Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.16, No.1, 2025

Heavy metals and Microbial Quality of *Zoom-Koom* sold in Tamale's Central Business District

Enock Boadu Dadson[1], Matthew Nkoom[2*]
1. Department of Environment and Sustainability Sciences, Faculty of Natural Resources and Environment, University for Development Studies Tamale Ghana
2. School of Built Environment, University of Environment and Sustainable Development, PMB, Somanya, Ghana
*Email of the corresponding author: mnkoom@uesd.edu.gh

Abstract
Food safety issues continue to be prevalent worldwide and pose ongoing challenges for both the public and governmental authorities. *Zoom-Koom* is a nourishing ready-to-eat drink eaten by various families in Ghana, especially in the northern region**.** The study examines heavy metal levels as well as microbial quality in *Zoom-Koom* sold in Tamale's Central Business District. Pb, Fe, and Zn concentrations were below the regulatory bodies' permitted level. Also, the study found a high level of *Salmonella* spp., which implies a high level of poor personal hygienic practices and inappropriate washing of raw materials used in the preparation of *Zoom-Koom*. All of the *Zoom- Koom* samples that tested positive with *Salmonella* spp. are deemed unfit for human consumption. It is advised that the Food and Drugs Authority should ensure rigorous adherence to food quality standards in the Central Business District of Tamale.
Keywords: *Zoom-Koom,* Lead, Iron, Zinc, *Salmonella* spp.
DOI: 10.7176/JNSR/16-1-06
Publication date: May 30th 2025

1. Introduction

All organisms need food for the sustenance of life and its associated functions, such as growth, development, and body composition (Kok, 2014). The multimillion dollar street food selling business offers urban residents quick, inexpensive meals. In many developing country cities and towns, the street food business is crucial in providing majority of the population with a wide range of reasonably priced, easily accessible foods that meet their daily nutritional needs (Tambekar *et al.*, 2008). These are prepared, ready-to-eat foods and drinks that are sold by hawkers and vendors, usually on the streets near marketplaces and other public areas (Umoh and Odoba, 1999).
In Ghana, food sold on the side of the road not only helps with the problem of feeding the urban population, but also plays a key role in employment, household income, and food security, all of which have a big impact on the country's economy. Food production is a multi-stage, highly complicated process that can expose food to several types of contamination. Thus, preventing contamination during the production process is always essential (Sargeant *et al.*, 2006).
In Ghana, *Zoom-Koom* is a famous drink (TAPSOBA *et al.*, 2017). The popularity of the *Zoom-Koom* drink has recently skyrocketed in Ghana. Although beverages are occasionally produced by homes to be given as desserts, they are frequently used as traditional treatments since they are thought to have medicinal properties (Guardiola and Mach, 2014). Due to the current increase in demand for these local beverages, the production and sale of *Zoom-Koom* has become a growing and profitable venture that is being pursued by several individuals. The production processes of sidewalk drinks and snacks, such as *Zoom-Koom*, are controlled by the interaction of individuals that do not adhere to appropriate hygienic norms, making them susceptible to contamination by pathogenic bacteria(Akinbode, Dipeolu and Okuneye, 2011). Ingestion of contaminated food, drink, or water spreads foodborne diseases. These include contaminants such as *Escherichia coli,* total coliform, *Salmonella* spp., and heavy metals.
Salmonella spp. are key zoonotic bacterial pathogens responsible for global foodborne illnesses and deaths linked to the intake of contaminated food products (Abebe, Gugsa and Ahmed, 2020). Numerous countries have reported food products tainted with these human pathogens, with *Salmonella* spp. and being the most prevalent (Omemu *et al.*, 2006; Duhain, 2011). The presence of *Salmonella* spp. in food typically signals fecal contamination from either polluted water or cross-contamination during preparation. Therefore, research on the contamination of *Zoom-Koom* with *Salmonella* spp. is crucial, given the limited data in the study area and the increasing popularity of the drink.
Trace metals in our local beverages are likely due to metals bioaccumulating in the plants used in the manufacturing process. Heavy metals in food are often the product of contamination from industry and the

environment (Nnorom, Osibanjo and Ogugua, 2007). Heavy metals can be present in drinking water and the purification of ingredients used in beverage preparation. Plant products are often used as active ingredients in beverage manufacturing. Contaminated food and the use of soiled equipment also introduce heavy metals into the human body.

In Ghana, metallic machines, also known as "Nika Nika," are a particular commodity produced by small-scale foundries (Andrews and Gikunoo, 2011). Since they are relatively inexpensive and readily available, numerous factory drivers chose disk plates made in their own country (Kwofie, Andrews and Mensah, 2011). Metal disk drives with an equally hard surface made of ridges are employed inside the workshop, which is housed in a round chamber. The friction force, which is created by applying compression and shear forces, allows the grains to be ground. Pollution of milling process grains with heavy metals has been linked to the drainage of metals such as iron (Fe), lead (Pd), and zinc (Zn) from the mechanical disk into the wheat produced during the end milling. The aims of this study were to: (1) quantify the levels of lead (Pb), Iron (Fe), Zinc (Zn) in *Zoom-Koom* sold in Tamale metropolis, (2) assess the microbial loads of *E. coli* and Salmonella in *Zoom-Koom* sold in Tamale metropolis.

2. Materials and Methods

2.1 Study Area

The research was conducted in the central area of Tamale, the capital of Ghana's Northern Region. Located between latitudes 9° 15′ N and 9° 05′ N and longitudes 0° 45′ W and 1° 0′ W, Tamale sits at an altitude of 185 meters above sea level. With 537,986 inhabitants, it is the third most populated city in Ghana (Ghana Statistical Service, 2010). Tamale is a city that is expanding quickly, and many people move there in search of commercial possibilities (Abankwa *et al.*, 2009) . Both local and foreign communities call it home.

2.2 Sample collection, preparation and analysis

The *Zoom-Koom* samples were collected using the cluster random sampling technique. Five zones were established within Tamale's central business district. The Transport Yard, Nyohini, and the Timber Market are located in Zone 1, whilst Zobgeli, Aboabo, and Sabonjida are located in Zone 2. Changli, Taxi Rank, and Bus Stop were the localities that comprised Zone 3, while Moshie, Zongo, and Tishigu comprised Zone 4. Gumbihini, Parks & Gardens, and the Metropolis's environs are included in Zone 5.

Twenty-five (25) sample drinks (*Zoom-Koom*) were purchased from different vendors each day (five from each zone) for three days from the central business area. The samples were stored on ice cubes in an ice chest before being transported to a laboratory for analysis. In Folin-Wu tubes, 1–5 mL of the liquid and drink samples were digested with 3 mL concentrated HNO_3 for 1 hour at 145 °C in an electrically heated block. After that, 4 mL of $HClO_4$ was added, and the mixture was heated for one more hour to 240 °C. After diluting the substance with 100 milliliters of deionized water, it was corked. The content of heavy metals in the samples was measured using Flame Atomic Absorption Spectroscopy (FAAS).

The American Public Health Association's (APHA)(2008) standard protocols for analysis were followed for performing the microbiological analysis. Salmonella species and *E. coli* were counted from the samples using a three-fold serial dilution. *Salmonella* spp. and Escherichia coli were detected using Salmonella-Shigalla (SS) agar and Hi-crome, respectively. The material was plated in Hi-chrome and incubated for 18 to 24 hours at 37±2 °C in order to detect *Escherichia coli*. colonies were counted. In the aftermath of priming a membrane filter with 10 ml of sample dissolved in water, 10 ml of the supernatant was filtered for the detection of Salmonella spp. The inner edges of the funnel were rinsed with an additional 5 milliliters of the sample dissolved in water. Using sterile forceps, the membrane filter was subsequently placed into Salmonella Shigalla agar to detect the target microorganisms.

2.3 Statistical analysis

SPSS Statistics 24.0 software was utilized to carry out the statistical analysis. Data were expressed as the mean ± standard deviation of three replicates. The significant differences between the Zones were assessed using one-way analysis of variance (ANOVA) as well as Tukey's post hoc tests. All differences were deemed significant at $p < 0.05$.

3. Results and Discussions

Heavy metals are regarded among the most important environmental components of food poisoning due to their ability to persist, accumulate, and become toxic to living organisms through the intake (Díez *et al.*, 2009). Concentration of Pb varied between 0.0375 to 0.0517mg/L with an average of 0.0458±0.0074 mg/L in zone 1, 0.0137 to 0.0497 mg/L with an average of 0.0340 ± 0.00184 mg/L in zone 2, 0.0225 to 0.0537 mg/L with an average 0.0397±0.0158 mg/L in zone 3, 0.0297 to 0.0401 mg/L with an average of 0.0336 ± 0.0056 mg/L in zone 4, and 0.0229 to 0.0402 mg/L with an average of 0.0325± 0.0088 mg/L in zone 5, respectively.

The levels of Pb in *zoom-koom* obtained herein were lower than the allowable limit established by the FAO and WHO (2011). The Pb concentration found in this study was higher than that found in an Iraqi investigation in milled wheat (Jawad and Allafaji, 2012). When compared to the values found in this investigation, samples from another study on the Pb content of milled maize had higher Pb contents (0.210 ± 0.15 mg/kg) (Adeti, 2015). Another study conducted in Tolon district, Northern Ghana also reported higher concentration of Pb in milled maize as well as millet (Larsen *et al.*, 2020). Likewise, Asdeo (2014) reported higher concentration of Pb in wheat and millet. These result can be partly attributed to the metal leaching incident during the milling process when the two metallic disks in the corn mill come into contact. Again, the elevated levels of Pb observed by previous researchers can be attributed to soil contamination resulting from continuous tillage (Agbenin, 2002), as well as other potential sources of heavy metal pollution, including effluents from industrial activities (Olu *et al.*, 2013) consistent with our study.

Even just a lower rate of Pb found in *Zoom-Koom* herein raises environmental concerns. Because, Pb has been identified as a pervasive, bio-accumulative, and poisonous compound on the USEPA's prime concern record of pollutants (Check and Marteel-Parrish, 2013). It's important to remember that regularly consuming *Zoom-Koom* could lead to greater contamination. Whenever Pb accesses a living organism's tissues, it can accumulate, causing adverse impacts. Continuous exposure to Pb in some animals and humans gave rise to cancer of the bladder, lungs as well as stomach in certain living creatures. Again, continuous exposure to Pb resulted in higher brain and heart difficulties, anemia as well as reproductive defects, and other health problems in some animals and humans as reported in previous studies (Rehman *et al.*, 2018).

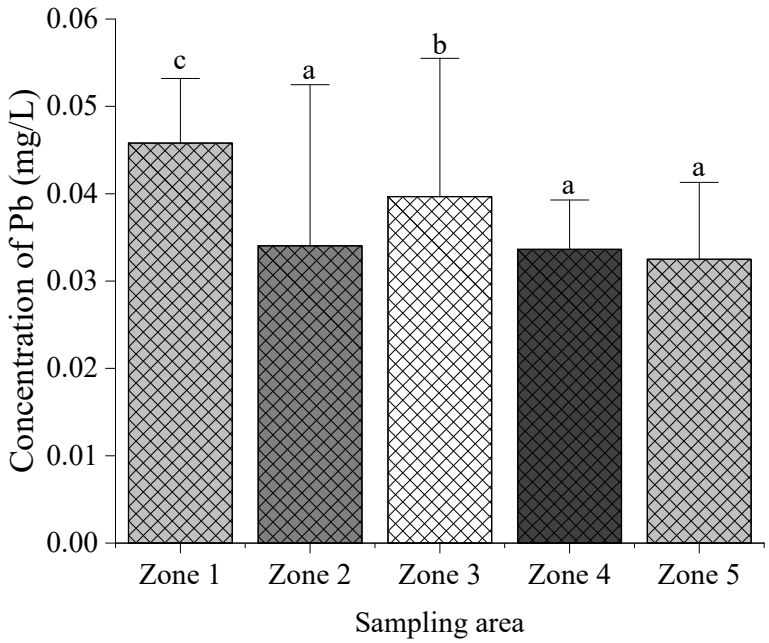

Figure 2: Concentration of Pb (mean ± standard deviation of 3 replicates) determined in *Zoom- Koom* sold in Central Business area in Tamale metropolis. Significant differences ($p < 0.05$) across zones are shown by different letters.

The concentration with respect to Fe ranged from 2.0000 to 4.3000 mg/L with an average of 3.1900±1.1521 mg/L in zone 1, 1.3800 to 4.7000 mg/L with an average of 3.3233 ± 1.7310mg/L in zone 2, 1.0200 to 7.4000 mg/L with an average of 3.5066 ± 3.4147 mg/L in zone 3, 1.1000 to 1.9000 mg/L in zone 4, and 1.9000 to 7.7500 mg/L with an average of 4.1600 ±3.1436 mg/L in zone 5, respectively. The average level of Fe was the highest among the average levels of Pb and Zn. The Fe, levels were below the FAO and WHO, (2011) permitted limits. The findings of Fe obtained herein agrees with the findings of a previous researchers. In their study, they claimed that Fe predominated in milled meals and that the metallic composition of a sintering furnace was a key factor to the contamination rates. According to their findings, the mill introduces higher concentrations of contaminants into the food. The increased Fe level might be attributable to the milling surfaces' degree of wearing which is consistent with our study (Oniya *et al.*, 2018). Also, previous researchers in Ghana reported

increased concentrations of Fe in milled maize samples as well as in milled millet samples relative to the control sample's comparable amounts. The metals leaching from the milling plates' friction was the reason given by the researchers for this phenomena (Larsen *et al.*, 2020). This is supported by a study by Kalagbor et al. (2017), which found that compared to the control samples, milled maize had greater amounts of iron (Fe). Additionally, according to a study conducted in Nigeria by Israila and Halima (2016), milled maize samples had higher iron levels than control samples.

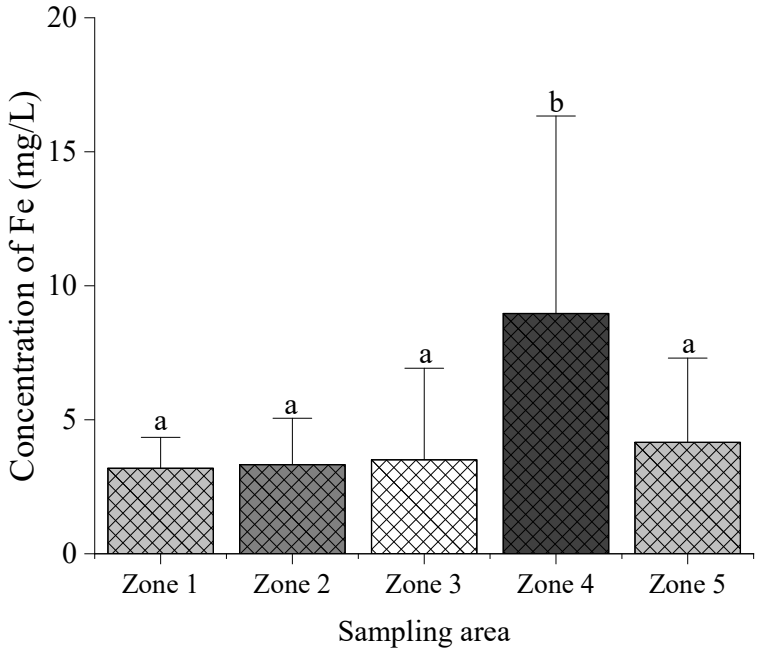

Figure 3: Concentration of Fe (mean ± standard deviation of 3 replicates) determined in *Zoom- Koom* sold in Central Business area in Tamale metropolis. Significant differences ($p < 0.05$) across zones are shown by different letters.

Zn concentration ranged from 3.4000 - 13.4000 mg/L with an average of 8.0333±5.0401 mg/L in zone 1, 2.0400 to 2.8000 with an average of 2.4133±0.3802 mg/L in zone 2, 1.5000 to 1.9000mg/L with an average of 2.7667±1.8583 mg/L in zone 3, 1.1000 to 1.9000 mg/L with an average of 0.2133±0.4619 mg/L in zone 4, and 1.8000 to 4.1000mg/L with an average of 2.9000 ±1.1533mg/L in zone 5, respectively. The average concentration of Zn obtained herein was the second highest among the average concentration of Pb and Fe. The levels of Zn obtained herein were below the FAO and WHO (2011) permitted limits.

A previous study conducted in India reported higher concentration of Zn in wheat and millet (Asdeo, 2014). Also, when compared to a previous study conducted in Northern Ghana, the concentration of Zn was greater in millet control samples in comparison to the milled samples. The authors reported that the elevated Zn levels in the control samples could be ascribed to agricultural practices such as the use of pesticides and inorganic fertilizers which contaminates the soil upon which the millet is planted. Research by Srinivasarao et al. (2014) indicated that heavy metal-containing phosphate rocks are the source of phosphate-based fertilizers, including Zn and Pb. These reasons accounts for the level of Zn obtained herein.

Zn is recognized as an essential element that plays a crucial role in controlling the growth, differentiation, and expression of genes in humans and other living things. Similar to other essential metals, consuming higher concentrations of Zn through contaminated food can lead to toxic effects (Reilly, 2008). However, the relatively low levels of Zn found in *Zoom-Koom* herein indicate that it is safe for consumption.

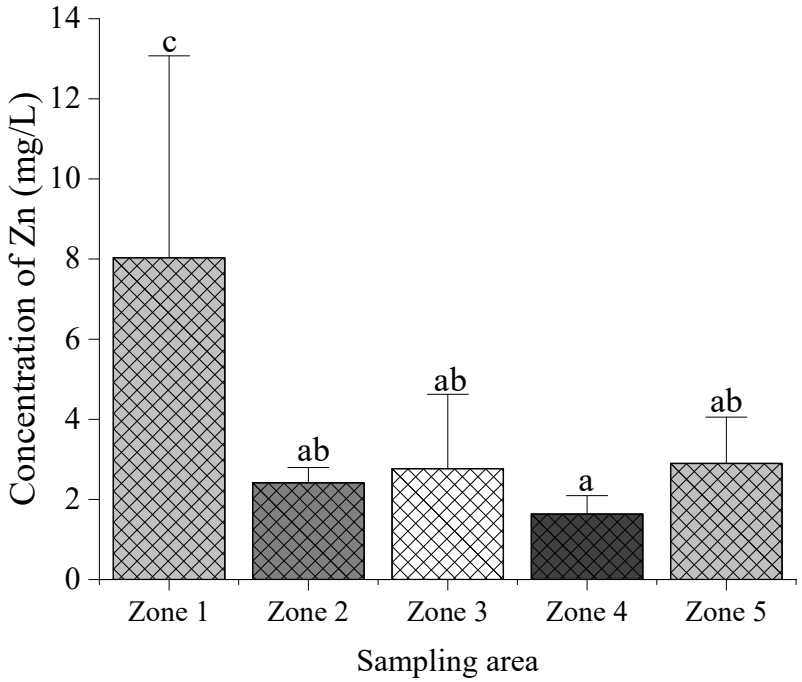

Figure 3: Concentration of Zn (mean ± standard deviation of 3 replicates) determined in *Zoom- Koom* sold in Central Business area in Tamale metropolis. Significant differences ($p < 0.05$) across zones are shown by different letters.

Street food provides a convenient source of low-cost food for the general public (Privitera and Nesci, 2015). Notwithstanding, if food safety and hygiene protocols are not observed, it may be a source of contamination. Grain products, such as *Zoom-Koom,* undergo a number of preparation and handling steps prior to being sold to customers.

None of the *Zoom-Koom* drink formed even a colony of *E. coli*, after the experiment. This implies that coliform bacteria were absent in all the *Zoom-Koom* drinks. The absence of *E. coli* in the *Zoom-Koom* samples suggests that there was no fresh fecal matter contamination. This could be because sellers are washing their hands properly (Bakobie *et al.*, 2017).

Salmonella spp. levels varied between 0 to 2.18 $\log_{10}$cfu/mL with an average of 1.16 ±1.09 $\log_{10}$cfu/mL in zone 0 to 1.48 $\log_{10}$cfu/mL with an average of 0.65±0.75 $\log_{10}$cfu/mL in zone 2, 0 to 1.70 $\log_{10}$cfu/mL with an average of 1.23±1.08 $\log_{10}$cfu/mL in zone 3, 0 to 3.0 $\log_{10}$cfu/mL with an average of 1.53±1.50 $\log_{10}$cfu/mL in zone 4, and 1.48 to 1.94 $\log_{10}$cfu/mL with an average of 1.67±0.25 $\log_{10}$cfu/mL in zone 5, respectively. The levels of *Salmonella* spp. found in our study are higher that what was found (0-0.9 $\log_{10}$cfu/mL with an average of 0.38 ± 0.31 $\log_{10}$cfu/ mL) in typical species and spice mixtures utilized in Tamale, Ghana (Bakobie *et al.*, 2017).

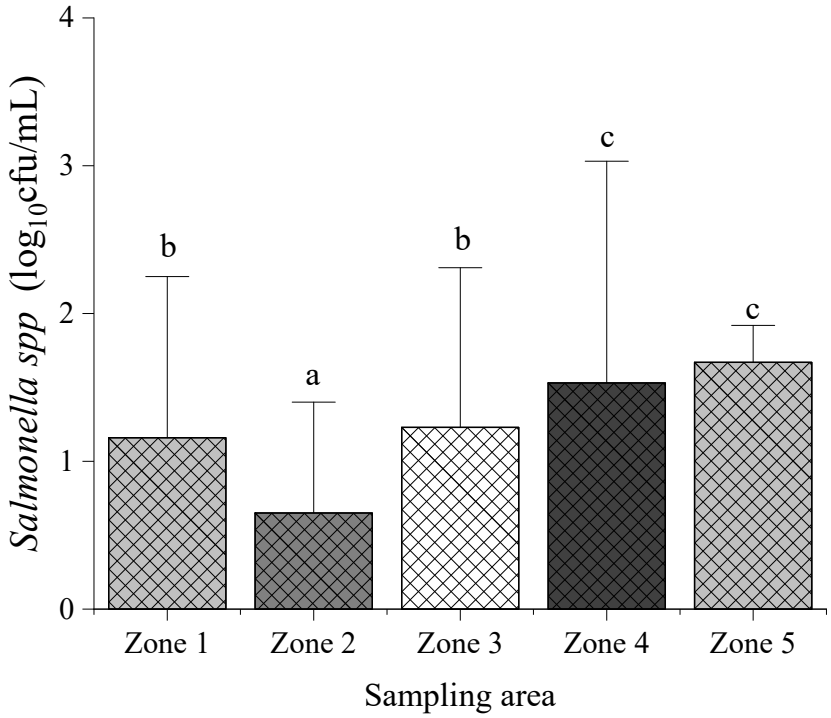

Figure 5: Concentration of *Salmonella* spp (mean ± standard deviation of 3 replicates) determined in *Zoom-koom* sold in Central Business area in Tamale metropolis. Significant differences ($p < 0.05$) across zones are shown by different letters.

Also, our study found an increased prevalence of *Salmonella* spp. in samples of *zoom-koom* than Acheampong (2015), who found *Salmonella* spp. in 32 % of food samples. However, a study that assessed microbiological quality of ready-to-eat vegetable salads sold in Tamale, Ghana, found higher levels (from 0 to 4.54 $\log_{10}$cfu/g) of *Salmonella* spp. than what was found in our study (Abakari, Cobbina and Yeleliere, 2018). These researchers attributed the presence of *Salmonella* spp. to poor hygienic practices and inappropriate washing of raw materials used in the preparation of the food which is consistent with our study.
The main route of germs usually from feces, nose and skin to the food being cooked is through the hands of food handlers. *Salmonella non-typhi salmonella* bacteria *Campylobacter* can survive on fingertips for varied durations of time and leave residues even after washing (Rane, 2011). This agree with a study that was conducted in Colombia on a group of food vendors, and their findings revealed that 30% of food vendors were carriers of pathogenic bacteria such as Salmonella spp., Salmonella enteritidis, and Shigella (Buchanan and Whiting, 1998). The high bacteria count on *Salmonella* spp. point to the fact that *Zoom-Koom* drink is typically produced under unregulated and unstructured conditions, resulting in substantial microbiological quality and safety variability (Omemu and Bankole, 2005). The presence of *Salmonella* spp. in food indicates a higher rate of exposure illness for those who consume it. They are most commonly linked to food contamination, particularly unpasteurized foods. *Salmonella* is the bacteria that causes the majority of food-borne illnesses (Bakobie *et al.*, 2017). All of the *Zoom-Koom* samples that tested positive with *Salmonella* spp. are deemed unfit for human consumption.

4. Conclusion

The study was carried out to assess the level of selected heavy metals as well as microbial quality in *Zoom-Koom* sold in Tamale's Central Business District. The concentrations of Pb, iron, and Zn in *Zoom-Koom* were below the WHO maximum permissible limits which might not be harmful to consumers. The possible sources of these heavy metals include milling machine operations (painting and alignment of mill plates), soil pollution, and the use of phosphate-based fertilizers and pesticides. On the other hand, bacterial counts (*Salmonella* spp) were extremely high, having a greater level of contamination. This is extremely harmful to the general public, as these contaminants can cause a variety of diseases. It is recommended that the Food and Drugs Authority in the Central Business District of Tamale assure the strict observance of food quality standards.

Acknowledgements
The authors are grateful to Mr. Prince Owusu, Ecological Laboratory, University of Ghana for his timely analysis of the samples.

References

Abakari, G., Cobbina, S. J. and Yeleliere, E. (2018) 'Microbial quality of ready-to-eat vegetable salads vended in the central business district of Tamale, Ghana', *International Journal of Food Contamination*, 5(1), pp. 1–9.

Abankwa, V. *et al.* (2009) *United Nations Human Settlements Programme (UNHABITAT).*

Abebe, E., Gugsa, G. and Ahmed, M. (2020) 'Review on major food-borne zoonotic bacterial pathogens', *Journal of tropical medicine*, 2020(1), p. 4674235.

Acheampong, B. E. (2015) 'Assessment of food hygiene practices by street food vendors and microbial quality of selected foods sold. A Study at Dunkwa-On-Offin, Upper Denkyira East Municipality of the Central Region.'

Adeti, P. J. (2015) *Assessment of heavy metals introduced into food through milling process: health implications*. Available at: http://inis.iaea.org/search/search.aspx?orig_q=RN:47048409.

Agbenin, J. O. (2002) 'Lead in a Nigerian savanna soil under long-term cultivation', *Science of the Total Environment*, 286(1–3), pp. 1–14.

Akinbode, S. O., Dipeolu, A. O. and Okuneye, P. A. (2011) 'Willingness to pay for street food safety in Ogun State, Nigeria', *Journal of agricultural & food information*, 12(2), pp. 154–166.

American Public Health Association. (2008) *Standard Methods for the Examination of Water and wastewater. 20th Edition, American Public Health Association, American Water Works Association, Water Environment Federation*. USA: United Book Press, Inc.

Andrews, A. and Gikunoo, E. (2011) 'Small scale foundries in Ghana: the challenges', *Leonardo Electronic Journal of Practices and Technologies*, 19(7), pp. 1–12.

Asdeo, A. (2014) 'Toxic metal contamination of staple crops (wheat and millet) in periurban area of Western Rajasthan', *Int Ref J Eng Sci*, 3(4), pp. 8–18.

Bakobie, N. *et al.* (2017) 'Microbial profile of common spices and spice blends used in Tamale, Ghana', *International Journal of Food Contamination*, 4(1), p. 10. doi: 10.1186/s40550-017-0055-9.

Buchanan, R. L. and Whiting, R. C. (1998) 'Risk assessment: a means for linking HACCP plans and public health', *Journal of food protection*, 61(11), pp. 1531–1534.

Check, L. and Marteel-Parrish, A. (2013) 'The fate and behavior of persistent, bioaccumulative, and toxic (PBT) chemicals: examining lead (Pb) as a PBT metal', 28(2–3), pp. 85–96. doi: doi:10.1515/reveh-2013-0005.

Díez, S. *et al.* (2009) 'Prenatal and early childhood exposure to mercury and methylmercury in Spain, a high-fish-consumer country', *Archives of environmental contamination and toxicology*, 56, pp. 615–622.

Duhain, G. L. M. C. (2011) *Occurrence of Cryptosporidium spp. in South African irrigation waters and survival of Cryptosporidium parvum during vegetable processing*. University of Pretoria (South Africa).

FAO and WHO (2011) 'Report of the fifth session of the Codex Committee on Contamination in Foods. Joint FAO/WHO Food Standards Programme Codex Alimentarius Commission Thirty-fourth Session', *Codex*, (March), pp. 4–9. Available at: www.symbiosisonlinepublishing.com.

Ghana Statistical Service (2010) *Population census*.

Guardiola, S. and Mach, N. (2014) 'Therapeutic potential of Hibiscus sabdariffa: A review of the scientific evidence', *Endocrinología y Nutrición (English Edition)*, 61(5), pp. 274–295.

Israila, Y. Z. and Halima, S. (2016) 'Effect of grinding plates (GUK, Parpela and Premier) on maize flour milled within Samaru, Nigeria', *International Journal of Biochemistry Research & Review*, 12(1), pp. 1–7.

Jawad, I. and Allafaji, S. H. (2012) 'The levels of trace metals contaminants in wheat grains, flours and breads in Iraq', *Aust J Basic Appl Sci*, 6(10), pp. 88–92.

Kalagbor, I. A. *et al.* (2017) 'Estimation of the levels of Fe in wheat and maize flour milled using commercial milling machine and a home blender', *Journal of Applied Sciences and Environmental Management*, 21(2), pp. 341–344.

Kok, R. (2014) 'Street Food Vending and Hygiene Practices and Implications for Consumers', *Journal of Economics and Behavioral Studies*, 6(3 SE-Research Paper). doi: 10.22610/jebs.v6i3.482.

Kwofie, S., Andrews, A. and Mensah, E. (2011) 'The quality of locally-manufactured cornmill grinding plates', *Journal of Science and Technology (Ghana)*, 31(1).

Larsen, K. *et al.* (2020) 'Quantification and health risk assessment of heavy metals in milled maize and millet in the Tolon District, Northern Ghana', *Food science & nutrition*, 8(8), pp. 4205–4213.

Nnorom, I. C., Osibanjo, O. and Ogugua, K. (2007) 'Trace heavy metal levels of some bouillon cubes, and food condiments readily consumed in Nigeria', *Pakistan journal of nutrition*, 6(2), pp. 122–127.

Olu, M. *et al.* (2013) 'Evaluation of heavy metal concentration in maize grown in selected industrial areas of Ogun State and its effects on urban food security', *International Journal of Science, Technology and Society*, 1(2), pp. 48–56.

Omemu, A. M. *et al.* (2006) 'A survey of the microflora of Hibiscus sabdariffa (Roselle) and the resulting "Zobo" juice', *African Journal of Biotechnology*, 5(3), pp. 254–259.

Omemu, A. M. and Bankole, M. O. (2005) 'Ready-to-eat (RTE) vegetable salad: effect of washing and storage temperature on the microbial quality and shel-life', in *the Book of Abstract of the 29th Annual Conference & General Meeting (Abeokuta 2005) on Microbes As Agents of Sustainable Development, organized by Nigerian Society for Microbiology (NSM), UNAAB, from*, p. 28.

Oniya, E. O. *et al.* (2018) 'Effect of milling equipment on the level of heavy metal content of foodstuff', *Physical Science International Journal*, 20(2), pp. 1–8.

Privitera, D. and Nesci, F. S. (2015) 'Globalization vs. local. The role of street food in the urban food system', *Procedia Economics and Finance*, 22, pp. 716–722.

Rane, S. (2011) 'Street vended food in developing world: hazard analyses', *Indian journal of microbiology*, 51(1), pp. 100–106.

Rehman, K. *et al.* (2018) 'Prevalence of exposure of heavy metals and their impact on health consequences', *Journal of cellular biochemistry*, 119(1), pp. 157–184.

Reilly, C. (2008) *Metal contamination of food: its significance for food quality and human health*. John Wiley & Sons.

Sargeant, J. M. *et al.* (2006) 'Methodological quality assessment of review articles evaluating interventions to improve microbial food safety', *Foodbourne Pathogens & Disease*, 3(4), pp. 447–456.

Srinivasarao, C. H. *et al.* (2014) 'Long-term manuring and fertilizer effects on depletion of soil organic carbon stocks under pearl millet-cluster bean-castor rotation in Western India', *Land Degradation & Development*, 25(2), pp. 173–183.

Tambekar, D. H. *et al.* (2008) 'Identification of microbiological hazards and safety of ready-to-eat food vended in streets of Amravati City, India', *Journal of Applied Biosciences*, 7(3), pp. 195–201.

TAPSOBA, F. W. *et al.* (2017) 'Effect of the fermentation on the microbial population occurring during the processing of zoom-koom, a traditional beverage in Burkina Faso', *African Journal of Microbiology Research*, 11(26), pp. 1075–1085.

Umoh, V. J. and Odoba, M. B. (1999) 'Safety and quality evaluation of street foods sold in Zaria, Nigeria', *Food Control*, 10(1), pp. 9–14. doi: https://doi.org/10.1016/S0956-7135(98)00149-2.