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Comparative Study on the differences in Elemental-Uptake by Seeds and Leaves of *Datura Stramonium* (Linn)

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Currently, *D. stramonium* is handled as an esoteric plant, and its toxicity is arbitrarily attributed to the phytochemicals without consideration of heavy metals and macro-elements. The ingestion of the leaves and seeds causes many consumers to suffer innumerable health effects connected to heavy metals toxicity. This research determined the uptake of metals by the seeds and leaves of *Datura stramonium*. Atomic absorption spectrophotometer (Thermo Scientific Pvt. Ltd. India Model No. AA 303) Double Beam was used to screen nine heavy metals in the leaves and seeds of *D. stramonium*. The heavy metals - Ag, Cr, Cu, Fe, Hg, Mn, Ni, Pb and Zn, and macro-elements - Ca, K, Mg, P, and N were quantified and compared. Result gave Ag: 0.0569 ± 0.02 ppm for the seeds and 0.0285 ± 0.01 ppm leaves. Cr had 0.0583 ± 0.01 ppm in seeds but undetected in leaves. Cu 0.4203 ± 0.03 ppm in seeds and leaves 0.3557 ± 0.05 ppm. Fe had 4.0349 ± 0.10 ppm in seeds and 4.6463 ± 0.01 ppm in leaves. Mercury was undetected in the seeds, but 4.0000 ± 0.03 ppm was detected in leaves. Mn - 0.0972 ± 0.02 ppm in seeds, and 0.3565 ± 0.05 ppm in leaves. Ni - 0.1026 ± 0.1 ppm in seeds, and 0.9231 ± 0.02 ppm in leaves. Pb was undetected in seeds, but 0.5000 ± 0.01 ppm in leaves. Zn 0.4069 ± 0.02 ppm in seeds and 0.5368 ± 0.04 ppm leaves. The permissible limit of some metals is Cr 0.003 ppm, Cu 0.010 ppm, Fe 5.000 ppm, Mn 0.30 ppm, Ni 0.020 ppm, and Zn 2.00 ppm, respectively. The uptake of macro-elements - Ca, K, Mg, P, and N showed that the seeds had 9.3333 ± 0.03 ppm, and leaves 90.6667 ± 0.03 ppm for Ca. K - 6.4972 ± 0.04 ppm in seed, and 6.7293 ± 0.03 ppm in leaves. Mg - 11.0892 ± 0.02 ppm in seed and 12.3083 ± 0.01 ppm in leaves. P - 0.2000 ± 0.01 % in seeds and 0.38000 ± 0.21 % leaves, while N had 1.8910 ± 0.02 % in seed and leaves 4.4040 ± 0.32 %. The concentration of Ni, Zn, Cr, Pb, and Mn are above the permissible limits prescribed by the WHO. High accumulation of some heavy metals in leaves and seeds was due to plant tendency to accumulate precise metals. The contents of trace elements may be due to the polluted soil where the plant grows and its ability to selectively hoard elements.

Keywords: Heavy metals, elemental-uptake, Toxicity, bioaccumulation, and health-effect

INTRODUCTION

Elemental compositions of leaf and seed of *Datura stramonium* have been learned. *D.*

stramonium leaves and seeds are rich in mineral elements. The study showed the existence of cobalt, nickel, zinc, copper, potassium, calcium,

and nitrogen (BHATTACHARJEE et al. 2012). *Datura stramonium* as noxious herbs is scattered over humid and temperate regions of the world. Roughly ten types of *datura* have been identified as important drug plants (SCHULTES and HOFFMAN, 1979). *Datura* is also referred to as hallucinogen. The practice of *Datura stramonium* in medicine and traditional was witnessed in North America (LITZINGER, 1981). *D. stramonium* is customarily applied as antihelmintic, antiparasitic, and repellent (GUARRERA, 1999). In primeval India, *D. stramonium* is recognized in Ayurveda medicine (BHATTACHARYYA, 1994). *Datura stramonium* is used in the management of Parkinson's disease (PARKINSON'S DISEASE STUDY GROUP, 1995). The extract of *D. stramonium* is an effective toxin and if used indiscriminately, may lead to hallucination and severe poisoning that may ultimately lead to death (ASCHNER, 2005). *D. stramonium* is an imperative fragment of the human remedy since it contains minerals and trace elements (SOBOKOLA AND DAIRO, 2007). The accumulation of heavy metals by *D. stramonium* is due to the soil and atmospheric contamination (YUSUF et al., 2003). An elevated level of heavy metals (Cu, Cd, and Pb) in seeds and leaves is connected with a great incidence of toxication (TURKDOGAN et al., 2003). Many anthropogenic sources usually emit heavy metals to the atmosphere (BENSON AND EBONG, 2005). Heavy metals have a precise density of more than 5 g/cm³ with the harmful outcome on the location and living organisms (EBONG et al., 2003). Some heavy metals are central to the diet/food for plants and humans when they occur in adequate quantity. Some elements may be toxic to animals at greater concentrations. For instance, copper (Cu), chromium (Cr), fluorine (F), molybdenum (Mn), nickel (Ni), selenium (Se), or zinc (Zn) can be toxic. Heavy metals such as arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb) are toxic even at lesser concentrations (DIVRIKLI et al., 2006). Heavy metals can be recalcitrant and non-biodegradable; they can be remediated by typical cropping and washing away by running rainwater (KHADEEJA et al., 2013). They might be carried from the soil into ground waters or taken up by plants. For this purpose, the awareness of metal plant interactions is significant for the well-being of the environment and human health (DIVRIKLI et al., 2006). There has been increasing interest in determining heavy metal levels in public food supplied (Uroko et al., 2019). Conversely, their absorption in bio-available

usage is not comparable to the total concentration of the metal (NEAL et al., 2012; NWACHUKWU et al., 2010). In one way, *D. stramonium* has proved to be a possible indicator or heavy metal polluted soil since it has a high tendency to rapidly accumulate heavy metals from the polluted soils. The sustained ingestion of risky heavy metals in medicinal plants may cause the disorder of biological courses in the human body. Therefore, this investigation has established the identification of metals and macro-elements in both leaves and seeds of *D. stramonium* and the concentration relatively (YUSUF et al. 2003).

MATERIALS AND METHODS

Leaves and seeds of *D. stramonium*

D. stramonium leaves and seeds were used for this study. The fruits were sought from Kakwagom community in Boki local government area of Cross River state, by Mr. Anthony Bisong.

Preparation of samples

The seeds and leaves samples were washed with tap water followed by distilled water to remove adsorbed elements. Samples were cut into small pieces; air-dried for six days. The dried samples were crushed to particle sizes and sieved with a 1 mm mesh. Thereafter, 0.5 g of the dried samples (seeds and leaves) was digested with HNO₃, and HClO₄, in a 5:1 ratio until a transparent solution was obtained. The sample's digests were filtered and diluted to 25 ml, with distilled water. The heavy metals in the acid digests of samples were analyzed using atomic absorption spectrophotometer (AAS).

Instruments/Equipment

The concentration of heavy metals was carried out using Atomic Absorption Spectrophotometer, (Thermo Scientific Pvt. Ltd. India Model No. AA 303) Double Beam and deuterium background hollow cathode lamps of Fe, Pb, Cd, Zn, and Cu, respectively were used at specific wavelengths. Experimental studies of both seeds and leaves samples were carried out at the University of Nigeria, Nsukka, using Atomic absorption spectrophotometer (AAS).

Chemicals/Reagents

The chemicals and reagents used in the study were of analytical grade and were sourced from chemical stores in the Onitsha market, Anambra State, and Multi-User Laboratory at the Department of Biochemistry, University of Nigeria.

A 30 cm³ of aqua regia (a mixture of HNO₃ and HCl in the ratio of 1:3); de-ionized water, double distilled water, concentrated HCl, and 3 M HNO₃.

Estimation of Nitrogen/Crude Protein

Apparatus used: Micro-Kjeldahl digestion flask (500ml capacity) (Make: Barloworld U.K, model Fk 500/3I) Ohaus weighing balance (0.001g accuracy, model AR3130, Made in England). A catalyst (Mixture of 20g potassium sulfate, 1g copper sulfate, and 0.1g selenium powder), concentrated tetraoxosulphate (vi) acid. A quantity, 1g of the ground samples were weighed into the Kjeldahl digestion flask. 1g of the catalyst mixture was weighed and added into the flask. 15 ml of concentrated H₂SO₄ was also added. Heating was carried out cautiously on a digestion rack in a fume cupboard until a greenish clear solution appeared. The digest was allowed to clear for about 30 minutes. It was further heated for an additional 30 minutes and allowed to cool. 10 ml of distilled water was added to avoid caking. The digest was transferred into a 100 ml volumetric flask and made up to the mark with distilled water.

Statistical analysis

The data were laid open to One-way Analysis of Variance (ANOVA). Significant differences were accepted at $p < 0.05$. Results are expressed in means \pm standard errors of means (SEM). The analysis was computed using Statistical Product and Service Solutions (SPSS) software version 22.

RESULTS

The concentration of heavy metals in the seeds and leaves of *D. stramonium* was determined. Nine heavy metals were screened in both the leaves and seeds. The screened metals include Ag, Cr, Cu, Fe, Hg, Mn, Ni, Pb, and Zn. The concentrations of heavy metals in the leaves

and seeds differ. For example, comparing the leaves and seeds, Ag has 0.0569 ± 0.02 ppm for the seeds and 0.0285 ± 0.01 ppm in leaves, their concentration difference is (0.0284 ppm) less than $P < 0.05$. Cr had 0.0583 ± 0.01 ppm in seeds but was undetected in leaves. Cu had 0.4203 ± 0.03 ppm in seeds and leaves 0.3557 ± 0.05 ppm with difference (0.0646 ppm) greater than $P > 0.05$. For Fe, the seeds and leaves had 4.0349 ± 0.10 ppm and 4.6463 ± 0.01 ppm with a difference of 0.6114 ppm. Mercury was undetected in seed but had a concentration of 4.0000 ± 0.03 ppm in leaves. Mn had 0.0972 ± 0.02 ppm in seeds and 0.3565 ± 0.05 ppm in leaves with a concentration difference of 0.2593 ppm.

Nickel - 0.1026 ± 0.1 ppm was detected in seeds, and 0.9231 ± 0.02 ppm. Pb was undetected in seeds but had 0.5000 ± 0.01 ppm in leaves. Zn had 0.4069 ± 0.02 ppm for the seeds and 0.5368 ± 0.04 ppm in leaves. The tolerable maximum (TM) of some metals according to WHO standard are 0.003 ppm for Cr, Cu 0.010 ppm, Fe 5.000 ppm, Mn 0.30 ppm, Ni 0.020 ppm, and Zn 2.00 ppm, respectively. The concentration differences were calculated by subtracting the highest value either from the seed or leave, accessible in Table 1.

The uptake of macroelements - Ca, K, Mg, P, and N was stately measured. Investigation confirms that the seed and leaves of *D. stramonium* had 9.3333 ± 0.03 ppm and 90.6667 ± 0.03 ppm Ca, with a concentration difference of 81.3334 ppm, which is far greater than ($P > 0.05$) degree of confidence interval. A 6.4972 ± 0.04 ppm of K was found in seed and 6.7293 ± 0.03 ppm in leaves, with a difference of 0.2321 ppm. Mg had 11.0892 ± 0.02 ppm in seed and 12.3083 ± 0.01 ppm in leaves, P - 0.2000 ± 0.01 % seed and 0.38000 ± 0.21 % leaves and N 1.8910 ± 0.02 % in seeds and leaves 4.4040 ± 0.32 %, with difference of 2.5130% see Table 2.

Table: 1 Heavy metals concentration of *D. stramonium* seeds and leaves

| Heavy metals | <i>D. stramonium</i> seeds | <i>D. stramonium</i> leaves | Conc. difference between seeds and leaves | Permissible limits |
|--------------|----------------------------|-----------------------------|---|--------------------|
| Ag | 0.0569 ± 0.02 ppm | 0.0285 ± 0.01 ppm | 0.0284 ppm | - |
| Cr | 0.0583 ± 0.01 ppm | 0.000 ± 0.03 ppm | 0.0583 ppm | 0.003 ppm |
| Cu | 0.4203 ± 0.03 ppm | 0.3557 ± 0.05 ppm | 0.0646 ppm | 0.010 ppm |
| Fe | 4.0349 ± 0.10 ppm | 4.6463 ± 0.01 ppm | 0.6114 ppm | 5.000 ppm |
| Hg | 0.0000 ± 0.00 ppm | 4.0000 ± 0.03 ppm | 4.000 ppm | - |
| Mn | 0.0972 ± 0.02 ppm | 0.3565 ± 0.05 ppm | 0.2593 ppm | 0.30 ppm |
| Ni | 0.1026 ± 0.01 ppm | 0.9231 ± 0.02 ppm | 0.8205 ppm | 0.020 ppm |
| Pb | 0.0000 ± 0.00 ppm | 0.5000 ± 0.01 ppm | 0.5000 ppm | 0.010 ppm |
| Zn | 0.4069 ± 0.02 ppm | 0.5368 ± 0.04 ppm | 0.1299 ppm | 2.00 ppm |

The concentration difference was calculated by subtracting the highest value either from the seed or leave.

Table 2: Concentration of Macro-elements in seeds and leaves of *D. stramonium*

| Trace Elements | <i>D. stramonium</i> seeds | <i>D. stramonium</i> leaves | Conc. difference between seeds and leaves |
|----------------|----------------------------|-----------------------------|---|
| Ca | 9.3333 ± 0.03 ppm | 90.6667 0.03 ppm | 81.3334 ppm |
| K | 6.4972 ± 0.04 ppm | 6.7293 ± 0.03 ppm | 0.2321 ppm |
| Mg | 11.0892 ± 0.02ppm | 12.3083 ± 0.01 ppm | 1.2191 ppm |
| P | 0.2000 ± 0.01 % | 0.38000 ± 0.21% | 0.1800% |
| N | 1.8910 ± 0.02 % | 4.4040 ± 0.32% | 2.5130% |

DISCUSSION

An investigation to determine the elemental uptake by the seeds and leaves of *Datura stramonium* was carried out. Atomic Absorption Spectrophotometer, (Thermo Scientific Pvt. Ltd. India Model No. AA 303) Double Beam was used to quantitatively and qualitatively analyze the metals. Heavy metals are elements of toxic waste from the telluric environment due to noxiousness and buildup in part of plants such as seeds and leaves (ALAM et al. 2003). Heavy metals are involved in enrichers and insect killers as micro-nutritional or biocidal constituents; they may exist in nature as contaminants. Most seeds and leaves samples revealed measurable levels of the elements. The buildup of these elements in seeds and leaves may epitomize a health risk, particularly in a population with high ingestion proportions (DIEZ et al. 2009). For that reason, estimated daily intake or 'tolerable intake' is extensively used to designate 'safe' levels of intake of heavy metals. Chromium has been termed an indispensable trace element in humans and some animals (NGUTA, 2010). The permissible limit of Cr 0.0583 ± 0.01 ppm in the seed was above the established tolerable permissible limit of 0.003 ppm (USDOE, 2011). The concentration 0.5000 ± 0.01 ppm of lead in leaves sample and mercury 4.0000 ± 0.03 ppm was high, compared to their nonexistence or unobserved in seeds, which confirmed that the source of these metals was from the atmosphere. The undetected Cr in leaves and 0.0583 ± 0.01 ppm in seeds may reveal its natural occurrence or bioaccumulation from the soil. For example, comparing the leaves and seeds, Ag has 0.0569 ± 0.02 ppm for the seeds and 0.0285 ± 0.01 ppm leaves, with a concentration difference of (0.0284 ppm) less than ($P < 0.05$). Cr had 0.0583 ± 0.01 ppm in seeds but was undetected in leaves, which make the concentration difference (0.0583 ± 0.01 ppm), greater than ($P > 0.05$) confidence interval. Cu had 0.4203 ± 0.03 ppm in seeds and leaves

0.3557 ± 0.05 ppm with difference (0.0646 ppm) greater than ($P > 0.05$). For Fe, the seeds and leaves had 4.0349 ± 0.10 ppm and 4.6463 ± 0.01 ppm with a difference of 0.6114 ppm. Mercury was undetected in seed but had a concentration of 4.0000 ± 0.03 ppm in leaves. Mn had 0.0972 ± 0.02 ppm in seeds and 0.3565 ± 0.05 ppm in leaves with a concentration difference of 0.2593 ppm. For Ni, 0.1026 ± 0.1 ppm was detected in seeds, and 0.9231 ± 0.02 ppm. Pb was undetected in seeds but had 0.5000 ± 0.01 ppm. Zn had 0.4069 ± 0.02 ppm for the seeds and 0.5368 ± 0.04 ppm leaves. The permissible limit of some of the metals was investigated such as Cr 0.003 ppm, Cu 0.010 ppm, Fe 5.000 ppm, Mn 0.30 ppm, Ni 0.020 ppm, and Zn 2.00 ppm, respectively see Table 1.

The cases of metabolic disorders and diseases have been linked to the toxicity of heavy metals in food crops. The consumption/ingestion of contaminated fruits is the shortest route where humans and animals are exposed to heavy metal (UROKO et al., 2019). The intake of foods with elevated heavy metals has amplified the likelihood of inviting cancer and health ailments. This is because the uptake of heavy metals by plants and progressive apportioning alongside the food chain is a budding risk to the animals and human health. The uptake of macro-elements such as Ca, K, Mg, P, and N was also quantified in the seeds and leaves of *D. stramonium*. Data shows that the seed and leaves of *D. stramonium* had 9.3333 ± 0.03 ppm and 90.6667 0.03 ppm Ca, with a concentration difference of 81.3334 ppm, which is far greater than ($P > 0.05$) degree of confidence interval. A 6.4972 ± 0.04 ppm of K was found in seed and 6.7293 ± 0.03 ppm with a difference of 0.2321 ppm. Mg had 11.0892 ± 0.02ppm in seed and 12.3083 ± 0.01 ppm in leaves, P, 0.2000 ± 0.01 % seed and 0.38000 ± 0.21% leaves and N 1.8910 ± 0.02 % seed and leaves 4.4040 ± 0.32%, with difference of 2.5130% see Table 2.

(ASHRAF et al. 2010), reported that leaves can readily accumulate metals more proficiently

than seed. Chromium is an element in vegetables that plays a critical role in the metabolism of nutrients by aiding insulin. Chromium picolinate is a dietary supplement (OKPASHI et al. 2019). Copper is a vital micronutrient whose catalytic roles in humans are prerequisites for body pigmentation, central nervous system, and avert anemia (SOBUKOLA et al. 2007). Yet slight increases in the levels of copper and chromium (beyond the permissible limits) may inhibit physiological processes leading to organ damage (MATHEW et al. 2011). In humans, lead reasons a wide range of biological effects conditional to the level, and frequency of exposure and duration of ingestion. High lead intake may affect the interior organs together with the nervous, renal, reproductive, and hematological and immune system (DONGRE et al. 2010). During this investigation, the outcome suggests that *D. stramonium* has a very high concentration of metals far above the recommended permissible limit. Comparatively, there was no clear distinction of excess metal accumulation between the seeds and leaves. Therefore, one can infer that both the leaves and seed of *D. stramonium* bio-accumulate metals. Thus, the ingestion of either the leaves or seeds may elicit toxicity.

CONCLUSION

An attempt was made to provide an exhaustive elemental composition of two parts of *Datura stramonium*, with the view of bridging the existing knowledge. There were dissimilarities in the accumulation of mineral elements in the seed and leaves of *D. stramonium*. The Unsafe elements like lead and mercury were detected at a level higher than the permissible standards. *Datura* leaves showed high accumulation of Mn and Fe. Nevertheless, higher levels of heavy metal were detected in both samples. Ni, Zn, Cr, and Pb and Mn levels were above the WHO 2011 guidelines. Higher accumulation of heavy metals was attributed to the tendency of plants to accumulate particular metals in several environments.

CONFLICT OF INTEREST

The authors declared that the present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

The design, field and laboratory study was done by VEO. Writing of the manuscript was carried out by AFE, Supervision and review of the manuscript was done by OUA. Gathering of literature and laboratory analysis was done by KMU. Statistical analysis and data interpretation was done by IIH. All authors read and approved the final version.

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