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Comparative analysis of heavy metal contamination in raw and smoked meat and fish samples from Eke-Awka market, Awka Anambra State

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ABSTRACT

Heavy metal contamination in food products has emerged as a significant public health concern globally, particularly in developing countries like Nigeria. This study investigates the concentrations of heavy metals in smoked meat and fish samples sourced from the market, focusing on cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), and mercury (Hg). Results indicate that Cd concentrations were highest in smoked fish (0.284 ± 0.059 mg/kg) and lowest in fresh meat (0.171 ± 0.083 mg/kg), with significant differences observed among sample types ($p<0.05$). Notably, average Cr levels in all samples exceeded the WHO/FAO acceptable limits. Ni levels peaked in smoked meat (0.063 ± 0.044 mg/kg) and were undetectable in fresh fish, with significant differences across sample types ($p<0.05$), yet all Ni levels remained below WHO/FAO limits. Pb concentrations were highest in smoked meat (0.347 ± 0.030 mg/kg) and lowest in smoked fish (0.088 ± 0.027 mg/kg), again showing significant differences ($p<0.05$), with all samples exceeding WHO/FAO standards. Hg levels were highest in smoked meat (0.232 ± 0.066 mg/kg) and lowest in fresh fish (0.065 ± 0.015 mg/kg), with significant differences noted ($p<0.05$), and all samples also surpassed WHO/FAO acceptable limits. Overall, the study highlights concerning levels of heavy metal contamination in smoked meat and fish, emphasizing the need for regulatory measures and monitoring to ensure food safety and public health.

Keywords: *Market, focusing on cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), mercury (Hg).*

1.INTRODUCTION

Heavy metal contamination in food products has emerged as a significant public health concern globally, particularly in developing countries like Nigeria. The ingestion of heavy metals such as lead, cadmium, mercury, and arsenic can lead to severe health issues, including neurological disorders, kidney damage, and increased cancer risk [6]. While the presence of heavy metals in various food matrices has been extensively studied, there remains a notable gap in comparative analyses of raw versus processed food items, particularly in the context of traditional smoking practices prevalent in Nigeria. Recent studies have highlighted the alarming levels of heavy metals in various food sources, including vegetables and grains [1] [10]. However, there is limited research focusing specifically on the comparative levels of heavy metal contamination in raw and smoked meat and fish samples. The smoking process, commonly used in Nigeria for preservation and flavor enhancement, may influence the concentration of heavy metals due to environmental exposure during the smoking process or the use of contaminated wood [9]. Moreover, the lack of standardized methods for assessing heavy metal levels in smoked products further complicates the existing body of literature. This gap indicates an urgent need for comprehensive studies that not only quantify heavy metal levels in both raw and smoked meat and fish but also evaluate the implications of these findings for public health and food safety regulations in Nigeria. This study aims to fill this critical gap by conducting a comparative analysis of heavy metal contamination in raw and smoked meat and fish samples across various regions in Nigeria. By providing updated evidence on this pressing issue, the research will contribute to the understanding of food safety risks associated with traditional food processing methods and inform regulatory frameworks to protect consumer health.

2. MATERIALS AND METHODS

2.1 Study Area

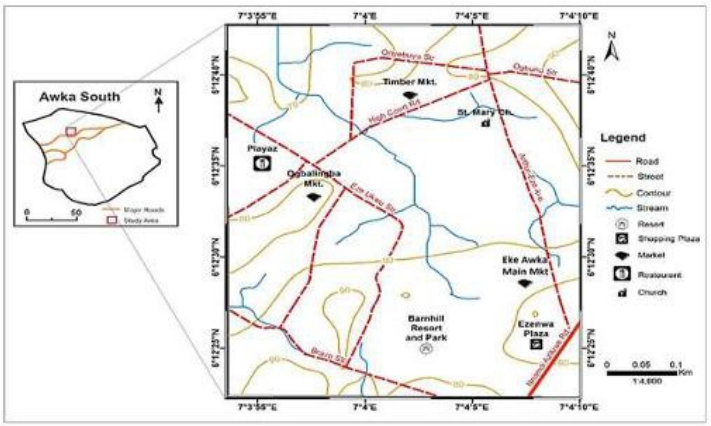

Fig 1. Map of Study area (Eke-Awka market, Awka)

The research was conducted at Eke-Awka Market,a significant commercial hub in Awka, the capital city of Anambra State, Nigeria, situated at geographical coordinates 6.2100° N latitude and 7.0833° E longitude [8]. This market serves as a vital center for trade and commerce, providing a wide range of goods and services to the local population and surrounding communities[5]. Awka is located in the southeastern region of Nigeria, approximately 30 kilometers from the commercial city of Onitsha and about 60 kilometers from Enugu, the capital of Enugu State.

2.2 Material collection and preparation

For this study, a total of twelve samples were collected, consisting of six raw and six smoked meat samples from cows, as well as six raw and six smoked mackerel fish samples. These samples were randomly sourced from various vendors in the market. They were then stored at low temperatures and transported to the laboratory for heavy metal analysis. Sample preparation for heavy metal analysis involved homogenization, drying, digestion, and extraction processes. The analysis was performed using the Agilent FS240AA Atomic Absorption Spectrophotometer, following the methodology outlined by the American Public Health Association (APHA) in 1995[14]. Each sample weighed 2.0 grams. The study focused on the detection of five heavy metals: cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), and mercury (Hg).

2.3 Statistical Analysis

Statistical analysis to compare the variance in heavy metal concentration in collected samples was conducted using SPSS 2020.

3. RESULTS

The findings of the study comparing heavy metal contamination in raw and smoked meat and fish samples are presented below.

3.1 Cadmium

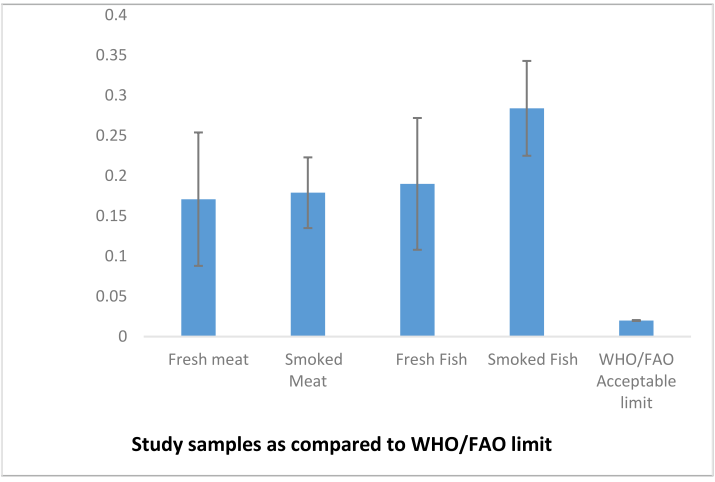

Fig 2. Concentration of Cadmium (ppm) in study samples as compared to the WHO/FAO limit

The findings indicate that the concentration of Cd was highest in smoked fish (0.284 ± 0.059) and lowest in fresh meat (0.171 ± 0.083). A significant difference in mean Cd levels was observed among the four sample types ($p<0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Cd levels in all four sample types collected from the market exceeded the acceptable limit established by WHO/FAO.

3.2 Chromium

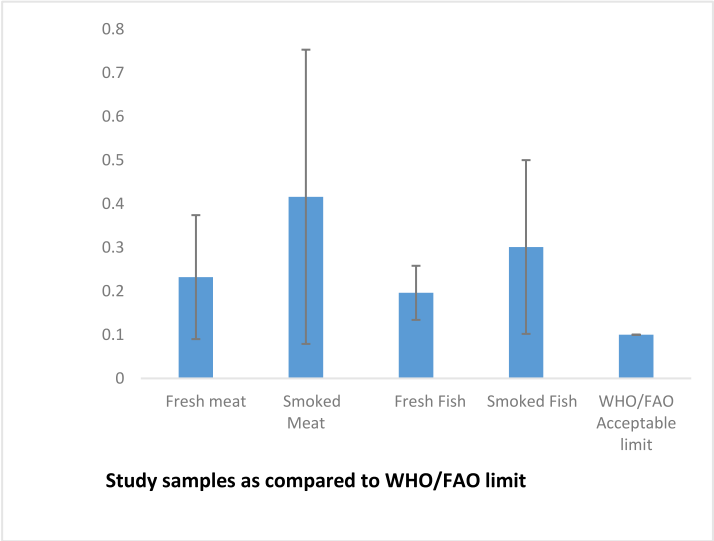

Fig 3. Concentration of Chromium (ppm) in study samples as compared to WHO/FAO limit

The findings indicate that chromium (Cr) levels were highest in smoked meat (0.416 ± 0.337) and lowest in fresh fish (0.196 ± 0.062). There was no significant difference in the mean Cr concentrations among the four sample types ($p>0.05$). However, when compared to the standards set by WHO/FAO, the average Cr levels in all four sample types from the market exceeded the acceptable limits established by WHO/FAO.

3.3 Nickel

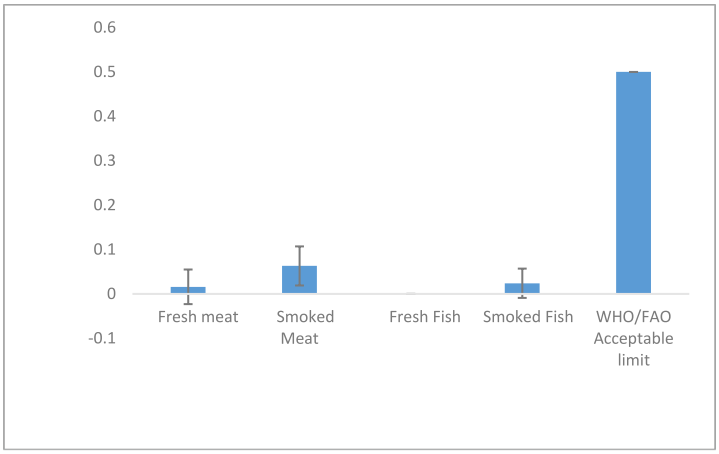

Fig 4. Concentration of Nickel (ppm) in study samples as compared to WHO/FAO limit

The findings indicate that nickel (Ni) levels were highest in smoked meat (0.063 ± 0.044) and lowest in fresh fish (not detected). A significant difference was observed in the mean Ni concentrations across the four sample types ($p<0.05$). Nevertheless, when compared to the standards set by WHO/FAO, the average Ni levels in all four sample types collected from the market were below the acceptable limit established by WHO/FAO.

3.4 Lead

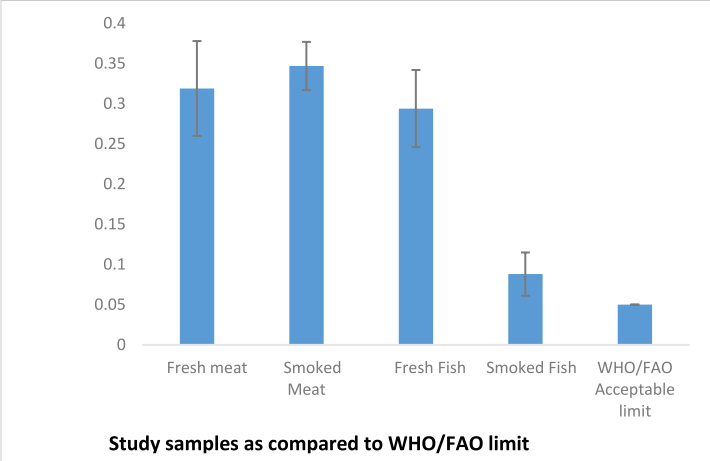

Fig 5. Concentration of Lead (ppm) in study samples as compared to WHO/FAO limit

The findings indicate that the lead (Pb) concentration was highest in smoked meat (0.347 ± 0.030) and lowest in smoked fish (0.088 ± 0.027). A significant difference was observed in the mean Pb levels among the four sample types ($p<0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Pb levels in all four sample types collected from the market exceeded the acceptable limit established by WHO/FAO.

3.5 Mercury

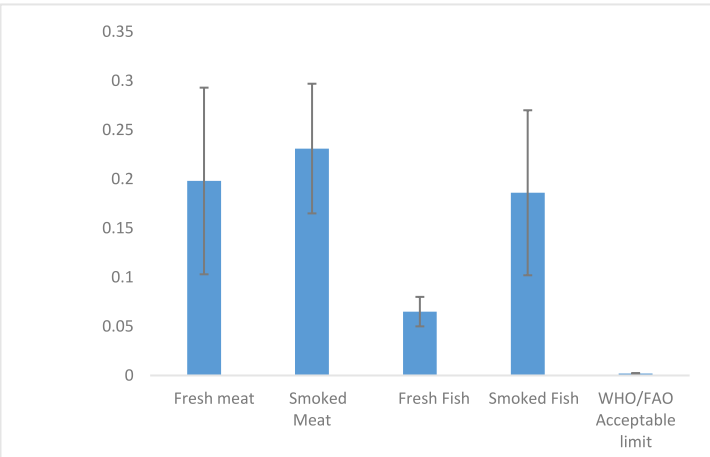

Fig 6. Concentration of Mercury (ppm) in study samples as compared to WHO/FAO limit

The findings indicate that the mercury (Hg) concentration was highest in smoked meat (0.232 ± 0.066) and lowest in fresh fish (0.065 ± 0.015). A significant difference was observed in the mean Hg levels among the four sample types ($p<0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Hg levels in all four sample types collected from the market exceeded the acceptable limit established by WHO/FAO.

DISCUSSION AND CONCLUSION

The comparative analysis of heavy metal contamination in raw and smoked meat and fish samples reveals significant insights into the prevalence of hazardous substances in food products. The findings of this study indicate that cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), and mercury (Hg) were present in varying concentrations across different sample types. Cadmium (Cd) The results show that the concentration of Cd was highest in smoked fish (0.284 ± 0.059 mg/kg) and lowest in fresh meat (0.171 ± 0.083 mg/kg). The significant difference in mean Cd levels among the sample types ($p<0.05$) suggests that smoking processes may enhance the concentration of this toxic metal, potentially due to the absorption of contaminants from the smoking environment or the use of contaminated wood. This finding aligns with recent literature indicating that smoking can increase the bioavailability of heavy metals in fish products [2] [7]. Moreover, the levels of Cd in all sample types exceeded the acceptable limits set by WHO/FAO, raising concerns regarding public health implications, particularly with chronic exposure linked to renal and bone damage [4].

Chromium (Cr) The analysis indicated that the average Cr levels in all sample types exceeded WHO/FAO standards. This finding is particularly concerning as Cr, while essential in trace amounts, can be toxic at higher concentrations. The elevated levels may be attributed to environmental contamination from industrial activities or agricultural runoff, as noted in recent studies [11]. The significant differences observed in Cr levels across sample types highlight the need for continuous monitoring and regulation of heavy metal concentrations in food products.

Nickel (Ni) Nickel levels were highest in smoked meat (0.063 ± 0.044 mg/kg) and lowest in fresh fish (not detected), with significant differences across sample types ($p<0.05$). Although the average Ni levels were below WHO/FAO limits, the presence of Ni in smoked meat raises questions about the sources of contamination, which may include the use of contaminated feed or environmental exposure [14]. This finding emphasizes the importance of assessing not only the levels of heavy metals but also their sources to mitigate contamination.

Lead (Pb) The study found that Pb concentrations were highest in smoked meat (0.347 ± 0.030 mg/kg) and lowest in smoked fish (0.088 ± 0.027 mg/kg), with significant differences among the sample types ($p<0.05$). Alarmingly, Pb levels exceeded WHO/FAO acceptable limits in all sample types. Lead is a well-known neurotoxin, and its presence in food products can pose serious health risks, particularly for vulnerable populations such as children [12]. The results underscore the need for stringent regulations and monitoring to prevent lead contamination in food chains.

Mercury (Hg) Mercury concentrations were highest in smoked meat (0.232 ± 0.066 mg/kg) and lowest in fresh fish (0.065 ± 0.015 mg/kg), with significant differences observed ($p<0.05$). Similar to Pb, Hg levels exceeded WHO/FAO limits in all sample types. The presence of mercury, particularly in fish, is a significant concern due to its bioaccumulation and potential to cause neurological and developmental issues [3]. The findings necessitate further investigation into the sources of mercury contamination, particularly in smoked products. Conclusion The comparative analysis of heavy metal contamination in raw and smoked meat and fish highlights significant public health concerns due to elevated levels of Cd, Cr, Pb, and Hg exceeding WHO/FAO standards.

The findings suggest that smoking processes may exacerbate contamination levels, necessitating stricter regulations and monitoring of food safety standards.While, the limited number of samples used in the study may impact the statistical power of the results and the ability to generalize the results to a broader population. Future research should consider increasing the sample size. It should also focus on identifying the sources of contamination and exploring mitigation strategies to ensure food safety.

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