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RESEARCH ARTICLE

COMPARATIVE ASSESSMENT OF HEAVY METAL LEVELS IN CHICKENS (*GALLUS GALLUS DOMESTICA*) IN RURAL (ELELE) AND URBAN (NNEWI) AREAS

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ABSTRACT

Industrialization of the modern world has been found to generate compounds which are deleterious to life. This study assessed some heavy metal levels of the factory chickens in Nnewi, Anambra State, Nigeria. A total of twenty-nine (29) chicks aged between four (4) and five (5) months were grown to adult birds (chickens) for the study. They were allowed to feed from the surrounding homeland until they were due for the experiment. The chickens were sacrificed to obtain the blood for analyses. Approximately, 10ml of blood was collected from the heart into EDTA and Lithium heparin containers respectively for the estimation of lead (Pb) and other heavy metals (Nickel, Copper, Zinc, Arsenic and Selenium (Se). The plasma lead (Pb), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As) and Selenium (Se) were determined by atomic absorption spectroscopy (AAS).The data obtained were subjected to statistical analysis by Students t-test using Statistical package for social sciences (SPSS) (Version 16) software. A $P<0.05$ was considered as significant. The result showed a significant decrease in the mean plasma level of Nickel (Ni) in the factory chickens (Urban chicken) when compared with the control chickens (rural chickens),(2.45 ± 0.33 Vs 2.81 ± 0.35; $p=0.009$), whereas, the mean plasma level of copper (Cu) was significantly increased in the factory chickens in comparison with those of the control chickens (9.11 ± 0.92 Vs 8.37 ± 0.10; $p=0.049$).Interestingly, there were no statistical significant differences observed in the mean plasma levels of Zn, As, Se, and Pb respectively ($p>0.05$).Therefore, the implication of this finding is that the consumption of chickens reared in urban areas may predispose the consumers to copper toxicity which may cause harmful effects on the kidneys and liver. Hence, caution may be necessary in its consumption inorder to avoid the bio-accumulative effects.

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INTRODUCTION

Industrialization of the modern world has been found to generate compounds which are deleterious to life especially to those who work in such industries. Nnewi is one of such growing industrial towns in South Eastern Nigeria and it is the second largest city in Anambra State. The city spans over 2,789 square kilometers (2,789 km^2). According to a 2005 estimate, Nnewi metropolitan area and its satellite towns is home to nearly 2.5 million residents with the geographical coordinates of 6° 1' 0" North, 6° 55' 0" East.

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Several of such industries in Nnewi are manufacturers of such products as motor car and motor cycle spare parts, electrical appliances, cooking utensils, lead acid batteries, plastics, lead ingots etc. Many of such industries are in close proximity with the living population with the attendant poor enforcement of environmental laws (Orisakwe *et al.,* 1999). One of the major effluents of some of these industries is'heavy metals'. Heavy metals are those components of the earth's crust that cannot be degraded or destroyed. They are of relatively high density and are toxic or poisonous even at low concentration (Lide, 2002); of atomic density greater than 4gmcm^{-3} with a specific gravity that is at least 5 times the specific gravity of water (Jarup, 2003). Some of the heavy metals such as zinc (Zn), copper (Cu), selenium (Se) have been reported to be useful to the human system (Chatterjea and Shinde, 2007). There are, however, some other heavy metals such as lead (Pb), nickel

(Ni), and arsenic (As) etc, which are of no bio-importance whose levels have been found to be high and uncomfortable in soils, rivers and plants surrounding such industries in Nnewi that suggest possible threat to the living population (Orisakwe, *et al.,* 1999, 2004; Asomugha *et al.,* 2005; Nduka and Orisakwe, 2010; Bronstein, 2012). Threatening levels of such metal pollutants have been detected in meat (Akan *et al.,* 2010); chickens (Okoye *et al.,* 2011) and vegetables (Harmanescu *et al.,* 2011; Suruchi and Pankaj, 2011) and soil (Nduka *et al.,* 2006) around such sites. Many of the effluents of such industries have been known to compromise liver and kidney functions in artisans occupationally exposed to them (Dioka *et al.,* 2004; Wu *et al.,* 2012). Chronic (long-term exposure) effects of Cu can damage the liver and kidneys (Niebeor *et al.,* 2007). Exposure to cadmium has been found to disturb the metabolism and functions of some essential elements including copper, zinc, iron, calcium and magnesium (Jurczuk *et al.,* 1997a, b). Excess of some heavy metals have been found to stimulate the formation of free radicals and reactive oxygen species (ROS) perhaps resulting in oxidative stress (Dietz *et al.,* 1999; Bal *et al.,* 2000). Metals such asPb have been shown to be toxic to humans and animals by causing liver cells to enlarge leading to hyperplasia and initiating the formation of tumors in liver cells (Goyer, 1995; Durgut *et al.,* 2008).

Zinc, on a long term exposure, interferes with metabolism of other trace elements (Fisher *et al.,* 1984).Very high zinc levels can lead to the damage of pancreas and disturb protein metabolism and it can also lead to health problems like stomach cramp, skin irritation, vomiting and nausea. Asseth *et al.* (1986), reported that acute and sub-acute Cu intoxication can affect the liver, kidney and brain functions, while mercury is hazardous and toxic to cause neurological disturbances (Rao, 1989). It has been reported that Ni can cause morphological transformation and chromosomal aberration in cells (Coen *et al*., 2001) and can lead to cancer (Tokar *et al*., 2011). Chronic selenium (Se) poisoning in people is characterized primarily by loss of hair and changes in fingernail morphology (FNB, 2000). Skin lesions (redness, blistering) and nervous system abnormalities (paresthsia, paralysis, aophelmilegia) are also observed. While in animals, liver damage is a common feature of chronic selenosis; humans have not shown a convincing evidence of hepatic effect. Exposure to arsenic (As) at low levels for extended periods of time can cause a discoloration of the skin and the appearance of small “corns” or “warts” (Guha, 2001), while a large acute dose results in tachycardia, acute encephalopathy, congestive heart failure, stupor, convulsions, paralysis, coma and even death (Morton and Caron, 1989).

Copper toxicity usually occurs after a prolonged exposure to copper piping carrying drinking water supply. This may cause nausea, vomiting and diarrhea, while possibly causing liver damage in the long term (Ferner, 2001). In Nnewi, most of the industries and factories consume materials which contain many of these heavy metals. Since evidence abounds that effluents of these factories have been found to contain appreciable quantities of these metals either in soil, plant or running water (Orisakwe *et al.,* 1999, 2004), there is a strong indication that individuals who work in these factories would be accumulating them in their bodies. Birds are traditional objects of biological monitoring in polluted ecosystems, especially in territories adjacent to stationary sources of pollution. Extensive studies on heavy metal concentration in birds have been conducted in many countries. A few works on accumulation of toxicants in populations of different bird species in particular regions of Russia (Dobrovol’skaya, 1980; Glazov and Leontyeva, 1993), whereas monitoring of environmental quality is quality carried out on a large scale. Blood profiles of chickens can be used as a diagnostic tool to assess the health status of an individual and/or flock (Tras *et al.,* 2000). There is limited information concerning the normal blood profiles of different indigenous chickens of varying age and for husbandry regimens in Nigeria (Mushi *et al.,* 1999). Such information apart from being useful for diagnostic and management purposes could equally be incorporated into breeding programmes for genetic improvement of indigenous chickens (Krall and Suchy, 2000). Hence, this study comparatively assessed the Heavy Metal Levels in Chickens (*Gallus gallus domestica*) in rural (Elele) and urban (Nnewi) Areas.

MATERIALS AND METHODS

Experimental design: A total of twenty-nine (29) chicks were grown to adult birds (chickens) for the study. The chicks in the exposed group were obtained from the surrounding households, about 250m to these factories under study (lead acid battery factory, cable manufacturing factory, metal fabricating factory and metal forging factory) while the chicks to serve as control were obtained from Elele. They were aged between four (4) and five (5) months. They were allowed to feed from the surrounding homeland until they were due for the experiment. Control chickens of the same age group were obtained from environments outside Nnewi. The chickens were sacrificed to obtain the blood for analyses.

Collection of blood from the chickens: At the end of the study period that lasted eighteen (18) weeks, the (birds) chickens were each anaesthetized with ether soaked in absorbent cotton wool and kept in a dessicator with the lid firmly put in place to prevent evaporation. Approximately, 10ml of blood was collected from the heart. Blood samples for the determination of lead (5ml) were delivered into new EDTA containers, mixed and stored frozen at -4^{0}C until analyzed. The rest of the blood sample was delivered into new lithium-heparin containers, stoppered and gradually mixed to prevent clotting. The blood samples were then centrifuged for 3 minutes at 2000 rpm. The plasma were separated and put into clean dry sample containers and stored deep-frozen at -4^{0}C until analyzed. The plasma was used for the estimation of heavy metals (Pb, Ni, Cu, Zn, As and Se) by atomic absorption spectroscopy (AAS) according to the method of Smith *et al.* (1979).Determination of lead in whole blood was done using the method as described by Hessel, (1968).

Ethical Consideration: Ethical approval for the research was obtained from Faculty of Health Sciences and Technology Ethical Committee, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria (NAUTH/CS/66/Vol.2/149).

Statistical Analysis: The data were presented as mean±SEM and the mean values of the control and test group were compared by Students t-test using Statistical package for social sciences (SPSS) (Version 16) software. A $P<0.05$ was considered as significant.

Table 1. Assessment of metal levels of the factory chickens

Chickens	Ni (µmol/L)	Cu (µmol/L)	Zn (µmol/L)	As (µmol/L)	Se (µmol/L)	Pb (µmol/L)
Control (n=13)	2.81±0.35	8.37±0.10	2.39±0.54	1.21±0.01	0.36±0.505	0.89±0.10
Factory (n=16)	2.45±0.33	9.11±0.92	2.65±0.43	1.19±0.00	0.35±0.05	0.95±0.12
t-value	2.799	-2.091	-1.464	-0.409	0.580	1.006
p-value	0.009	0.049	0.155	0.689	0.567	0.323

*Statistically significant at $p<0.05$; Results are Mean± SD.

RESULTS

In this study, there was a significant decrease in the mean plasma level of Nickel (Ni) in the factory chickens when compared with control subjects (2.45±0.33 Vs 2.81±0.35; p=0.009), (See Table 1). However, the mean plasma level of copper (Cu) was significantly increased in the factory chickens in comparison with those of the control subjects (9.11±0.92 Vs 8.37±0.10; p=0.049), (See Table 1). Interestingly, there were no statistical significant differences observed in the mean plasma levels of Zn, As, Se, and Pb respectively (p>0.05), (See Table 1).

DISCUSSION

The result of the present study showed that there was a significant decrease in Nickel level in the factory chickens (*Gallus gallus domestica*) than the controls(2.45±0.33 Vs 2.81±0.35; p=0.009), while Copper level was significantly elevated in the factory chickens(*Gallus gallus domestica*) than the control(9.11±0.92 Vs 8.37±0.10; p=0.049), (See table 1). The levels of Zn, As, Se, and Pb did not differ significantly from the control although Pb level was higher in the factory chickens than the control (p>0.05). There is paucity of reference values for these metals in blood of chickens but Price and Birge, (1998) reported elevated whole blood concentrations of copper (Cu), lead (Pb), nickel (Ni), and Zinc (Zn), in hawks as compared with mean values for chicken blood. The low level of metals obtained in this work may be due to the fact that metals have a shorter half-life in blood than in most other tissues (e.g. liver), and, therefore, blood values are not necessarily the best measure of the metal exposure. In addition, certain metals (e.g. Cu, Zn) are effectively down-regulated in homeotherms that experience exposure to metal pollution. The level of Ni obtained in this work calls for concern because occupational exposure to Ni has been found to result in increased urinary Ni excretion (Neiboer *et al.,* 1988; Smith-Siversten *et al.,* 1998). Earlier work reported showed that a metal such as lead (Pb) has been found to be high in the soil surrounding one of these factories under study (Asomugha *et al.,* 2005) and this reflects the tendency for the metal to accumulate in the multitude of pollutant sites along the food chain such as consumable domestic chickens. However, the non-significant posture presented by the levels of most of these metals may be attributable to the short duration of exposure of these chickens to the environment under review.

Conclusion

In conclusion, there was a significant decrease and increase in the mean plasma levels of Nickel and copper respectively in the factory chickens when compared with the control subjects. However, the mean plasma levels of Zn, As, Se, and Pb did not differ significantly in both test and control chickens. Therefore, the implication of this finding is that the consumption of chickens reared in urban areas may predispose the consumers to copper toxicity which may cause harmful effects on the kidneys and liver. Hence, caution is necessary in its use.

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