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Street Sugar Cane Vendors Practices, Metals and Microbial Levels of Sugar Cane Sold In Kumasi, Ghana

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ABSTRACT

A study which aimed at identifying practices of street sugar cane vendors, heavy metals, and microbial food contaminants which could pose a public health risk concern was done in the Kumasi Metropolis in Ghana**.** Thirty sugar cane vendors were interviewed and representative samples were purchased for analysis. Lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn), manganese (Zn), iron (Fe) were analyzed with AAS. Total coliform, fecal coliform, and E. coli were determined by the standard most probable number method. The sugar cane selling business from the survey is generally dominated by females within the working age group. From the field survey it was realized that packaged sugar cane was patronized mostly in the evening period. Out of the total of 30 vendors, 12 of them just peel the sugar cane and cut into pieces for package and sales while 18 of the vendors washed the product before peeling and cutting it into pieces for packaging. All the metals analyzed were detected in the various samples. The maximum concentration of Pb recorded was 0.193 mg/kg dry weight and the minimum concentration was 0.066 mg/kg dry weight. The estimated mean daily intakes of Pb, Cd, Cu, Zn, Mn and Fe are 1x 10^{-5}, 3 x 10^{-6}, 2.6 x 10^{-4}, 7x 10^{-5}, 1x 10^{-5}, 7x 10^{-5}, 1.7x 10^{-4} mg/kg bw/day respectively. The health risk assessments (HRI) values of the various metals considered in this study were less than 1. This indicates that individuals will not experience any significant health risk if they only consume metals from these sugar cane examined. Microbial results showed at least one of total coliform, faecal coliform and E. coli determined. E. coli was present in 16.7 % of all the samples analyzed.

Keywords*: Sugar Cane, Vendors, Total Coliforms, Faecal Coliforms, Metals*

1. INTRODUCTION

Vending of street food in urban areas is a growing and worldwide phenomenon and street foods have in many studies been associated with microbiological contamination and low hygienic standards (WHO, 2006). Hence, street food vendors are of massive importance for public health since they have influence on the health of thousands of people every day. Sugar cane vending is a common practice in Ghana and other African countries. Mostly, sugar cane is sold as sticks but in the past decade vendors have been peeling the sticks and selling their products in white polyethene bags. This has made the sugar cane vending lucrative, because most working class people patronize the product sold on the street. The possibility of the commodity becoming hazardous to consumers is unknown and could increase significantly if sanitation or hygiene is compromised during the preparation. This study sought to assess the method by which the sugar cane is prepared before sale. This study concentrated on sugar cane vendors in Kumasi, the second largest city in Ghana, West Africa. Several studies from the Ghanaian capital Accra have already confirmed that the street food sector is facing serious challenges in maintaining hygiene and safety of foods (Mensah et al., 1999, Tomlins, 2002). With more than 10,000 street vendors, the rapidly expanding Kumasi is now facing the same challenges. Studies conducted in Kumasi under IWMI have also identified vegetables prepared by street food vendors to be highly contaminated with fecal material and harmful micro-organisms (Amoah et al., 2006) and several related risk practices of food handling have been identified by Henseler et al., (2005).

There is a lot of heavy metals in our environment: cadmium, chromium, iron, lead, copper etc. In small quantities, certain heavy metals are nutritionally essential for a healthy life but they become toxic when they are not metabolized by the body and accumulate in the soft tissues. Most plants species growing in metal- polluted soils are unable to avoid the absorption of these elements (Baker, 1981). Accumulation of heavy metals and metalloids is a subject of increasing concern due to food safety issues and potential health risks. In Ghana, sugar cane is mostly cultivated in wetlands and in areas which are highly polluted with solid and liquid waste. Toxic effects of metals have been widely described. Elements such as nickel, cadmium, chromium and arsenic are considered carcinogenic (Costa, 1998). This study focuses on hygiene and food safety; it is aimed at assessing the hygienic practices of street sugar cane vendors in three different corridors: Amakom to Asafo road corridor, Anloga Junction to Tech Junction road corridor, and Abrepo Junction to Sofoline road corridor all in the Kumasi metropolis using field survey, to determine the total coliform, faecal coliform and E. coli levels on the sugar cane sold by the street vendors interviewed and to determine the concentrations of Cd, Pb, Cu, Zn, Mn, and Fe, in sugar cane bought from vendors.

2. METHODS

2.1. Validation of Analytical Procedure

All glassware used were washed with detergent, rinsed with tap water, soaked in 10% nitric acid overnight and afterward rinsed with distilled water before drying.

All chemicals used were analytical grade. The nitrate salts of Cd, Pb, Cu, Zn, Mn and Fe (bought from Merck Chemicals,

Germany) were used to prepare 1000 mg/l stock solution. Serial dilutions were prepared from this for various elements.

Calibration curve was prepared for various elements using triplicate of serial dilution standard solution. Detection limit was determined with blank solution and spike recovery was performed for the various elements by adding 50 mg of each element to one of the samples and followed the same digestion procedure and determination. The amount recovered was then calculated. Precision of the instrument was determined by running on sample for eight times and calculating the standard deviation.

2.2. Selection of Vendors

Information was first collected from people who usually buy sugar cane packed in white polythene bags to know where they do sell their product followed by a reconnaissance visit in February 2014 to locate sugar cane vendors and enroll them for the project. After the reconnaissance visit, a road corridor was adopted to classify the vendors since the latter were always hawking their products as traffic builds up and were not stationed at bus stations or traffic light points, as was initially assumed.

The three different corridors, i.e., Amakom – Asafo road corridor, Anloga Junction – Tech junction road corridor, and Abrepo junction – Sofoline road corridor – all in the Kumasi Metropolis in Ghana were chosen. Ten sugar cane vendors were identified at the Amakom – Asafo road corridor and were interviewed and their sugar cane bought for analysis. At corridors where the sugar cane sellers were more than ten, random selection of vendors was used to select ten vendors. In all, thirty sugar cane vendors were interviewed and some of their product bought for analysis.

2.3. Collection of sugar cane for analysis

A total of 270 sugar cane packs, packaged in white polythene bags, were bought. Two sets of triplicate sugar cane packs were bought from each sugar cane vendor. There were ten sugar cane vendors selected randomly from three different corridors, Amakom – Asafo road corridor, Anloga Junction – Tech junction road corridor, and Abrepo junction – Sofoline road corridor all in the Kumasi Metropolis. One set of triplicate sugar cane packs was used for the metal analysis while the other was used for the microbial analysis.

2.4. Sample preparation for metal analysis

Samples were chopped into small sizes and dried in an oven at 30^{o} C overnight. The samples were ground in a laboratory mortar.

Digestion of samples was done using the Akagi and Nishimura (1991) procedure, where 0.5 g of dried homogenized samples were weighed into 50 ml digestion tubes. De-ionized water (1 ml) was added, the tubes were swirled to ensure complete wetting of samples, 2 ml (1 + 1 HNO_3 and $HClO_4$) was then added followed by 5 ml of H_2SO_4. The samples were heated at 200 ± 5°C until clear digest was obtained, without covering the flasks and then cooled to room temperature and diluted to 50 ml with de-ionized water. The solutions were transferred into 125 ml brown ember bottles and kept in a freezer at 2°C. The metals were analyzed with PG-990 Flame Atomic Absorption spectrometer (PG Instruments Ltd, UK).

2.5. Sample preparation for microbial analysis

Total coliforms, faecal coliforms and Escherichia coli in the sugar cane samples were enumerated by the standard most probable number method as described in US FDA (1998). Results were expressed as the most probable number per 100 ml (MPN/ 100 g).

2.6. Health Risk Index

The exposure pathway of heavy metals to human through ingestion of contaminated food has been studied by many researchers (Copat et al., 2012; Xue et al., 2012). The estimated daily intake (EDI) of each heavy metal in this exposure pathway was determined by the equation:

$$EDI = (E_F \times E_D F_{IR} \times C_f \times C_m)/ (W_{AB} \times T_A)$$

Where E_F is the exposure frequency (365 days/year); E_D is the exposure duration, equivalent to average lifetime (64 years for Ghanaian population); F_{IR} is the fresh food ingestion rate (g/person/day), which was considered to be 48 g/person/day; C_f is conversion factor (0.208) for fresh weight (F_W) to dry weight (D_W), C_m is the heavy metal concentration in foodstuffs (mg/kg F_W); W_{AB} is the average body weight (average adult body weight was considered to be 75 kg); and T_A is the average exposure time for non-carcinogens (equal to E_F x E_D) (Saha and Zeman, 2012).

Health risk of consumers due to intake of metal contaminated sugar cane was assessed by using Health Risk Index (HRI). A HRI less than 1 means the exposed population is unlikely to experience obvious adverse effects; whereas a HRI above 1 means that there is a chance of non- carcinogens effects, with an increasing probability as the value increases. The HRI was calculated by using the equation below (Wang et al., 2005). HRI = EDI/ R_fD. Where the reference oral doses (R_fD) for Pb, Cd, Cu, Zn, Fe and Mn are 3.5 x10^{-3}, 1.0 x10^{-3}, 4.0 x10^{-2}, 3.0 x10^{-1}, 7.0x10^{-1} and 1.4 x10^{-1} mg/kg/day respectively (USEPA, 2009).

2.7. Statistical analysis

Field survey, means and standard deviations of metal and microbial data were computed using Statsgraphics Centurion XV, 2005 Version 15 statistical software (Statpoint. Inc, USA) and Microsoft Office Excel 2013 (Version 15, Microsoft, USA).

3. RESULTS AND DISCUSSION

3.1. Survey Dissertate

From the survey, the sugar cane selling business is generally dominated by females within the working age group. Out of the total of 30 vendors, 25 of them constitute females while only 5 constitute males. Also, 70% (21 vendors) fall within the

working age group and 30% (9 vendors) fall below the working age group.

The study tried to identify the relationship between seller's level of educational attainment and reason for choice of packaging material. Nine (9) out of the 13 JHS leavers interviewed preferred their packaging material because of its attractiveness, while 3 selected their packaging material because the material was cheaper compared to other materials. The study also revealed that vendors with primary school education selected their packaging material largely based on the cost of the material.

From the field survey, it was realized that packaged sugar cane is patronized mostly in the evening period, on the road corridors surveyed, vendors along the Abrepo junction corridor reported that their wares (packaged sugar cane) were patronized in the afternoons. This finding was different from the other road corridors where the product was patronized mostly in the evening periods. The situation on the Abrepo junction corridor was due to the traffic jam along the corridor – mostly in the afternoons – thus creating the opportunity for the vendors to transact business. The situation was different on the other road corridors studied as traffic was more congested in the evenings which could have paved way for the vendors to do their business.

Preparation and packaging of sugar canes produce a lot of waste. The research also looked at the mode by which these waste materials are disposed. Unhealthy waste disposal methods may lead to contamination of the packaged sugar cane. Twenty (20) out of the 30 respondents dispose waste associated with preparation into refuse bins. Disposal of waste into refuse bins, though perceived a safe mode of waste disposal, may lead to contaminations and environmental health problems due to the lackadaisical attitude of city authorities in ensuring that the bins are emptied when they get filled up. Five out of the thirty respondents leave their waste products on the farms, 2 of the respondents leave their waste products in the open, a practice which is highly unhygienic, 2 other respondents burn their waste in the open.

This study also assessed the method by which the sugar cane was prepared before being sold to customers and to ascertain whether the method is hygienic or not. Out of the total of 30 vendors, 12 of them just peel the sugar cane and cut into pieces for package and sales while 18 of the vendors washed the product before peeling and cutting it into pieces for packaging and sales. Although 60% (18 vendors) wash the sugar cane before cutting, the water quality is questionable. The water could be contaminated with microbes. It is less likely that vendors use high quality treated water to wash the sugar cane, due to water scarcity. Twelve (12) vendors, constituting 40%, do not wash the sugar cane before peeling and cutting it into pieces for packaging. This unhygienic method may serve as a threat to the health of customers who buy the product. The study further looked at how vendors displayed their wares (packaged sugar cane) to the public, after preparation of sugar cane, since the means of display also determines their exposure to contamination. Four (4) of the sellers display their wares in basket, covered with lace; 8 display their wares in a flat pan with a lace covering it, 18 (60%) display their wares in a basket without covering, thus exposing their wares to houseflies and air-borne pathogens.

3.2. Metal Levels Dissertate

The procedures taken to ensure the validity of the metal analysis data in this study have been described in the method section above. The recoveries, regression co-efficiencies and detection limits of the elements are presented in table 1 below.

Table 1: Recoveries, regression co-efficiencies and detection limits of elements

Element	Detection limits (mg/l)	Recovery (%)	Regression coefficient (R^2)
Pb	0.001	97	99
Cd	0.002	95	98
Cu	0.003	98	99
Fe	0.006	96	99
Zn	0.005	95	97
Mn	0.002	99	99

The recoveries of the obtained in this study ranging from 95 % to 99 % were with the acceptable limits of 95% to 100.4%.

The results for heavy metal concentrations in sugar cane samples from Kumasi metropolis are presented in table 2 below. All the six metals analyzed were detected in the various samples.

The maximum concentration of Pb recorded in all the sugar cane samples was 0.193 mg/kg dry weight and the minimum concentration was 0.066 mg/kg dry weight. The average concentration was 0.10±0.032 mg/kg. The Maximum Tolerable Limit (MTL) of Pb in food is 0.3 mg/kg (EU, 2006). The concentrations of Pb in all the samples were below the EU MTL for Pb. Segura-Muñoz et al., (2006) reported higher Pb levels ranging from 1.76 to 2.28 mg/kg dry weight in sugar cane collected from area under direct influence of municipal landfill site and medical waste treatment system of Ribeirao Petro, Brazil.

The maximum concentration of Cd reported in all the sugar cane samples was 0.041 mg/kg dry weight and the minimum concentration was 0.012 mg/kg dry weight with a mean value of 0.02± 0.007 mg/kg dry weight. The concentration of Cd in the sugar cane samples were below the MTL of 0.05 set by EU (EU, 2006). Segura-Muñoz et al., (2006) reported higher Cd mean value of 0.034±0.02 mg/kg dry weight for sugar cane samples from Ribeirao, Brazil.

The Cu concentration in all the sugar cane samples fluctuated between 0.006 mg/kg dry weight and 0.192 mg/kg dry weight with mean value of 0.49±0.599 mg/kg dry weight. The Cu levels found in this samples were far below EU MTL of 20 mg/kg (EU, 2006). Segura-Muñoz et al., (2006) reported higher values of Cu ranging from 22.2 to 45.7 mg/kg dry weight.

The maximum concentration of Mn in all the sugar cane samples was 1.42 mg/kg dry weight and the minimum level was 0.06 mg/kg dry weight. These are far lower than the range 148.8 mg/kg to 232.5 mg/kg dry weight reported by Segura-Muñoz et al., (2006). The average Mn concentration in all the samples was 0.50±0.362 mg/kg dry weight.

Table 2: Results for Heavy Metal Levels in Sugar cane samples from Kumasi metropolis

Sample Corridor	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)
All Corridors	0.066-0.193 (0.1±0.032)	0.012-0.041 (0.02±0.007)	0.006- 1.92 (0.49±0.599)	0.23-1.92 (1.29±0.465)	0.006-0.149 (0.050±0.045)	0.06- 1.42 (0.50±0.362)
Amakom to Asafo	0.069-0.176 (0.12±0.03)	0.012-0.019 (0.015±0.002)	0.008- 0.33 (0.05±0.099)	0.23-1.82 (1.071±0.573)	0.021-0.149 (0.093±0.037)	0.18- 0.85 (0.436±0.179)
Anloga to Tech J.	0.066-0.193 0.093±0.037)	0.013 –0.034 (0.019±0.007)	0.006-1.92 (1.052±0.748)	0.87-1.92 (1.27±0.375)	0.008-0.113 (0.039±0.04)	0.06-0.441 (0.329±0.115)
Abrepo to Sofoline	0.066- 0.121 (0.084±0.017)	0.012-0.041 (0.017±0.009)	0.23-0.5 (0.36±0.083)	1.06-1.92 (1.525±0.34)	0.006-0.028 (0.018±0.008)	0.18-1.42 (0.72 ±0.53)
(EU, 2006)	0.300	0.050	20	1.000	1.000	

3.3. Health Risk Index

The estimated mean daily intakes of Pb, Cd, Cu, Zn, Mn and Fe are 1x 10^{-5}, 3 x 10^{-6}, 2.6 x 10^{-4}, 7x 10^{-5}, 1x 10^{-5}, 7x 10^{-5}, 1.7x 10^{-4} mg/kg bw/day respectively. The individual EDI's were far below RfD values recommended by the international regulatory bodies (USEPA, 2009). The RfD represents an estimation of the daily exposure of a contaminant to which the human population may be continually exposed over a lifetime without an appreciable risk of harmful effects. The concentrations of heavy metals found in the sugar cane were below the EU MTL and also below the RfD set by USEPA. The levels found in the sugar cane do not pose any risk to human health since the health risk assessments (HRI) value of the various metals considered in this study were less than 1. This indicate that individuals will not experience any significant health risk if they only consume metals from this sugar cane examined. The HRI values for Pb, Cd, Cu, Zn, Mn and Fe are 3.8x 10^{-3}, 3x 10^{-3}, 2x 10^{-3}, 2x 10^{-5}, 5x 10^{-4}, 2x 10^{-4}, 3.8x 10^{-3} respectively. Among the heavy metals examined in this study, Pb with HRI value of 3.8x 10^{-3} would have a relatively higher potential health risk whiles Zn (HRI value of 2x 10^{-5}) has the lowest potential risk.

3.4. Microbial Dissertate

The samples were analyzed quantitatively for total and faecal coliform (Most Probable Number method) using standard procedures (APHA, 1989). Faecal and total coliform populations were normalized by log transformation. The International Commission on Microbiological Specification for Food (ICMSF) recommended that levels of Fecal coliform on food should not exceed 3 (log MPN/100g) for fresh weight (ICMSF, 1986). Table 3 presents the range, mean ± standard deviation, percentage detection (number of samples detected positive) of total coliform, faecal coliform and E. coli in the sugar cane samples. The samples which tested negative were represented as zero (0). The standard deviation and mean values were calculated with samples which tested positive. Where only one sample tested positive, the value was written in place of the mean ± standard deviation. The study revealed that, 76.7 % of all the sugar cane samples purchased had total coliform, total coliform populations (in log MPN/100g) range from 0.0 to 7.90 with mean value of 6.6 ± 0.7. The faecal coliform populations fluctuated between 0.00 and 6.20 with mean value of 5.5±0.8. Faecal coliform was identified in 60% of all the samples analyzed. However, the average fecal coliform level is still higher than the International Commission on Microbiological Specification for Food- (ICMSF 1986) recommended levels of 3 (log MPN/100g) or 1 x 10^3 100 g-1 fresh weight. E.coli population (in log MPN/100g) in all the samples range from 0.00 to 2.20 with 16.7 % of all the samples tested positive. Ready-to-eat foods are considered to be still of 'acceptable' quality in England if they contain <100 E. coli per gram wet weight (i.e., <10^4 per 100 g) or 4(log MPN/100g) (Gilbert et al. 2000). This guideline value is used in many other countries, including Australia, Canada and New Zealand. The E. coli values observed in this study could be considered as acceptable using this guideline.

Table 3: Results of Total coliform, faecal coliform And E. coli in sugar cane sample from Kumasi metropolis

Sample Corridor	Total coliform (log CFU/100g)	Faecal coliform (log CFU/100g)	E. coli (log CFU/100g)
All corridors	0.00-7.90 (6.6±0.7) 76.7% (23)	0.00-6.20 (5.5±0.8) 60% (18)	0.00-2.20 (1.4±0.5) 16.7% (5)
Amakom - Asafo	0.00-7.90(6.3±0.8) 90% (9)	0.00-5.60(4.9±0.8) 70% (7)	0.00-2.20(1.6±0.6) 30% (3)
Anloga - Tech	0.00-7.30(6.7±0.5) 50% (5)	0.00-6.20(5.7±0.4) 50% (5)	0.00-1.20(1.20) 10% (1)
Abrepo - Sofoline	0.00-7.90(6.8±0.7) 90% (9)	0.00-6.20(6.0±0.3) 60% (6)	0.00-1.00(1.0) 10% (1)

4. CONCLUSION

From the field survey, it was realized that packaged sugar cane was patronized mostly in the evening period. Out of a total of 30 vendors, 12 simply peel the sugar cane and cut it into pieces for package and sales while 18 washed the product before peeling and cutting it into pieces for packaging. All the metals analyzed were detected in the various samples. The maximum concentration of Pb recorded was 0.19 mg/kg and the minimum concentration was 0.07 mg/kg. The estimated mean daily intakes of Pb, Cd, Cu, Zn, Mn and Fe are $1x\ 10^{-5}$, $3 x\ 10^{-6}$, $2.6 x\ 10^{-4}$, $7x\ 10^{-5}$, $1x\ 10^{-5}$, $7x\ 10^{-5}$, $1.7x\ 10^{-4}$ mg/kg bw/day respectively. The health risk assessments (HRI) values of the various metals considered in this study were less than 1. This indicate that individuals will not experience any significant health risk if they only consume metals from these sugar cane examined. Microbial results showed at least one of total coliform, faecal coliform and E. coli determined. E. coli was present in 16.7% of all the samples analyzed.

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