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ORIGINAL RESEARCH ARTICLE

Analysis of Heavy Metals in some Processed Forms of *Cannabis Sativa* Commonly Consumed in Adamawa State, Nigeria

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ABSTRACT

This study assesses the concentrations of heavy metals in three major cannabis processed forms (*Bush*, *Arizona*, and *Loud*) sold in Adamawa State, Nigeria. Cannabis samples were systematically collected from three key locations—Numan, Mubi, and Yola—representing the state's senatorial districts. The study employed standardized methodologies for sample pre-treatment, digestion, and analysis using atomic absorption spectrometry (AAS) to quantify seven heavy metals: cadmium (Cd), zinc (Zn), iron (Fe), chromium (Cr), manganese (Mn), lead (Pb), and copper (Cu). A rigorous digestion process was utilized, combining concentrated nitric acid and hydrochloric acid in optimal ratios to ensure comprehensive analysis. The findings revealed the absence of cadmium (Cd) and chromium (Cr) in all tested cannabis samples. Lead (Pb), however, was detected in the *Bush* and *Arizona* varieties obtained from Numan, with levels reaching 0.68 mg/kg—exceeding the regulatory limit of 0.5 mg/kg set by WHO. Iron (Fe) emerged as the predominant metal across all samples, presenting a mean concentration of 19.36 mg/kg, followed by copper (Cu) at 5.86 mg/kg, manganese (Mn) at 2.79 mg/kg, and zinc (Zn) at 1.68 mg/kg. Despite most metals adhering to permissible thresholds, the elevated levels of lead (Pb) and iron (Fe) raise significant health concerns. Lead contamination poses a severe risk of neurological, respiratory, and cardiovascular disorders through immune modulation and oxidative stress mechanisms, while excessive iron accumulation disrupts cellular functions, potentially leading to liver damage, metabolic acidosis, and organ failure. These findings underscore the health hazards associated with heavy metal contamination in cannabis varieties sold in Adamawa State. The research advocates for stringent regulatory measures, public health awareness campaigns, and continuous monitoring to mitigate the risks posed by cannabis consumption and ensure consumer safety.

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Introduction

Substance abuse remains a serious preventable public health hazard, contributing to premature deaths around the world. According to WHO (2019), drug abuse is the harmful or dangerous use of psychoactive substances. These psychoactive substances include drugs such as amphetamine-type stimulants (ATS) and methamphetamine, as well as alcohol and other beverages. WHO (2022) reported that at least 15.3 million people have drug use problems, whereas Sarfo (2020) projected that smoking-related mortality will reach 8 million per year by 2030. Furthermore, about half of the world's population (38.3%) consumes alcohol, which causes 3.3 million deaths per year due to abuse. According to WHO (2019), *Cannabis sativa* is the most widely used illicit substance in Africa, with West Africa having the highest prevalence, with a 5.2% annual growth rate. Nigeria was the world's third largest consumer of cannabis. According to the UNODC (2019), Nigeria has about 10.6 million cannabis users. The large number of *Cannabis Sativa* users in Nigeria can be ascribed to a range of consuming methods, such as joint smoking, bunts/bongs, food, and beverages Center for Disease Control (2021).

Dahlawi *et al.,* (2021) reported that the reasons for cannabis usage are complex, ranging from peer pressure, pleasure, habit, ritualistic significance, addiction, and self-medication. Furthermore, sociodemographic patterns in cannabis consumption are associated with a population's gender, age, and urbanization rate.

Cannabis is grown illegally and widely throughout the country, outside of public access zones. According to UNODC (2019) cannabis is typically produced in forested areas that are difficult for law enforcement to detect or approach. Unfortunately, many of the farmers who have illegally grown this plant lack the necessary experience and background to fully comprehend all of the safety, quality, and toxicological challenges associated with the cultivation and manufacturing of pure *Cannabis Sativa* .

Milam et al., (2015) Heavy metal contamination presents serious risks due to their toxic properties, accumulation in organisms, and magnification through food chains. These metals can enter humans and animals through diet and other pathways. Livestock exposed to high levels of toxic metals like cadmium and lead, or insufficient amounts of essential trace elements such as copper, cobalt, and zinc, may suffer adverse effects including reproductive problems, physiological disorders, behavioural changes, or even death. In cattle, lead poisoning symptoms include depression, blindness, teeth grinding, muscle spasms, eyelid twitching, and seizures. Lead accumulates in bones, leading to osteoporosis, and affects the liver and kidneys, disrupting manganese and iron metabolism and potentially causing anaemia. Cadmium, a highly toxic metal, damages tissues, particularly the liver and kidneys. Cobalt, essential in small amounts as part of vitamin B12 (cyanocobalamin), becomes toxic in excess and may result in pernicious anaemia. Copper, vital in small quantities for humans and animals, can also be harmful at high levels due to its various forms in food. Likewise, zinc is an essential dietary element, but both deficiency and excess can negatively impact human health.

According to Robert (2020), cannabis will quickly acquire trace elements from the growing media, dirt, fertilizers, and even metallic equipment needed to prepare and process the various concentrates and oils. As a result, measuring the levels of heavy metals in cannabis is critical for ensuring that the

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products are safe to eat. Unfortunately, there are no traditional criteria in place to ensure that *Cannabis Sativa* is completely devoid of foreign components such as heavy metals, which can harm the body, because growth, processing, and distribution take place privately and covertly. As a result, using diverse *Cannabis Sativa* strains endangers the health of individual users, their families, and the general population. Therefore, this study assessed the level of heavy metals presence in three major brands of *Cannabis Sativa* commonly consumed in Adamawa State.

Materials and Reagents

Concentrated Nitric Acid (HNO_3), distilled water, thermometer, hot plate, beakers, water bath, fume board, hydrochloric acid (HCl), volumetric flask, deionized water, ethanol, methanol, chloroform, ferric chloride, Whatman filter paper, Plastic Sample bottle, Atomic Absorption Spectrometry

Identification and Procurement of processed forms of Cannabis Sativa

The three major varieties of cannabis such as Bush, Arizona and Loud were purchased at three different major retail distribution points in Numan, Mubi and Yola metropolis. The processed forms of cannabis were labelled and stored in a plastic sample bottle till time for analysis.

Pre-treatment and Digestion of Cannabis Sativa

The pre-treatment and digestion of the variety of cannabis samples were carried out according to the method described by Dahlawi *et al.,* (2021). 1.0g each of the powdered variety of cannabis samples was weighed into a 250 mL beaker. The 10 mL of concentrated nitric acid (HNO_3) was added and allowed to stand overnight in a fume hood. The solution was subsequently heated carefully in a water bath at 60 °C until the emission of red nitrous oxide fume ceased to evolve. The solution was allowed to cool at room temperature. Consequently, a partial extraction was done using nitric and hydrochloric acids at a 1:3 ratio, the digestion was carried out at relatively low temperature which allows Hg, which is volatile at high temperature to be analysed at the same time as the multi-element suite. The solution was made to mark with distilled water and kept in a plastic sample bottle and analysed by Atomic Absorption Spectrometry (AAS).

Analysis of the digested samples of cannabis

The analysis of the digested samples of cannabis was analysed using atomic absorption spectrometry according to the method described by Dahlawi *et al.,* (2021). The samples were tested for the following heavy metals; Cadmium (Cd), Zinc (Zn), Iron (Fe), Chromium (Cr), Manganese (Mn), Lead (Pb), and Copper (Cu).

Statistical Data Analysis

The result obtained were analysed statistically by using SPSS version 22 statistical software, for the level of significance of variation between data of the samples.

Results

Analysis of Heavy metals presence in Cannabis

The Table 1 presents the analysis results of the heavy metals in three major brands of Cannabis found in Adamawa State.

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Table 1: Analysis results of heavy metals presence in cannabis.

Sample	Elements (mg/kg)						
	Cd	Zn	Fe	Cr	Mn	Pb	Cu
Numan Loud	BDL	1.22	5.30	BDL	3.39	BDL	5.80
Yola Arizona	BDL	1.65	27.12	BDL	4.05	BDL	4.04
Bush Yola	BDL	1.81	17.84	BDL	2.25	BDL	2.91
Numan Arizona	BDL	2.49	13.86	BDL	2.16	0.68	6.11
Mubi Bush	BDL	1.99	23.39	BDL	1.90	BDL	4.67
Mubi Arizona	BDL	1.06	5.93	BDL	3.09	BDL	5.16
Yola Loud	BDL	1.71	39.45	BDL	2.63	BDL	5.82
Mubi Loud	BDL	1.77	25.93	BDL	3.43	BDL	6.91
Numan Bush	BDL	1.39	15.42	BDL	2.23	0.68	11.33

* Detectable Limit

Table 2: Summary of heavy metals analysis of Cannabis.

Metals	Mean	Standard Deviation	Minimum	Maximum	Maximum allowed *et al.*, (2021); (2022).	LimitOral DahlawiInhalation ICH.
Zinc (Zn)	1.676	0.427	1.06	2.49	50	-
Iron (Fe)	19.36	10.893	5.30	39.45	0.05	-
Manganese (Mn)	2.792	0.730	1.90	4.05	25	-
Lead (Pb)	0.686	0.299	0.68	0.68	0.50	0.50
Copper (Cu)	5.861	2.372	2.91	11.3	100	3.00

Table 2 presents the results for the heavy metal analysis of the three different kind of cannabis procured in three different senatorial zones of Adamawa State. The concentration of Cadmium (Cd) and Chromium (Cr) were below detection limit in all the samples. The highest zinc (Zn) concentration was observed in Numan Arizona with 2.49 mg/Kg; followed by Numan Bush 1.99 mg/Kg and Yola Bush with concentration of 1.81 mg/Kg. The least zinc concentration was observed in Mubi Arizona with 1.06 mg/Kg; Numan Loud with 1.22 mg/Kg; and Numan Bush with 1.39 mg/Kg Also Yola Arizona has 1.65 mg/Kg; Yola Loud 1.71 mg/Kg and Mubi Loud with 1.77 mg/Kg. Yola Loud has the highest concentration of Iron (Fe) with 39.45 mg/Kg; followed by Yola Arizona with 27.12 mg/Kg and Mubi Loud with 25.93 mg/Kg. The least concentration of iron (Fe) was found in Numan Loud with 5.30 mg/Kg; followed by Mubi Arizona with 5.93 mg/Kg and Numan Arizona with 13.86 mg/Kg. furthermore, Numan Bush contain 15.42 mg/Kg; Yola Bush with 17.84 mg/Kg and Mubi Bush with 23.39 mg/Kg. the highest concentration of Manganese (Mn) was found in Yola Arizona with 4.05 mg/Kg; followed by Mubi Loud with 3.43 mg/Kg, and Numan Loud with 3.39 mg/Kg. The least concentration of manganese (Mn) was found in Yola Bush with 1.90 mg/Kg; Numan Arizona with 2.16 mg/Kg and Numan Bush with 2.23 mg/Kg. also, Yola Bush has 2.25 mg/Kg; Yola Loud-2.63 mg/Kg and Mubi Arizona with 3.09 mg/Kg. The Lead (Pb) was detected in both in Numan Bush and Arizona with same quantity of 0.68 mg/Kg. The highest copper (Cu) concentration was

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observed in Numan Bush with 11.33 mg/Kg; followed by Mubi Loud with 6.91 mg/Kg and Numan Arizona- 6.11 mg/Kg. The least Arizona with 4.04 mg/Kg and Mubi Bush-4.67 mg/Kg. Also, Mubi Arizona has 5.16 mg/Kg; Numan Loud-5.80 mg/Kg and Yola Loud 5.82 mg/Kg respectively.

Discussion

Heavy Metals Analysis of Cannabis Sativa

The heavy metals analysis of all the samples procured in Adamawa state showed absence of cadmium and chromium content. This result is in consonance with Zafeiraki et al., (2021), which reported the absence of cadmium content in cannabis examined in Greece. Cadmium and chromium compounds cause cancer of the lung. Also, positive associations have been observed between exposure to cadmium compounds and cancer of the kidney and of the prostate. The highest mean concentrations in *Cannabis Sativa* were found for Fe (19.36mg/kg) > Cu (5.86mg/kg) > Mn (2.792mg/kg) and > Zn (1.676mg/kg) > Pb(0.68mg/kg). This is to attest the high tendency of cannabis plant to bioaccumulate heavy metals from the soil. This result is similar to Amendola et al., (2021) who reported highest concentration of iron in many *Cannabis Sativa* products in Italy. The mean concentration of iron (Fe) in this study is 19.36 mg/kg. This is much higher compared to permissive limit by WHO/FAO of 0.05 mg/per day. Higher concentrations of Fe (245.55 mg/kg) were also reported for Cigar by Dahlawi et al., (2021), and different range of iron concentration (306.03–595.42 mg/kg) was also reported for different kinds of cigarette in Kogi, Nigeria Onojah et al., (2015). This accumulated Fe can be utilized in different biochemical processes. Excess iron, while normally vital for oxygen transport and enzymatic activity, can catalyze reactive oxygen species that damage DNA and cellular structures (Andrews, N. C. (2021). Redox-active iron, in particular, drives oxidative stress and mutations through Fenton chemistry (Valko et al,, 2024).

concentration of Copper (Cu) was found in Yola Bush with 2.91 mg/Kg; Yola

Also, the presence of lead (Pb) was observed in two samples (Numan Bush and Numan Arizona) in each cases, the concentration of Lead (0.68mg/kg) is higher than maximum limit (0.5 mg/kg) permitted Robert (2020) WHO (2024) reported that exposure to lead has a wide consequence for the general well-being, as ICH (2022) reported that lead has been associated with haematological and neurological disorders, renal failure, cardiovascular malfunction, and reproductive system. The body has the ability to accumulate heavy metals until it reaches a threshold where harmful destruction takes place. The abusers of *Cannabis Sativa* are prone to lead poisoning which has grave consequences on their health.

The mean concentration of Copper (Cu) was found to be 5.86 mg/kg with minimum concentration of 2.91 mg/kg and maximum concentration of 11.3mg/kg. The value is lower compared to maximum daily intake by the World Health Organisation. The copper (Cu) is an essential trace element for the body and also a nutrient for plants. It is usually bioaccumulated in nature. According to WHO (2019), oral exposure to copper levels greater than 70 mg/day can have serious health repercussions, including liver damage and gastrointestinal problems. Given that copper is highly bioaccumulated in nature, the likelihood of exposure to copper increases. Thus, the WHO recommends controlling copper levels in plants, such as herbal ones, that are likely to persist. WHO (2019).

The mean concentration of zinc in this study is 1.676 mg/kg which is lower than daily limit of

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Zinc (50 mg/kg). This value of zinc is similar to 1.641 mg/kg, reported for Cigar by Dahlawi et al., (2021), and much more lower compared to Zn concentrations in the range of 8.5– 23.18 mg/kg by Engida and Chandravanshi (2017). The variation in zinc concentration maybe due to soil factors and types of cannabis assessed. Zinc is an essential element for proper growth and development of human. The high concentration of zinc has been associated with copper deficiency in the liver, serum, and heart, interference with the functioning of copper metalloenzymes, as well as the storage of iron Galić et al., (2019).

The mean concentration of manganese (Mn) in this study was 2.792mg/kg which is significantly lower than permissive level (25 mg/kg per day). The value of manganese in this study is lower compared to manganese concentration (87.42–106.22 mg/kg) in cigar rete as reported by Poorolajal et al., (2020). Gauvin Gauvin et al., (2018)reported that the high concentration of manganese has the ability pass *via* olfactory receptor neurons from the nasal lumen through the cribriform plate to the olfactory bulb where it is accumulated before causing damages. The excess manganese in the body has been associated with difficulty walking; tremor and permanent neurological disorders such as manganism.

Conclusion

This research determined the levels of some heavy metals present in cannabis sold in Adamawa state. The three major brands of cannabis (Loud, Bush and Arizona) were procured from the three designated areas (Yola, Mubi and Numan) representing the three senatorial districts in Adamawa State. The samples were digested and analysed for Heavy metals (Fe; Cd, Pb, Cr, Cu, Mn and Zn) using standard procedures. The result of heavy metals revealed the absence of cadmium and chromium in all the samples, while lead (Pb) was found in Numan Bush and Numan Arizona brands of Cannabis. Iron (Fe) remains the highest concentration of analysed elements in all the samples. for Fe (19.36mg/kg) > Cu (5.86mg/kg) > Mn (2.792mg/kg) and > Zn (1.676mg/kg) >. Pb(0.68mg/kg). Although, most of the metals are within the acceptable regulatory limit, however, accumulation of those metals in a body could pose a great threat to general wellbeing.

Recommendation

The result of this research should be used for enlightment campaigns on Drug Demand Reduction because the most common drug abuse in Adamawa State, Nigeria is Cannabis. This study also recommends an assessment on the severe impact of cannabis users on the environment as that will help to implement policy that will be beneficial to Adamawa State Community Drug Control Committee.

Conflicts of Interest

The authors declare no conflict of interest.

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