The bioaccumulation of mercury in kidney and liver of wistar rat exposed to methyl mercury

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ABSTRACT

The bioconcentration of mercury in the kidney and liver of rats was studied. Twenty-four wister rats were randomly divided into four experimental groups (n=6). Group A (control) were given rat chow and drinking water. Group B (given rat chow +10% by mass of Solanum lycopersicum). Group C (given rat chow + mercury in water at a concentration of 10 ppm). Group D (given rat chow +Hg in 10 ppm+10% by mass of sl).

The result shows a statistically significant increase (P<0.05) in the concentration of mercury in the liver and kidney. There was also a statistically significant increase (P<0.05) in liver enzyme Glutamate Pyruvate Transaminase(GPT) and Glutamate oxaloacetate Transaminase (GOT), which shows the destructive effects of mercury in the organs. The study also shows a statistically significant decrease in the destructive effects as a result of the administration of Solanum lycopersicum.

Key words : Bioaccumulation, Mercury poisoning, Solanum lycopersicum, Liver enzymes.

INTRODUCTION

With increasing industrialization, there is an increased release of toxicants including heavy metal into the environment, with subsequent effects on the public health.

Methyl mercury (MeHg) intoxication has been a public health problem for many decades (WHO 1990). Mercury is naturally occurring element, existing in multiple forms and in various oxidation states. It is used in a wide variety of products and processes. Exposure to mercury can occur in both occupational and environmental setting, the later primarily dietary exposure (ATSDR, 1989).

The most famous methyl mercury poisoning cases occurred in Minamata and Niigata in Japan in the 1950-1960s, where the consumption of methyl mercury contaminated sea food caused the death or incapacitation of many people (Takeuchi,1998). The neuropathy caused by this is named Minamata disease. Methyl mercury is known to pass through the placental barriers and produce many deleterious effects on the unborn fetus (Mottet, 1987). Some evidence suggests that mercury accumulates on the fetal side of the placenta resulting in higher concentration in the fetus (Viny et al.,1990) and accumulates in the brain (Choi, 1989), this results to cerebral palsy, mental retardation, low birth weight and early sensorimotor dysfunction (Gilbert and Grant-Webster, 1995).

Organic mercury is readily distributed throughout the body but tends to concentrate in the brain and kidneys (ATSDR,1989;Goyer, 1991).Mercury is known to bind to microsomal and mitochondrial enzymes resulting in cell injury and death. Mercury in renal cells localizes in lysosomes (Madsen and Christensen, 1978).
A report from Dutclak et al (1991) indicates that extensive absorption of methyl mercury occurs in the gall bladder and subsequent biliary-hepatic cycling of the compound contributes to its long biologic half life.

Mercury is not destroyed by metabolism, but rather converted to different forms and oxidation state (ATSDR 1989) and involves an oxidation-reduction cycles. The primary route of its excretion is urine and faeces (ATSDR 1989). This may explain the renal damage and failure associated with its toxicity (Yasutake et al., 1990; Moreira and Moreira, 2004).

To lower the bioaccumulation of mercury in organs in the body chelating agents are used, a well known example is DMPS(2,3-dimercapto-1-propanesulphurnic acid). Repeated use slowly lower the level of methyl mercury in the brain but had little effect on inorganic mercury (Pinigree et al, 2001)

*Solanum lycopersicum* commonly called "Tomatoes" is a plant in the solanaceae family. It is native to central and south America. Tomatoes is one of the best sources of lycopene. It is the nutrient that gives it the red color. Chemically, lycopene is a bioflavonoid, closely related to beta carotene. It is one of the most important antioxidant (Ihesie, 2008). It helps strongly in neutralizing free radical and therefore protect cells and tissues from degenerative cancerous change. It also enhances the functional capacity of the liver. It is very useful in the treatment and prevention of prostate, breast, ovarian and cervical cancers (Ihesie, 2008).

Therefore this study is designed to find out the bioaccumulation of mercury in the kidney and liver of wistar rats and possibly the detoxification of the effect by the use of *Solanum lycopersicum*. The result of this study will help in ameliorating the increasing effect of mercury poisoning in our environment.

**MATERIAL AND METHODS**

Twenty-four rats of the wistar strain were purchased from the animal house unit of College of Health Sciences, Delta State University, Abraka. Nigeria. The rats weighed between 150g-180g. They were about 9-10 weeks old. The rats were kept in standard environmental conditions and allowed two weeks to acclimatize. The rats were randomly divided into four experimental groups of six rats in each group.

Group A (control) were given clean drinking water ad libitum and rat chow.

Group B were given rat chow +10% by mass of *Solanium lycopersicum*(sl).

Group C were given rat chow +mercury in water at a concentration of 10ppm.

Group D were given rat chow +mercury in water at a concentration of 10ppm +10% by mass of *Solanium lycopersicum*(sl)

**Preparation of tomatoes**

Riped tomatoes were bought from a local market in Warri, Delta State, Nigeria. It was rinsed to remove debris. It was milled and moderately dried in an oven to allow for good mixing with the rat chow. The required quantity was calculated and administered orally.

**Collection of samples**

The rats were sacrificed by decapitation after an overnight fast. The whole blood sample obtained was centrifuged at 1,200xg for 5 minutes at room temperature. The sera were used to analyze the liver enzymes within 1 hour of collection.

The kidney and liver were dissected out trimmed to remove fats and processed for mercury content. Local ethical committee gave approval for the handling and method of sample collection.

**Mercury bioaccumulation analysis**

The kidneys and liver were separately dried at 60°C and pulverized into a uniform particle size prior to analysis. Each component of the dried kidney and liver were weighed out and digested in a conical flask with mixed acid prepared from 2ml HCLO and 20ml HNO₃ (Ney, 1983).

The resultant solution in the conical flask were placed on hot plate with constant stirring before they were transferred into the fume cupboard and allowed to stand overnight. On cooling, the mixture was filtered and the filtrate was made up to 100ml in a volumetric flask with deionised water. The
solution were analyzed for mercury (as recommended by American Chemical Society, 1988). All acids and reagents were of analytical grade. All samples were analyzed in triplicate and coefficient of variation was less than 5%

Liver enzyme analysis

The serum was used for the analysis of Alkaline phosphatase (ALP), Glutamate oxaloacetate transaminase (GOT), and Glutamate pyruvate Transaminase (GPT). This was done using atomic absorption mass spectrophotometer as recommended by International Federation of Clinical Chemistry (IFCC).

Statistical analysis

All statistical analysis was done using the computer package SPSS-pc (version 7.5).

RESULTS

The results obtained are as shown in the tables below.

### Table 1: Liver Enzymes analysis at the end of the experiment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GP A n=6 (control)</th>
<th>GP B n=6 chow +10% mass of sl</th>
<th>Rat</th>
<th>GP C n=6 Rat chow +Hg at conc of 10ppm</th>
<th>GP D n=6 Rat chow +Hg at conc of 10ppm +10% mass of Sl</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPT µ/l</td>
<td>2.10± 0.09</td>
<td>2.20 ± 0.50</td>
<td>4.05 ± 0.05*</td>
<td>2.30 ± 0.04</td>
<td></td>
</tr>
<tr>
<td>GOT µ/l</td>
<td>1.85± 0.04</td>
<td>1.90 ± 0.29</td>
<td>4.47 ±0.14*</td>
<td>2.70 ± 0.60</td>
<td></td>
</tr>
<tr>
<td>ALP µ/l</td>
<td>4.45± 0.14</td>
<td>4.55 ± 0.90</td>
<td>4.60 ±0.22</td>
<td>4.40 ±0.20</td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SEM

GPT = Glutamate pyruvate transaminase. GOT = Glutamate oxaloactate Transaminase. ALP = Alkaline phosphatase; sl = Solanum lycopersicum; Hg = mercury; ppm = parts per million.

*statistically significant.

### Table 2: Bioconcentration of mercury in the kidneys and liver

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GP A n=6 (control)</th>
<th>GP B n=6 chow +10% mass of sl</th>
<th>Rat</th>
<th>GP C n=6 Rat chow +Hg at conc of 10ppm</th>
<th>GP D n=6 Rat chow +Hg at conc of 10ppm +10% mass of Sl</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIDNEYS (mg/kg)</td>
<td>0.01± 0.04</td>
<td>0.01 ± 0.01</td>
<td>0.36 ± 0.15*</td>
<td>0.14± 0.11</td>
<td></td>
</tr>
<tr>
<td>LIVER (mg/kg)</td>
<td>0.04 ± 0.02</td>
<td>0.03 ± 0.02</td>
<td>0.96 ± 0.18</td>
<td>0.37 ± 0.21</td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SEM. Hg = mercury; sl = Solanum lycopersicum; ppm = parts per million.

DISCUSSION

Table 1 shows the changes in the liver enzymes level at the end of the study. The result shows a statistically significant (P<0.05) in Glutamate pyruvate Transaminase (GPT) and Glutamate oxaloacetate Transaminase (GOT) in Group C (fed rat chow +Hg at a concentration of 10ppm). There was no statistically significant change in Group D (fed rat chow +Hg at concentration of 10ppm + 10% mass of Solanum lycopersicum). There was also no statistically significant difference in Alkaline phosphatase in all the groups. This is consistent with the finding of (UNEP 2002) that reported hepatic impairment. This study therefore shows that a degenerative/necrotic change occurs
with the administration of mercury and this effect could be reduced/ameliorate by the administration of *Solanum lycopersicum* as shown in Group D.

Table II shows the bioconcentration of mercury in the kidney and liver. The study shows a statistically significant increase (P<0.05) in the concentration of mercury in the kidney and liver as shown in Group C and an increase in the values in Group D but not statistically significant. There is a dearth of information on this aspect of the report. But this study shows that mercury accumulates in the organs studied with a progressive distruction of its primary function. The study also shows a decrease in bioaccumulation of mercury as a result of administration of *Solanum lycopersicum*.

**CONCLUSION**

The study has shown the degenerative effect of mercury toxicity in the organs studied and the ameliorating effect of *Solanum lycopersicum*. However a histopathological study of the organ is recommended for further knowledge on the extent of tissue damage.

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**REFERENCES**