) also observed high levels of organophosphates of vegetables. More than two thirds of tomato samples returned residue levels for alpha, beta sulphate and total endosulfans that exceeded permitted limits at the national customs and the European Union (EU) markets (Ibid). Closer home, a study by Kiwango et al. (2018) in Tanzania detected residues of permethrin, chlorpyrifos and ridomil (metalaxyl and mancozeb) at levels that could compromise the consumer’s health. Inonda *et al*. (2015) also observed that pesticide residues were common on vegetables especially during the hot/dry season and were mainly organophosphates. In all the examples, deviations were blamed on farmers’ spraying pesticides too close to the harvest and the habit of mixing-up pesticides of different kinds into a single spray for convenience. This was also confirmed by the study where not observing preharvest intervals was found to be a major issue.

Table 1. Chemical residues identified in the farm and market on tomatoes and kales

Agrochemical	Type	Group	Tomatoes Farm	Tomatoes Market	Kales Farm	Kales Market
1) Permethrin	Insecticide	Pyrethroid	☑	☑	☑	☑
2) Bifenthrin			☑	☑	☑	☑
3) Cypermethrin			☑	☑	☑	☑
4) Malathion		Organophosphate	☑	☑	☑	☑
5) Diazinon			☑	☑	☑	☑
6) Chlorpyrifos			☑	☑	☑	☑
7) Carbaryl		Carbamate	☑	☑	☑	☑
8) Carbofuran			☑	☑	☑	☑
9) Carbendazim	Fungicide	Benzimidazole	☑	☑	☑	☑
10) Chlorothalonil		Organic	☑	☑	☑	☑
11) Mancozeb		Dithiocarbamate	☑	☑	☒	☒
12) Metalaxyl-M		Acylalanine	☑	☑	☒	☒

3.2 Socio-demographic profiles

The study established that 46.4% of the participants were female while 53.6% of the respondents were male (Table 2). From the interviews, farmers explained that more men than women owned land, capital and other key assets of production including the know-how. This could explain the narrow difference in the participation of women in commercializing vegetables. Other studies in East Africa such as Kiriathi *et al*. (2016) have found more women participating in vegetable commercialization reason being that the men have to go to urban areas to do formal jobs for which women are less equipped. Nonetheless, gender disparity in Kenya is a major problem regarding farming. The study revealed that vegetable farming and commercialization increased with age of the respondents (Table 2). Respondents increased with increase on age. Majority of the respondents (83.9%) were over 33 years, followed by respondents between 28 to 32 years (12.8%) and between 23 to 37 years (3.3%), while none was between 18 to 32 years. Majority (63.8%) of the respondents were married while only 36.2% of the respondents were single. Based on education, 38.9% of the respondents had attained secondary (high school) education level, 26.9% had attained primary education, 26.2% had attained college/university education while only 8% had no education. A lack of education contributes to the abuse of agrochemicals (Kiriathi *et al*., 2016), particularly, overdosing, mixing-up pesticides, repeated applications and spraying close to harvests. An accurate interpretation of pesticide labels (which is often in English) and also outlines personal safety procedures, is untenable without a basic education. Information literacy is therefore is therefore important for greater adoption of best practices leading to food and personal safety. This could have a ripple-effect including but not limited to greater market access, household revenues and more education for farming communities.

Table 2. Socio-demographic profiles of vegetable farmers in the study area (n=384)

		Respondents	
Variable	**Categories**	**n**	**%**
Sex	F	178	46.4
	M	206	53.6
Age	18-22	0	0.0
	23-27	13	3.3
	28-32	49	12.8
	+33	322	83.9
Marital Status	Single	139	36.2
	Married	245	63.8
Education	College/ university	100	26.2
	Secondary	149	38.9
	Primary	103	26.9
	None	32	8.0
Economic Activity	Crop Farmer	337	87.9
	Mixed	47	12.1

3.3 Training

Based on training, majority of respondents in Kirinyaga (33.5%) and Kiambu (35.1%) had not attended any training concerning agrochemical use and food safety. However, in Nairobi County, majority of farmers had attended training on either agrochemical use (29.2%) or food safety (30.2%). The lowest number was that of respondents who had attended both training on agrochemical use and food safety in Nairobi (15.8%), Kirinyaga (15.3%), and Kiambu (10.4%) counties (Figure 1). According to the farmers interviewed, these trainings were organized by dealers of specific agrochemicals as promotions for single products. This could explain why the training was only geared towards single objectives rather than be multi-faceted. Nyamari *et al*. (2014) also reported that training can improve knowledge on matters food safety. The results of this study support the assumption that training on food safety and agrochemical use would help producers and consumers to use best practices to reduce agrochemical residue and food contamination. However, most of the producers of tomatoes and kales are small-scale farmers who are resource limited and may not afford fees to pay for trainings on agrochemical use and food safety and only rely on government support or donors for such trainings. This explains why there was limited trainings on food safety and/or agrochemical use, particularly in Kiambu and Kirinyaga counties.

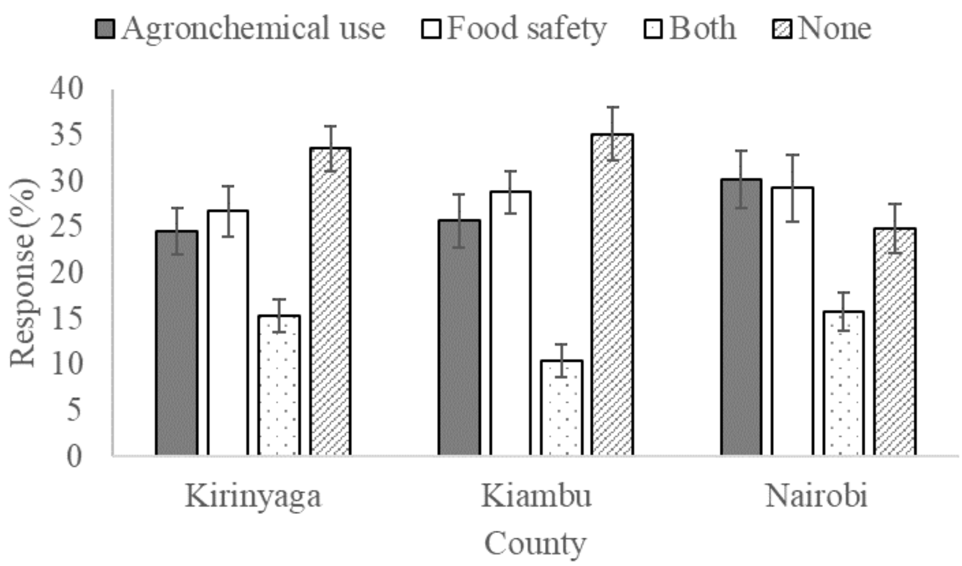

Figure 1. Number of respondents who attended training on agrochemical use and food safety. Bars represent means ± standard deviations.

3.4 Popularity of agrochemicals

Most of the respondents indicated that the agrochemicals were popular for use by farmers (Figure 2). The most common agrochemical was carbofuran (67%) in terms of insecticide. Some respondents also indicated pesticides like diazinon (52%), cypermethrin (50%), carbaryl (48%), bifenthrin (45%), chlorpyrifos (45%), malathion (41%), and permethrin (40%), in the order of popularity. For the case of fungicides, the most common was mancozeb (60%) and metalaxyl (58%). Others also indicated chlorothalonil (43%) and carbendazim (50%). The popularity of pesticides among farmers explained, the popularity of certain pesticides was related to information of successful application from peers, their affordability and their availability within local agro vet shops. The study finds that farmer characteristics crucial to vegetable commercialization were also important in predicting the intensity of agrochemical use and perhaps compromise ethics. Some insecticides like carbofuran is an N-methyl-carbamate insecticide/nematicide that inhibits acetylcholinesterase (AChE) and has been in use for over 40 year's world over as a systemic insecticide to control both soil-dwelling and leaf-eating insects (Gammon *et al*., 2012). In tomato, carbofuran is used to control white flies (*Bemisia tabaci*) a key vector of the dreaded Tomato Yellow Leaf Curl Virus (TYLCV) disease (Anandkumar and Hemalatha, 2018). During treatment, the insecticide is applied as either granules around the base or as a concentrate sprayed onto the leaves (Gammon *et al*., 2012).

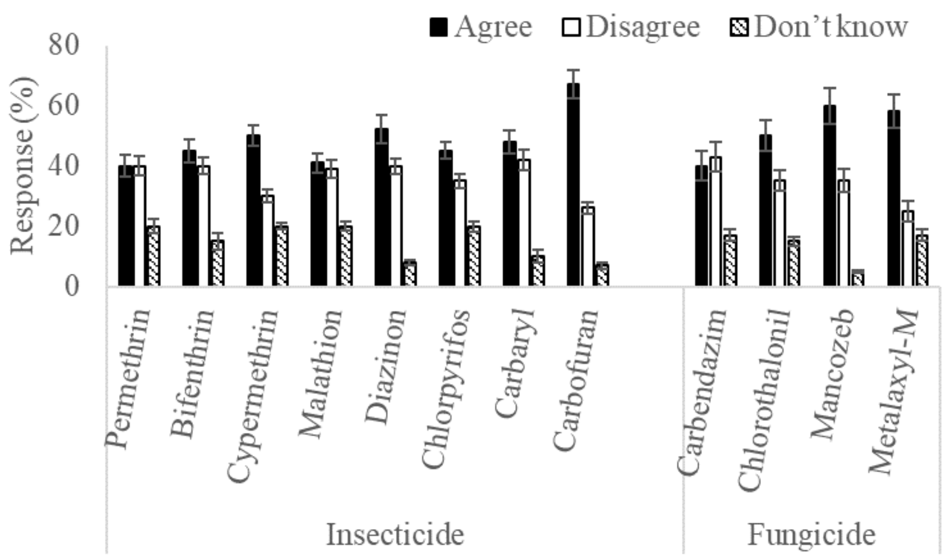

Figure 2. Popularity of agrochemicals among the respondents. Bars represent means ± standard deviations.

3.5 Causes of chemical residues

Based on causes of food toxicity regarding agrochemical use, majority of respondents in Kirinyaga (55%), Nairobi (58%) and Kiambu (65%) reported that food safety is caused by not observing preharvest intervals. Others indicated excessive application of chemicals while some indicated the use of illegal agrochemicals (Figure 3). Farmers in Kiambu and Kirinyaga overdosed pesticides reasoning that by exceeding the prescriptions on the label enhanced efficacy. This sentiment is often due to farmers' over-estimation of pest pressure and impact (Hou & Wu, 2010). Additionally, farmers in Kirinyaga resorted to overdosing permitted pesticides or using banned pesticides such as Malathion to repel wildlife from the nearby Aberdare National Park. This application of pesticides to combat wildlife depredation and crop damage is also widely acknowledged (Njoku *et al*., 2017). Vegetables like kales and tomatoes are also on demand among the consumers. However, in order produce substantial yield, farmers resort to excessive application of pesticides to control various pests in these crops. For effective management of these pests, some farmers go to the extent of using banned agrochemicals like dimethoate available in the black markets (Mutuku *et al*., 2014).

Small-scale farmers often grow tomatoes and kales in hardship or unplanned areas without the requisite advice by extension officers. As a result, farmers are vulnerable to outbreaks of pests, pesticide resistance and poor choice or application of pesticides all of which encouraged them to abuse pesticide application protocols. In their research of the red spider mite (*Tetranychus evansi*) infestation in key tomato growing hotspots in Kenya (Loitoktok, Kibwezi, Athi-River and Subukia), Toroitich *et al*. (2014) demonstrated how initial application of dimethoate on tomato reduced the efficacy of subsequent pesticides including bifenthrin, lambdacyhalothrin, dicofol, propargite and a mixture of profenofos and cypermethrin. In their opinion, prior applications resulted from lack of awareness, carelessness or accidents. However, farmers responded using illegal chemicals or unorthodox mixing and overdosing of available pesticides. Both of these practices were more prevalent among smaller farmers who, unlike their wealthy large-scale counterparts, could afford pest control expertise. Nonetheless, there was other compelling evidence in favour of the correlation that seemed to counter the notion of accidents and carelessness among small farmers. It portrayed large-scale farmers as being heavily pesticide-dependent given the sensitive nature of the crops they farmed and the strict market requirements they responded to (Toroitich *et al*., 2014). Inonda *et al*. (2015) also noted that adherence to recommended preharvest intervals resulted in 99% reduction of the pesticide residues, demonstrating that not observing preharvest intervals is a serious problem in vegetable farmers (kales and French beans).

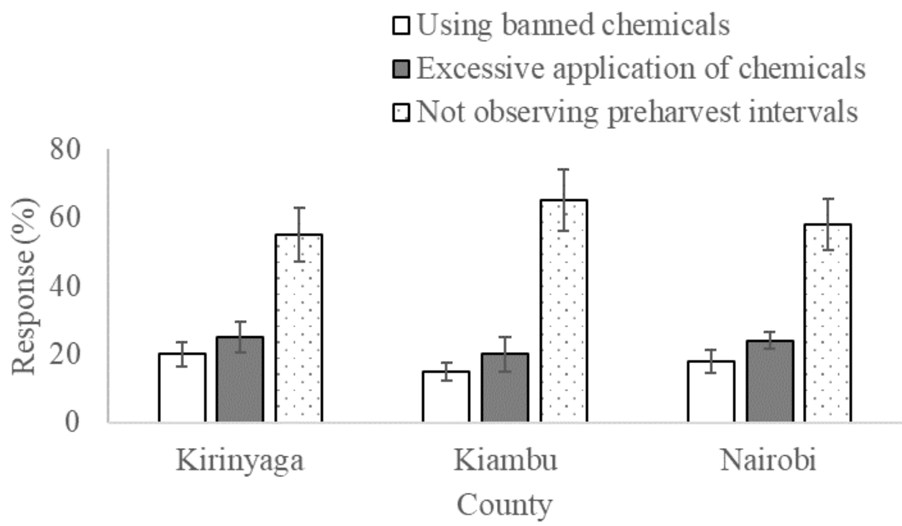

Figure 3. Main causes of chemical residues. Bars represent means ± standard deviations.

3.6 Effects of misuse of agrochemicals

Regarding effect of misuse of agrochemicals, majority of the respondents in Kirinyaga (49%), Nairobi (48%) and Kiambu (43%) reported that it results in carcinogenic diseases. Others reported that it causes stomach related problems (15 to 19%), eye related problems (10 to 15%), and skin related problems (11 to 14%) and breathing difficulties (10 to 12%) (Figure 4). There is, therefore, a heightened sense of awareness along the vegetable value-chains that pesticide contamination is hazardous. Amongst small-scale farmers, as was the case in Kirinyaga, awareness of pesticide misuse was also tied with their overestimation of the impacts of pest-damage. This is not a new finding and had already been documented in China (Hou & Wu, 2010). In human, carbofuran has been shown to be extremely toxic manifesting skin and later on, neurological effects (Ibid). The chemical has been shown to have more profound effects on wildlife, particularly birds, scavengers and predators such as lions and hyenas (Otieno *et al*., 2011). Matter of fact, the chemical drew tremendous publicity in Kenyan media as farmers bordering national parks and game reserves in which farmers applied it in baits targeting predators as retaliation against depredation (Ibid). Mancozeb and metalaxyl were often in use among small-scale farmers growing tomatoes, least among small-scale farmers growing kales. The results agree with those of Fatma, *et al.* (2018) who noted that mancozeb and chlorpyrifos have been proved to be effective in the reproduction in large scale system including and not limited to increasing vegetable production and these pesticides have recorded environmental persistence are highly toxic towards aquatic ecosystem including fish. De Silva *et al.* (2010) add that these pesticides are also toxic to pollinators such as bees and have been associated with reduced bee populations. Statistics on residual levels of mancozeb in Kenya are still limited but grey studies from elsewhere such as Chile (Elgueta *et al.*, 2020) and Uganda (Atuhaire *et al.*, 2017; Kaye *et al.*, 2015) have shown residue levels to be as much as seven times the prescribed levels. Sadly, mancozeb is a known carcinogen in rats and can cause Parkinsons' disease in humans (Ibid). It is assumed that farmers come into greater contact with pesticides during mixing, application and cleaning. However, reports show that ingestion (more prevalent among consumers) far outweighed inhalation and skin contact (more prevalent for farmers) for pesticide intakes in the human body. Gammon *et al*. (2012) observed that dermal exposures to carbofuran took 12 times longer to manifest impacts on brain activity (Acetycholiesterase inhibition) in lab rats compared to ingesting similar quantities.

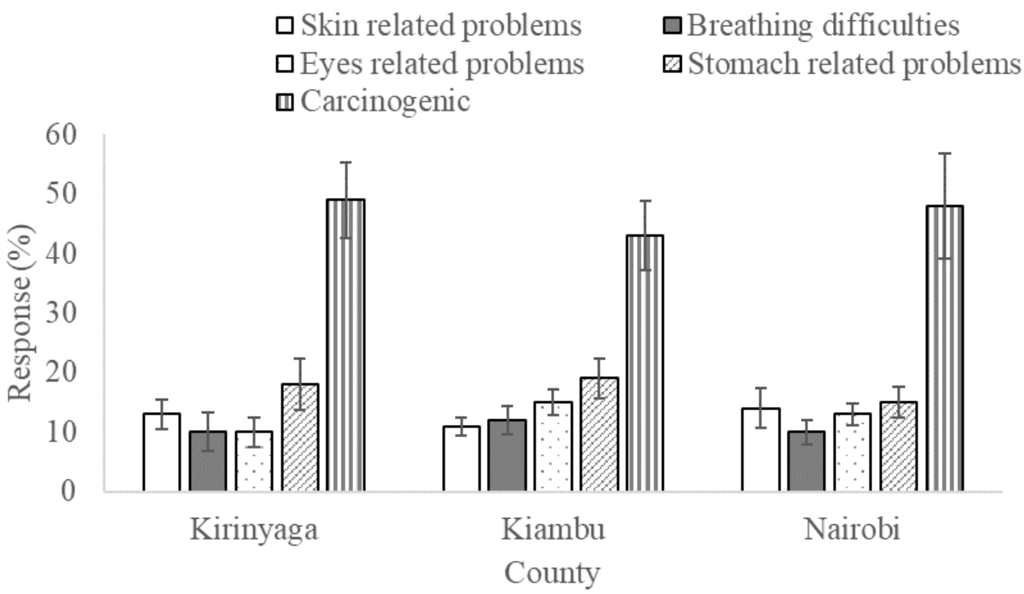

Figure 4. Effect of misuse of agrochemicals. Bars represent means ± standard deviations.

4. CONCLUSION AND RECOMMENDATION

The present study chemical residues are a major problem in kale and tomato value chain in Kiambu, Kirinyaga and Nairobi county, resulting in food safety concerns. The major problems of food safety and agrochemical use were attributed to low levels of education (38.9%) and lack of training (33.1 to 35.1%). The most common agrochemical was carbofuran (67%) in terms and insecticide. For the case of fungicides, the most common was mancozeb (60%) and metalaxyl (58%). Food safety issues are caused by mainly not observing preharvest intervals, excessive application of chemicals and use of illegal agrochemicals. Chemical residues in food mainly results in carcinogenic diseases (43 to 49%), stomach related problems (15 to 19%), eye related problems (10 to 15%), and skin related problems (11 to 14%) and breathing difficulties (10 to 12%). This study demonstrates that there is a problem of agrochemical use and food safety concerns and kale and tomato value chain. Therefore, there is need for the awareness creation and law enforcement on agrochemical use and food safety along the kale and tomato value chain. Further on, the study urges collaborative studies amongst agronomists and wildlife managers in assessing the extent of pesticide use in combating problematic wildlife. Relevant government authorities are encouraged to adopt the use of Swahili in the development and printing of agrochemical labels for easy communication with the farmers and general public, majority of whom do not understand the very technical language currently used.

5. ACKNOWLEDGMENT

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