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RESEARCH ARTICLE

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Analysis of Fluoride in Kales (*Brassicca oleracea*) and Tomatoes (*Lycopersicum esculentum*) from Nakuru County, Kenya

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Abstract

As vegetables normally form an integral portion of human diet, occurrence of high fluoride in their edible portions can cause significant human exposure to these fluoride residues. The present study was carried out to analyze of fluoride in kales (Brassicca oleracea) and tomatoes (Lycopersicum esculentum) from Nakuru County, Kenya and compared these levels with the World Health Organization/Food and Agriculture Organization standards. kales and tomatoes were collected from Nakuru County and analyzed using fluoride ion selective electrode. The fluoride concentration in tomatoes from 7 regions was found to vary from 11.66 to 16.70 mg/kg, while in kales it ranged from 5.63 to 17.33 mg/kg. All were above recommended daily allowances (RDA) level of 4 mg/day which poses health hazard to consumers. High F levels were recorded in tomatoes from all the 7 sub-counties of Nakuru County studied. Gilgil had the highest F levels of 16.70 ± 0.46 mg/kg and Nakuru East recorded low levels of 11.66± 0.50mg/kg in tomatoes from all the 7 sub-counties of Nakuru County. Naivasha had the highest levels of fluoride of 17.33 ± 0.55mg/kg and Molo recorded lower levels of 5.63 ± 0.38mg/kg in kales from all the 7 sub-counties of Nakuru County. ANOVA results indicated significant difference in fluoride levels in Njoro Naivasha, Molo-Gilgil and Molo-Naivasha in both tomatoes and kales. It's apparent from the study that tomatoes and kales were contaminated with high levels of fluoride posing high risks to the health of the consumers.

Keywords: Fluoride, Kales, Tomatoes, Fluorosis

INTRODUCTION

The presence of fluorides in high concentration pose health risks (Dey & Giri, 2016; Blaszczyk *et al.*, 2012; Moturi *et al.*, 2002' Mateus, 2010). High fluoride content affects bones and leads to mottled teeth. Prolonged exposure to high levels of fluoride can lead to dental fluorosis (Moturi *et al.*, 2002; Shomar *et al.*, 2004; Kanyora *et al.*, 2015; Dey & Giri, 2016). Generally, fluoride toxicity depresses thyroid activity and adversely affects the skeletal and bone tissue (Sarkar & Pal, 2015). It has also been implicated in premature ageing of the human body (Janiszewska & Balcerzak, 2013). The dental and skeletal fluorosis is irreversible and no treatment exists. The only remedy is prevention by keeping fluoride intake within the safe limits (Teutli-Sequeira *et al*., 2012 and Sujana *et al.*, 2009).

The highest natural fluoride concentration ever found in water (2,800 mg/L) was recorded in Lake Nakuru in the Rift Valley in Kenya (Nair *et al.*, 1984; IPCS, 2003). Kahama, *et al*., (1997) while analyzing fluorides in cows' milk from the same region recorded fluoride to range from 0.05-0.22 μg/mL, on the other hand Kahama, *et al*., (1997) recorded 7.9-59.3 μg/mL fluorides levels in vegetables. A study done in Njoro division of Nakuru district, Kenya on fluoride levels of water consumed indicated a fluoride mean of 0.5, 2.4, 4.1, 5.5 and 6.6 ppm, rainwater, dams, wells, springs and boreholes respectively (Moturi *et al*., 2002). A study carried out to determine the levels of fluoride in foods indicate that food categories with the highest mean fluoride levels were fish (2.118 mg/kg), beverages (1.148 mg/L), soups (0.606 mg/L) and tea (4.97 mg/L) (Agency for Toxic Substances and Disease Registry 2001).

Kales and tomatoes are the leading vegetable items consumed by large proportions of the population in Kenya and in the Eastern Africa region. It is estimated that 96 % and 82% urban households in Kenya purchase tomatoes and kales, respectively for their every daily consumption (Wiersinga and de Jager, 2007) and in our study area residents of Nakuru County consume kales and tomatoes daily. However, there is general data paucity on fluoride accumulation in other crops and vegetables cultivated in the study area.

The current research was design with a view to contribute to the understanding of the fluoride problem in Kenya by adding to the database for fluoride levels in vegetables and crop grown from farms of in Nakuru County, Kenya. Therefore, this County was selected as study area for conducting the present research because people of this county are not only consuming F-contaminated drinking water but also the crops/vegetables cultivated and irrigated by potentially high fluoride water in their own agricultural fields as food items.

METHODOLOGY

The Area under Study

The study was based in Nakuru County as shown in figure 1. The area is some 167 km north-west of Nairobi the capital city of Kenya and it lies within latitudes 0° 18' 11.1564" S and longitudes 36° 4' 48.0936" E. Nakuru County has an area of 2,325.8 km^2 (KPHC, 2010) with a population of 2,162,202 according to the 2019 Kenya Population and Housing Census (KPHC, 2019).

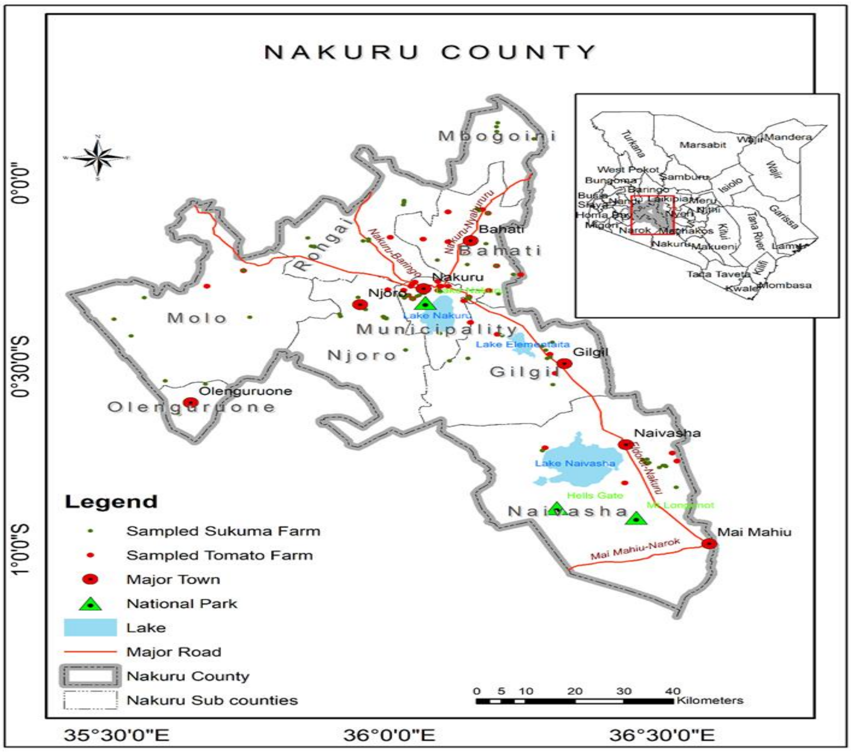

Figure 1: The Map of The Study Area.

The county comprises eight (8) subcounties namely, Njoro, Molo, Naivasha, Nakuru East, Nakuru West, Subukia, Rongai and Gilgil.

Sample Collection

A total of 161 samples consisting 120 kales samples and 41 tomato samples were randomly collected within the study area according to the criteria summarized in Table 1. The samples were collected in a clean *ziplock* polythene bags, they were transported in iced coolboxes and stored frozen at -10^{o}C before drying.

Sample Pretreatment and Preparation

Kales (*sukuma wiki*) and tomato samples were washed in excess distilled water to remove any contaminants on their surface. The samples were chopped and dried to constant weight in an oven at 60 ‒70^{o}C. They were then ground separately using an electric miller to pass through a 150-µm sieve and preserved in khaki bags for further analysis (Okalebo *et al.*, 2002).

Table 1: Kales and Tomatoes Collected from the Study Area for F Analysis

Sampling region	Kales	Tomatoes	Total samples
Njoro	34	3	37
Molo	3	-	4
Naivasha	20	4	24
Nakuru East	11	10	21
Nakuru West	19	11	30
Subukia	6	2	8
Rongai	22	6	28
Gilgil	5	5	10
Total	120	41	162

Analysis of Fluoride in Kales and Tomatoes Samples

Exactly 1.25 g ground kales and tomatoes samples were measured and placed into different digestion tubes. They were then treated with 10 mL of 6 M sodium hydroxide solution and the mixture heated over a water bath at a 100°C for 30 min or until kales and tomatoes sample were completely dissolved in molten alkali. The solutions were allowed to cool to room temperature and then neutralized by carefully adding 8 M sulfuric acid. The solutions were transferred into a 50-mL volumetric flask and the solution made up to 50-mL with double distilled water. The solutions were then mixed with total ionic strength adjustment buffer (TISAB) solution at a ratio of 1:1 to dissociate fluoride complexes, stabilize the pH at 5.5, and maintain a constant ionic strength (Adriano & Doner, 1982). Fluoride content was measured at room temperature using a fluoride ion selective electrode. The sample concentrations of fluoride were found using a standard/calibration curve depicted in figure 2.

CONC	0.1	1	3	5	7	10	20
MV	-277.9	-316.4	-346.4	-356	-367.5	-376.2	-394.6
LOG CONC	-1	0	0.477121	0.69897	0.845098	1	1.30103

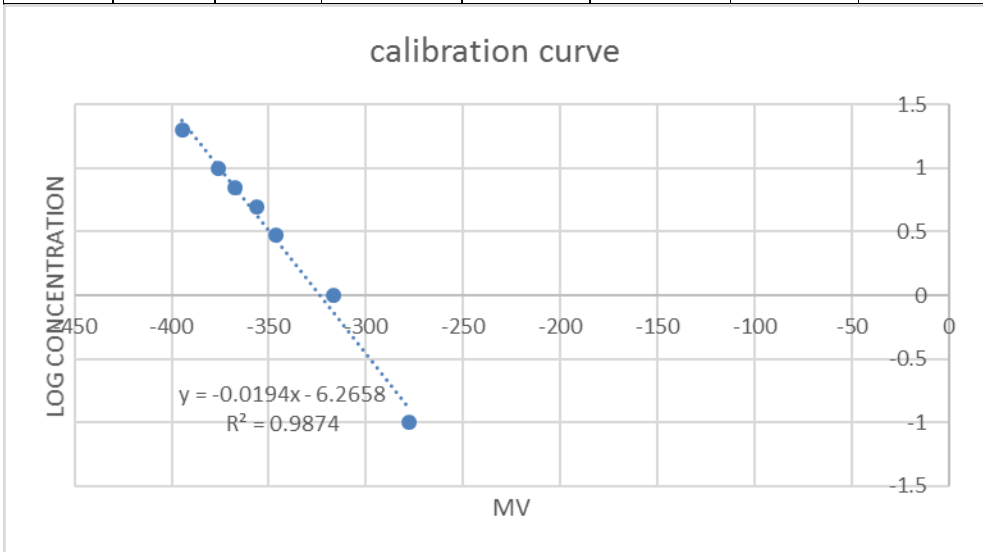

Figure 2: The Calibration Curve.

Statistical Analysis

The mean of the fluoride ions concentrations were calculated for tomatoes and kales samples and presented as mean ± standard error of triplicate measurements. Statistic t (t-test) and ANOVA were used to establish significance difference between and among sampling areas.

RESULTS

Distribution of F Levels in Tomatoes and Kales by Regions

The levels of F in kales and tomatoes collected from different sub-counties in Nakuru County were analyzed and the results presented in Table 2.

Table 2: Mean Concentration of F Levels in Tomatoes and Kales from Different Regions in Nakuru County

Sub-county	Kales		Tomatoes	
	n	Mean F ±S.E (mg/kg)	*n*	Mean F ±S.E (mg/kg)
Njoro	34	13.06 ± 0.33	3	13.39 ±0 .83
Molo	6	5.63 ± 0.38	-	-
Naivasha	20	17.33 ± 0.55	4	15.65±0.45
Nakuru East	11	12.04 ± 0.52	10	11.66± 0.50
Nakuru West	19	12.65 ± 0.49	11	11.72 ±0.53
Subukia	6	12.65 ± 1.24	2	12.97 ± 0.33
Rongai	22	13.33 ± 0.53	6	12.05 ± 0.39
Gilgil	5	16.94 ± 0.53	5	16.70± 0.46
Total	120	13.33 ± 0.29	41	12.94 ± 0.35

The F concentrations in tomatoes from 7 regions were found to vary from 11.66 to 16.70 mg/kg. For the Fluoride concentration ranged from 17.33 to 5.63 mg/kg. Naivasha recorded the highest levels in kales while the lowest concentration was recorded in Molo. For tomatoes, the highest mean F concentration was recorded in Gilgil while the lowest was found in Nakuru West. In all cases, however, the mean F levels in tomatoes and kales exceeded dietary recommended daily allowance (RDA) of 4 mg/day (Dhar & Bhatnagar, 2009).

Comparison of Fluoride Levels in Tomatoes and Kales between Regions

One way Anova and paired t-test was then used to determine if there was a significant difference in F levels in tomatoes and kales across the regions. Results indicated that there was a significant difference in F levels as shown in Table 2.

Table 2: One-way ANOVA to Compare F Levels in Tomatoes and Kales

Kales

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	725.859	7	103.694	23.388	.000
Within Groups	496.565	112	4.434		
Total	1222.425	119			

Tomatoes

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	138.571	6	23.095	10.976	.000
Within Groups	73.644	35	2.104		
Total	212.215	41			

Paired t-test in tomatoes and kales from selected horticultural farms in Nakuru County recorded was ($p < 0.05$) significantly different among eight regions.

Table 3: Paired Samples test-t for Kales and Tomatoes

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
	-.74929	4.60365	.71036	-2.18388	.68531	-1.055	41	.298

DISCUSSION

Fluoride levels in tomatoes and kales from selected horticultural farms in Nakuru County, all were above RDA level of 4 mg/day which poses health hazard to consumers (Al-Hwaiti & Al-Khashman, 2015). Several studies done on F levels in vegetables and fruits have shown that F has a predisposition to accumulate in plants (Gautam *et al.,* 2010; Bhargava & Bhardwaj, 2009; Yadav *et al.,* 2012). Nonetheless, in a study done by Moeinian *et al.* (2016) to determine F levels in soil, tomato and onion from some farms in Zanjan Province of Iranian Azerbaijan, low F levels of just 2.10±0.80 mg/kg were reported in the tomatoes. However, in another study carried out in some villages of India, Bhargava & Bhardwaj (2009) reported mean F concentration in tomatoes (13.48 ± 0.08 mg/kg) that were comparable to those observed in the present study.

High F levels were recorded in tomatoes from all the 7 sub-counties of Nakuru County studied in the present investigation. Gilgil had the highest F levels of 16.70 ± 0.46 mg/kg. This could be attributed to the low rains experienced in these areas, which reduce F solubility and leaching relative to that in the wetter regions. Then, as expected, the F levels in tomatoes from the wetter regions of Rongai (12.05 ± 0.39 mg/kg) and Subukia (12.97 ± 0.33 mg/kg) were lower in comparison to those from Gilgil areas. This was ascribed to greater leaching of fluoride levels in the wetter regions that reduce resident time of labile fluoride in the root zone soils and hence lower its uptake by the plants. Kales (*sukumawiki*) and tomatoes were collected in May, this showed that rainfall amounts strongly control fluoride availability to vegetation (McLaughlin *et al.,* 2000)

Nakuru East (11.66± 0.50 mg/kg) and Nakuru West (11.72 ±0.53 mg/kg), which also lie in close proximity to high-fluoride saline lakes showed lower fluoride levels in their tomatoes than the rest of the sub-counties. However, it was not immediately clear why the studied crops accumulated less F in an area of highest F contamination reported in water sources. It was obvious; however, that F content of agricultural water controlled the crops exposure to excessive F in the environment.

In the current study, high fluoride was recorded in kales from all the sub counties of Nakuru County, Kenya. Naivasha had the highest levels of F with a mean of 17.33 ± 0.55 mg/kg. This could be attributed to domination of these regions by alluvial soils, which have been linked to high fluoride content in nature and low rainfall that reduce solubility of F ions in the environment. Molo, on the other hand, had the lowest with a mean F of 5.63± 0.38 mg/kg, due to nitisol soil type which is deep red and have low F accumulation. Additionally, the rainfall is high solubilizing F ions in the parent rock leaching it away from the root zone.

Paired t-test in the tomatoes from selected horticultural farms in Nakuru County recorded was ($p < 0.05$) significantly different between Njoro and Naivasha, Molo and Gilgil region and between Molo and Naivasha (P=0.050, T=–3.151), (P=0.000, T= -23.329) and (P=0.018, T= -4.768) respectively. Variation of fluoride from one source to another is attributed to the irregular distribution of fluoride bearing minerals in the soils and bedrocks and also anthropogenic sources, such as fertilizers, herbicides and pesticides. Okoo *et al*., 2007 reported same variations in their study areas and they attributed to the nature of soil and human activities such as use of pesticides.

Paired t-test in the kales from selected horticultural farms in Nakuru County recorded was ($p < 0.05$) significantly different between Njoro and Naivasha, Molo and Gilgil region and between Molo and Naivasha (P=0.000, T=-6.745), (P=0.000, T= –14.232) and (P=0.000, T=-10.643) respectively. Variation of fluoride from one source to another is attributed to the irregular distribution of volcanic rock occurring in the rift area of Kenya. Ombaka *et al.,* 2013 reported same variations in their study areas and they attributed to the nature of soil and anthropogenic activities in the area.

CONCLUSION AND RECOMMENDATION

Based on the findings of this study it can be concluded that the tomatoes and kales from Naivasha, Gilgil, Rongai, Subukia, Nakuru West, Nakuru East and Molo are exposed to high levels of fluorides as all samples from these areas had fluoride level exceed RDA of 4mg/day. High levels of fluoride were attributed to fluorotic minerals from the volcanic rocks as Nakuru County lies along the Great Rift Valley. Elevated levels of fluorides in tomatoes and kales pose a high risk to the consumers. Therefore, intake of these foods should be reduced as much as possible. The study recommends that farmers should grow crops with relatively low capacities to enrich fluoride, such as those with seeds or tubers as the main edible parts.

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