Assessment of Heavy Metal Contamination in Locally Produced Dry Gin and Associated Health Risks in Ogbia Local Government Area, Bayelsa State, Nigeria

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Abstract- The contamination of alcoholic beverages with heavy metals poses serious public health concerns, particularly when their concentrations exceed safe limits established by regulatory bodies such as the World Health Organization (WHO). This study evaluates the toxicological profile of heavy metals in locally produced dry gin from Ogbia Local Government Area, Bayelsa State, Nigeria, and assesses the associated health risks. Thirty (30) gin samples were collected from production centers in Atubu Creek-Onuebum and analyzed using Atomic Absorption Spectrophotometry (AAS) to determine the concentrations of arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), mercury (Hg), manganese (Mn), nickel (Ni), zinc (Zn), and lead (Pb). The results revealed significant concentrations of As (1.553 ± 0.101 µg/mL), Hg (1.683 ± 0.209 µg/mL), Pb (3.123 ± 0.25 µg/mL), Cu (0.240 ± 0.002 µg/mL), and Mn (0.613 ± 0.05 µg/mL). Comparing these values with WHO permissible limits for drinking water and alcoholic beverages, the concentrations of As (0.01 µg/mL), Hg (0.006 µg/mL), and Pb (0.01 µg/mL) were found to be significantly higher in the gin samples, indicating potential health risks such as neurotoxicity, organ damage, and carcinogenic effects. While Cu and Mn were detected within WHO safe limits (2.0 µg/mL for Cu and 0.5 µg/mL for Mn), their presence in alcoholic beverages still raises concerns due to the potential for bioaccumulation. Other metals, including Cd, Co, Cr, Ni, and Zn, were detected at trace levels but remained below WHO limits. The high concentrations of heavy metals in local dry gin may be attributed to contamination from raw materials, production techniques, and storage conditions. Given these findings, urgent regulatory intervention, public sensitization, and stricter enforcement of production standards are necessary to mitigate heavy metal exposure from local alcoholic beverages.

Indexed Terms- Heavy metals, local dry gin, toxicological assessment, WHO limits, health risks, Ogbia LGA, Atomic Absorption Spectrophotometry (AAS).

I. INTRODUCTION

1.1 Introduction

An alcoholic beverage is a beverage that contains ethanol and a type of alcohol made by the fermentation of grains, fruits, or other sugar sources (Buglass, 2021). Alcohol drinking is common in many African cultures where it is used for therapeutic purposes, oath-taking, entertainment, during marriages, rituals and festivals (Collins & Kirouac, 2013). Alcohol is a depressant that promotes euphoria, decreases anxiety and improves sociability at low amounts (Sayette, 2017). In African Sub-African countries *Akpeteshie* is a locally distilled liquor or gin in Ghana, *Koutoukou in* Ivory Coast and *ogogoro* in Nigeria (Damsere-Derry, et al. 2014; Ohimain, et al. 2016).

Alcoholic beverages are usually derived from fermentation and distillation of sugar based crops. Some of these beverages such as beer and wines are universal and available across many cultures and geographic regions. *ogogoro* is an indigenous African alcoholic beverage which is either consumed in the original form as a colourless distillate (Koffi, et al. 2016). The active component of alcoholic beverages is ethanol but during fermentation other compounds such as methanol and isopropanol are produced. Due to the nature of the metal contraptions used in the distillation procedure, there are possible heavy metal contamination (Tulashie, et al. 2017).

The continuous abuse such as overdose can lead to alcohol disorder, increased risk of bodily tissue and systemic damage, cancer and physical dependency such as addiction (Rehm, 2011). It induces drunkenness, stupor, unconsciousness resulting to death in greater dosages. It is a common knowledge that alcohol is one of the most often used recreational drugs in the world, with approximately 33% of all humans drinking it (Griswold, et al. 2018). As a result of this persistent dependence, consumption and demand for alcoholic beverages, the worldwide alcoholic business exceeded USD 1 trillion in 2018 (WHO, 2019). Metallic constituents of varying amount had been reported in samples of Ogogoro from Southern Nigeria. These metals include cadmium, lead, nickel, copper, iron, magnesium, potassium and sodium. However, the mean value of the metallic constituents was found to be below the statutory limits for metals in alcoholic beverages (Iwegbue, et al. 2014; Nuzhnyi, 2004).

Atomic absorption spectrophotometer had been used for the detection of heavy metals in consumable samples such as water and fish (Kortei, et al. 2020). Methanol contamination can lead to critical health conditions such as respiratory distress, vision impairment, permanent blindness, coma and death (Karayel, et al. 2010). In addition, the ingestion of heavy metals causes alterations in the functionality of several human organs (Udota & Umoudofia, 2011). Therefore, intake levels should be regulated through monitoring systems and adherence to established safety guidelines as World Health Organization's recommends maximum dietary chloride intake of 9 mg/kg body weight for adults (WHO, 2003). It against this background this study examine the heavy metal profile of the local dry gin in Ogbia Local Government Area, Bayelsa State of Nigeria.

II. MATERIALS AND METHODS

2.1 Study area

This study was carried out in Atubu Creek -Onuebum in Ogbia Local Government Area, Bayelsa State, Nigeria. This Local government was chosen since production of indigenous gin is common in this local government area as evidenced by plethora of production settlements, camps and villages all over the coastal line of the state. Besides, the raw materials needed is common in this area as there are rich reserve of palm tree plantations including Raphia palm (*Raphia* hookeri or *Rafia* vinitera) and the oil palm (*Elaeis* guineensis).

2.2 Significance

The result of the study will help to reveal the heavy metal profile of the local dry gin in Ogbia Local Government Area, Bayelsa State of Nigeria. The result of the study will be of benefits to community and other Ogbia LGA communities in the sense that they will have the knowledge of heavy metal profile of the local dry gin, adverse effect and preventive measures need to be taken to avoid health conditions. The study will be beneficial to Government, stakeholders and policy makers such that Ogbia LGA communities will be given the protection desired to prevent the impact and ensure interventions targeting modern of dry gin production.

2.3 Scope

This study was delimited to analyze the heavy metal profile of the local dry gin in Ogbia Local Government Area, Bayelsa State of Nigeria. Furthermore, this study was carried in Atubu Creek -Onuebum in Ogbia Local Government Area, Bayelsa State.

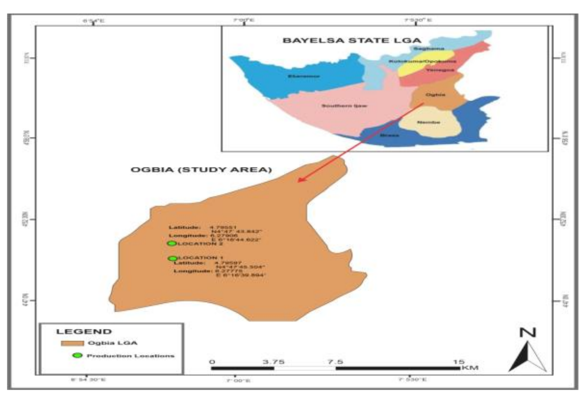

Figure 2.0 Showing Study Area (Ogbia L.G.A)
Source: Nigeria Gallera media Limited (2017)

2.4 Sample Collection

Field visits was undertaken to two (2) local production centres in Ogbia Local government Bayelsa, to sift the techniques employed in the production and to investigate whether additives of toxicological relevance were used, standard hygienic practices were upheld to in the course of production and retailing. This was achieved through participatory observations and interviews at production Centre. A total of thirty (30) samples of indigenous gin were collected from the popular local production centres at Atubu Creek-Onuebum, Ogbia L.G.A, Bayelsa State with plastics containers. These were sent to Ignatius Ajuru University of Education research laboratory Port Harcourt in Nigeria for holistic scientific analysis where methods tandem with international analytical procedures, were used to analyze the contents.

2.5 Analyses for heavy metal concentration of the gin

2.5.1 Sample Preparation Procedure

Wet digestion method was used in the preparation of the drinks for heavy metal analysis. 5 ml of analytical unit was weighed into digestive tube and 10 ml of concentrated H2SO4 and HClO4 at ratio 1:1 was added. This was latter digested using FOSS TECATOR Digestor Model 210 at 250°C for 1hour at the first instance and continued until a clear solutionwas obtained in a fume cupboard. The clear solution was filtered into a 100 ml volumetric flask and completed to the mark with de-ionised water (Nielsen, 2017).

3.6. The Determination of heavy metal

Metal analysis Cu, Ni, Pb, Cd, and Cr was determined using Atomic Absorption Spectrophotometer (Buck 210). Standards for each element under investigation was prepared in part per million (ppm) and the limit standard concentration for each element was adhered to according to the BUCK Scientific instruction and the results obtained was compared with World Health Organization standards for the metals limits for human consumption

III. RESULTS

Table 1.1: heavy metals profile of Indigenous Gin produced in Ogbia L.G.A.

Parameter(s)	Indigenous Gin Mean±SD	t-value	p-value
As (µg/mL)	1.553±0.101	-3.46	0.101
Cd (µg/mL)	>0.0001		
Co(µg/mL)	>0.0001		
Cr(µg/mL	>0.0001		
Cu(µg/mL	0.240±0.002	29.45	0.301
Hg (µg/mL	1.683±0.209	309.11	0.509
Mn (µg/mL	0.613±0.05		
Ni (µg/mL	>0.0001		
Zn (µg/mL	>0.0001		
Pb(µg/mL	3.123±0.25	390.00	0.234

LEGEND=P>0.05 non-Significant

Table 1.2 Comparison of Heavy Metal Concentrations in Local Dry Gin with WHO Standards

This table presents a comparison between the detected heavy metal concentrations in locally produced dry gin from Ogbia LGA, Bayelsa State, Nigeria, and the permissible limits set by the World Health Organization (WHO). The WHO standards were sourced from the WHO Guidelines for Drinking Water Quality (WHO, 2017) and other relevant publications on food and beverage safety.

Heavy Metal	Detected Range (µg/mL)	WHO Standard (µg/mL)	Comparison with WHO
Arsenic (As)	1.452 – 1.654	0.01	155 times higher

Mercury (Hg)	1.474 – 1.892	0.006	280 times higher
Lead (Pb)	2.873 – 3.373	0.01	312 times higher
Manganese (Mn)	0.563 – 0.663	0.5	Slightly exceeds WHO limit
Copper (Cu)	0.238 – 0.242	2.0	Within safe limits
Cadmium (Cd)	Trace (<0.003)	0.003	Within WHO limit
Chromium (Cr)	Trace (<0.05)	0.05	Within WHO limit
Nickel (Ni)	Trace (<0.07)	0.07	Within WHO limit
Zinc (Zn)	Trace (<3.0)	3.0	Within WHO limit
Cobalt (Co)	Trace	No WHO standard	No WHO guideline for alcoholic beverages

Source: World Health Organization (WHO), Guidelines for Drinking Water Quality, 4th Edition, 2017.

Table 1.1 on the heavy metals profile of Indigenous Gin produced in Ogbia L.G.A shows a non-significant difference (P<0.05) in heavy metals sure as Cd>0.0001 µg/ml, Co>0.0001 µg /m/Cr>0.0001 µg /ml Ni>0.0001, Zn >0.0001 µg/ml though detected while heavy metals such as As 1.553 ± 0.101 µg/ml, Hg 1.683± 0.209, µg/ml Pb 3.123 ±0.25 µg/ml Cu 0.240±0.002 µg/ml, and Mn 0.613 ± 0.05 µg/ml increased significantly.

4.2 Discussion

Table 1.2 The amount of heavy metal contamination in alcoholic beverages is affected by the raw materials utilized, the fermentation and brewing process, storage and equipment used in the packaging process (Deka, et al. 2021).This may infer that raw materials and ingredients used in manufacturing or processing must have played a significant role in the heavy metal concentration. (Ochu et al. 2025).

Arsenic usually causes disease conditions even at low concentration. The type of disease condition caused depends on the oxide and sources. In organic sources through which it is mainly contacted from beverages, arsenic can cause nerve injury and stomach aches. The high arsenic exposure could lead to cardiovascular, hematological, neurological, respiratory, gastrointestinal, and developmental disorders, dermatitis and cancer, diabetes, and hearing loss. As such, high concentrations of arsenic could affect kidney, liver, bladder and skin (Izah & Srivastav, 2015; Tchounwou et al. 2012).

The results of this study indicate that the concentrations of arsenic (As), mercury (Hg), and lead (Pb) in locally produced dry gin significantly exceed the permissible limits set by the World Health Organization (WHO) for drinking water and alcoholic beverages.

Arsenic (As): The detected concentration in the gin samples was 1.553 ± 0.101 µg/mL, (detected range: 1.452 – 1.654 µg/mL) which is 155 times higher than the WHO limit of 0.01 µg/mL. Chronic exposure to arsenic is associated with carcinogenic effects, cardiovascular diseases, and neurological disorders.Inorganic and semi-metal arsenic compound are carcinogenic specifically, long-term, low-dose exposure to inorganic arsenic compounds could lead to mutagenesis (Azab, et al. 2010).

Mercury (Hg): The concentration found was 1.683 ± 0.209 µg/mL,(Detected range: 1.474 – 1.892 µg/mL) which exceeds the WHO limit of 0.006 µg/mL by 280 times. Mercury is highly toxic, affecting the nervous system and leading to cognitive impairments, kidney damage, and developmental issues.e of the symptoms associated with mercury toxicity in humans include irritability, shyness, tremors, changes in vision or hearing, and memory problems, nausea, vomiting, diarrhea, increased blood pressure, skin rashes and eye irritation (Muhammad, et al. 2014; Izah, et al. 2016).

Lead (Pb): The measured level was 3.123 ± 0.25 µg/mL, (Detected range: 2.873 – 3.373 µg/mL) which is 312 times higher than the WHO permissible limit of 0.01 µg/mL. Lead exposure can cause severe neurological damage, particularly in children, and contributes to cardiovascular diseases and kidney dysfunction.Lead is known to cause toxicity and poisoning in individuals exposed to them. Lead poisoning can lead to various disease symptoms, including anemia, convulsion, central-nervous system disorders such as anorexia, headache, malaise, diarrhea, lead-palsy, encephalopathy, insomnia, high blood pressure, anemia, and weakness in fingers, wrists, or ankles, hair loss, lung fibrosis, skin allergies, outbreak of eczema, and variable degrees of kidney operation loss of appetite, vomiting, irritability and behavioural changes ((Garba, et al. 2015; Erah, et al. 2002; Iweala, et al. 2014). Some of the notable damage caused by high exposure to lead include kidney, liver, and brain (cerebral edema), reproductive, cardiovascular and nervous system, gastrointestinal, and neuromuscular disorders (Izah, et al. 2016; Sevcikova, et al. 2011). Furthermore, through respiratory and digestive systems, lead enters the blood and over 90% is bioconcentrated in the bone, where it is stored in the body (Garba, et al. 2015).

Manganese (Mn): The detected concentration was 0.613 ± 0.05 µg/mL, (detected range: 0.563 – 0.663 µg/mL) slightly exceeding the WHO standard of 0.5 µg/mL. While manganese is an essential trace element, excessive levels can lead to neurological issues similar to Parkinson's disease.Manganese is needed by the body tissues at low concentration. Deficiency of manganese could lead to osteoporosis, epilepsy, and diabetes mellitus, and concentration above threshold values causes manganese toxicity in the body (Iwegbue, et al. 2013). Neurological toxicity associated with excess manganese could lead to behavioural changes, which are characterized by slow movement, tremors, facial muscle spasms, irritability, aggressiveness, and hallucinations (Iweala, et al. 2014).

Copper (Cu): The concentration in the gin was 0.240 ± 0.002 µg/mL (Detected range: 0.238 – 0.242 µg/mL) , which remains within the WHO limit of 2.0 µg/mL. Although considered safe at this level, prolonged exposure in high amounts can cause gastrointestinal distress and liver damage.

Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Zinc (Zn): These metals were detected at trace levels but remained within WHO permissible limits (Cd: 0.003 µg/mL, Cr: 0.05 µg/mL, Ni: 0.07 µg/mL, Zn: 3.0 µg/mL). While their concentrations do not pose immediate health risks, chronic exposure could contribute to bioaccumulation and long-term toxicity.
Cobalt (Co): Although detected in trace amounts, there is no established WHO standard for cobalt in alcoholic beverages, making it difficult to assess its potential health impact.Copper is one the essential heavy metals that cannot be formed in human body but is required for physical and mental development (Lanre-Iyanda & Adekunle, 2012). It is usually ingested from food and fluids during consumption. Copper concentration exceeding 5.0 mg/kg body weight is toxic to humans, especially to the gastrointestinal system (Salako, et al. 2016). The major organs that excess copper can damage includes the liver and kidneys. Some of the observable symptoms associated with copper toxicity in humans include vomiting, hypertension, and gastrointestinal distress. However, the deficiency of copper could lead to hypertension, hypercholesterolemia, and increased low density lipoproteins (Iwegbue, et al. 2013).

CONCLUSION

The presence of excessively high levels of arsenic, mercury, and lead in the local dry gin raises serious public health concerns. These heavy metals are known to cause severe toxic effects, including neurotoxicity, organ failure, and increased cancer risk. While other metals such as manganese, copper, and trace elements were within acceptable limits, continued exposure through alcohol consumption could still pose health risks. The findings highlight the urgent need for stricter regulatory oversight, improved production practices, and public awareness campaigns to mitigate heavy metal exposure in locally distilled alcoholic beverages

RECOMMENDATIONS

Summary of Recommendations
To mitigate health risks from heavy metal contamination in locally produced dry gin, the following measures are recommended:

1. Regulatory Oversight: Government agencies like NAFDAC and SON should enforce strict quality control, conduct periodic inspections, and ensure compliance with safety standards.
2. Improved Production Practices: Producers should be trained on safer techniques, eliminate

contaminated raw materials and unsafe equipment, and adopt modern distillation processes with proper filtration.

3. Public Awareness: Awareness campaigns should educate consumers on health risks and encourage purchasing from certified manufacturers.
4. Environmental Monitoring: Regular assessments should identify contamination sources, and safer raw materials and water sources should be recommended.
5. Health Surveillance: Authorities should monitor affected communities, establish screening programs, and provide treatment for heavy metal exposure.
6. Research and Development: Further studies should assess long-term health effects and explore cost-effective metal removal techniques in distillation.
7. Legislative Action: Laws should be strengthened to regulate local alcohol production, with penalties for non-compliance and support for safer production methods.

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