Chromium induced changes in biochemical composition and gonado-somatic index of a teleost, *Oreochromis mossambicus* (Peters)

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**Abstract**

Biochemical composition such as total carbohydrates, cholesterol and proteins in ovary of a freshwater fish *Oreochromis mossambicus* were studied with respect to heavy metal chromium toxicity. Disparity in gonado-somatic index (GSI) of this fish was also observed. Significant changes in the biochemical contents (p<0.05) and GSI (p<0.001) were observed during this study. Diminution in total proteins was 1.36 ± 0.63 mg/g whereas significant elevations in total carbohydrates and cholesterol (0.59 ± 0.47, 364.17 ± 54.26 mg/g respectively) and in GSI (6.89 ± 0.30) as compared to the control fish were noted. These variations in biochemical constituents and GSI during the present study may be an indication of stress caused due to toxicant chromium.

**Keywords:** Heavy metals, Carbohydrates, Cholesterol, Proteins, Ovary, Tilapia

**1. Introduction**

Recently, it has been reported that there are 23 elements described as heavy metals. These are released in small amounts by various cataclysm processes such as weathering of rocks, volcanic eruptions, domestic, industrial (mining, electroplating, paints, dyes, battery makings etc.) and anthropogenic activities which increase their concentration into the environment [1, 2, 3]. The elevated concentration of heavy metals caused contamination of natural freshwater systems and may affect physiological, biochemical as well as behavioral pattern of aquatic organisms [4, 5, 6, 7]. Heavy metals bioaccumulation in fishes cause adverse effects at different functional levels such as reproduction, growth and development; ultimately leading to mortality of organisms [8, 9, 10, 11].

Among the aquatic pollutants, chromium (Cr) is one of the severe heavy metals which contaminates the environment through release from various industries such as oil, paint, motor vehicle, aircraft, printing, electroplating and chemical etc. It is a ubiquitous trace element which occurs in soil, air and water. Exposure of fish to chromium affects physiology and growth rate leading to deleterious health effects including allergy and even organ system-toxicity [11, 12, 13, 14].

The toxicity of Cr with respect to different physiological processes in fishes have been carried out by different researchers [12, 15, 16, 17, 18, 19, 20, 21, 22]. Chromium is an essential micronutrient playing an important role in carbohydrate and lipid metabolism of animals. Tilapia fishes belong to the family Cichilidae. They are highly tolerant to poor water quality, disease resistance and have good growth rate. They are exclusively freshwater inhabitants and widely distributed in tropical and sub-tropical regions of South, Central America and Africa [23].
*Oreochromis mossambicus* is introduced in India and other parts of the world extensively. It is commercially important in fisheries, aquacultures and ornamental purposes. Maximum size attained is 39 cm and weight of about 1.1 kg. It is mainly omnivorous, shows plasticity in its feeding habits and reproductive biology. It reaches sexual maturity at a length of 15 cm, is polygamous and maternal mouth breeder. This fish is extensively used in research to study its biology and physiology [24]. Present study was carried out to evaluate impact of Cr toxicity on biochemical constituents (total proteins, carbohydrates, cholesterol) and GSI in the fresh water teleost *O. mossambicus* as Cr can affect the reproductive physiology, growth and development of this commercially important fish.

2. Materials and Methods:
Freshwater tilapia fish *O. mossambicus* of average weight 30-40 grams were used in the study. Healthy fishes were collected from local Naik talao, a small freshwater pond situated at urban locality of Nagpur city in the State of Maharashtra, India. The collected fishes were brought to the laboratory and acclimatized for about 7 days in a rectangular glass aquarium of 50L capacity. Water quality parameters such as temperature, pH, dissolved oxygen and total hardness for acclimatization were 21.5 °C, 7.3, 7.7 mg/L and 140 mg/L respectively [25]. Acute toxicity test within the short period was conducted to determine the toxicity range of heavy metal Cr using potassium dichromate salt. The fishes were exposed to different concentrations of Cr. From mortality data of fishes, the median lethal concentration (LC$_{50}$) calculated [26]. It was found to be 101.78 mg/L. In order to determine the biochemical constituents of ovary and GSI, the fishes were exposed to one third (33.93 mg/L) of LC$_{50}$ as sub-lethal concentration for 7 days. The control (without Cr) was set separately. At the end of exposure period, the fishes were sacrificed and body weight of each fish from control and experimental groups were accurately measured using weighing balance. Ovaries were dissected out and accurately weighed for calculation of GSI as follows:

$$\text{GSI} = \frac{\text{Weight of ovary}}{\text{Body weight of fish}} \times 100$$

The biochemical constituents of ovary were determined by following methods -
- Total proteins: Lowry’s method [27] with slight modification [28]
- Total carbohydrates: Anthrone reagent method [29]
- Total cholesterol: Liberman- Burchard method [30]
- Statistical analyses: Data obtained was processed and analyzed using computerized application software Microsoft Office Excel version 2010 and was presented as mean, standard deviation and percent change. Student’s “t” test was used for statistically significance level at p < 0.05 and p < 0.001.

3. Results:
Biochemical constituents of ovary and GSI of control and experimental fish are depicted in Table 1. Results showed significant variations in biochemical constituents (total proteins, carbohydrates, cholesterol) and GSI. Mean concentration with standard deviation of total protein content in controlled ovary was 1.39 ± 0.53 mg/g of wet weight while in case of experimental ovary it was 1.36 ± 0.63 mg/g. The depletion of protein content was 2.16%. Total carbohydrates and cholesterol were 0.54 ± 0.13 mg/g and 334.33 ± 69.57 mg/g respectively of wet weight of controlled ovary. In case of experimental ovary, the mean concentration of total carbohydrates and cholesterol were 0.59 ± 0.47 mg/g and 364.17 ± 54.26 mg/g of wet weight respectively. The percent increase in total carbohydrates and cholesterol were 5.88 ± 0.11 while in case of experimental fish it was 6.89 ± 0.30. The variation in GSI was 17.18%. The variations in biochemical constituents and GSI were tested statistically which were significant at p < 0.05 and p < 0.001 as shown in following table.

<table>
<thead>
<tr>
<th>Exposure group</th>
<th>Biochemical constituents (mg/g)</th>
<th>Gonado-somatic index (GSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protein</td>
<td>Carbohydrate</td>
</tr>
<tr>
<td>Control (without Cr)</td>
<td>I</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>1.79</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>1.39 ±0.53*</td>
</tr>
<tr>
<td>Experimental (with Cr)</td>
<td>I</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>1.36 ±0.63*</td>
</tr>
<tr>
<td></td>
<td>Percentage change</td>
<td>-2.16</td>
</tr>
</tbody>
</table>

*Values are statistically significant at p<0.05 **Values are statistically significant at p<0.001
4. Discussion:
Biochemical composition of fish tissues is important to evaluate their specific physiological demands during various stages of life. Additionally, the proteins are important group performing different physiological functions. They act as nutrient and energy sources \(^{31, 32}\). Proteins and its metabolism are highly sensitive to environmental stresses \(^{33}\). Previous studies revealed that depletion in total proteins arrest metabolism to combat stress. Active degradation of proteins, destruction of cells due to impairment of protein synthesis and impending energy demands are major causes for depletion in total proteins under pollutants stress \(^{34, 35, 36, 37, 38}\). The declined total proteins in vital organs of different fishes with respect to heavy metal toxicity were carried out by many researchers \(^{39, 40, 41, 42, 43}\). A significant decrease in total proteins was observed during the study (Table 1 and Fig 1). This may be due to the difference in metabolic calibers (impaired rate of protein synthesis, utilization of proteins in cell repair, uptake of amino acids into polypeptide chains) of ovaries during the exposure period.

![Variation in total proteins and carbohydrates after chromium exposure](image)

Fig 1: Variation in total proteins and carbohydrates after chromium exposure

Fishes constitute very low amount of carbohydrates variable to environmental factors like seasons and physiological factors like feed intake \(^{44}\). Heavy metals affects the carbohydrate metabolism \(^{38, 45, 46}\). The heavy metals induced changes in carbohydrates in different fishes were reported by various authors explaining that the decline in carbohydrate contents may be due to metabolic stress \(^{39, 46, 47, 48, 49}\). In the present study, a significant elevation in total carbohydrates was observed (Table 1 and Fig 1). This may be due to decline in activity of some enzymes involved in the process of glycolysis. Impairment of the process of glycogenesis and glycogenolysis may be the reason for increased level of carbohydrates in ovary of experimental fish. Similar results were reported by some authors \(^{40, 50, 51, 52}\).

Lipids are vital energy source to maintain the structural and physiological aspects of cell membranes. They play an important role in transporting the substrates via circulatory system in animals \(^{53}\). Cholesterol is important for maturation of gonads as it is a precursor for steroid hormone synthesis. It is associated with reproduction in fish \(^{32, 54, 55, 56}\). In the present study, heavy metal Cr induces total cholesterol content in ovary of O. mossambicus. Cholesterol is significantly elevated in experimental fish as compared to controlled one (Table 1 and Fig 2).
The augmented cholesterol in experimental fish may be due to increase in tissue cholesterol synthesis and decrease in cholesterol catabolism as a result of metal toxicity. The elevated (accrued) cholesterol in ovary may be attributed to increase in cortisol synthesis needed for vitellogenesis during ovarian growth and development. Similar results were reported by various authors on the changes in cholesterol content in different fishes due to environmental contaminants like heavy metals \[46, 52, 57, 58, 59, 60\].

![Fig 2: Variation in total cholesterol after chromium exposure](image1)

![Fig 3: Variation in gonado-somatic index (GSI) after chromium exposure](image2)
Gonado-somatic index (GSI) is the measurement of gonadal weight relative to body weight in fish. It is used to study the maturation and development of gonads (ovary and testis) during the reproductive cycle of fish [64, 62]. Present study revealed the toxic effects of heavy metal Cr on GSI in tilapia fish, O. mossambicus. Significant elevation (17.18%) in GSI was observed in experimental fish as compared to the controlled one (Table 1 and Fig 3). Increase in GSI indicated adaptability of ovary in mature fish to heavy metal Cr toxicity.

5. Conclusion:
Present study revealed significant changes in biochemical constituents (total proteins, carbohydrates, and cholesterol) and GSI which may be due to heavy metal Cr toxicity. This might be due to the adaptive response which is characteristic of vertebrates. The data obtained from this study can be beneficial for explaining the reproductive physiology of fishes under toxicological stress of heavy metals.

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