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ORIGINAL ARTICLE

# Seasonal variations in the body composition and bioaccumulation of heavy metals in Nile tilapia collected from drainage canals in Al-Ahsa, Saudi Arabia

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**KEYWORDS**

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**Abstract** The body composition of Nile tilapia (*Oreochromis niloticus*) collected from drainage canals in Al-Ahsa, Saudi Arabia and the concentration of four heavy metals; zinc (Zn), cadmium (Cd), cobalt (Co) and lead (Pb) in both fish muscles and the water collected from this environment were assessed across the four seasons. The body composition was found to change with the seasons, with the best body composition being recorded in autumn and winter, where higher levels of protein (17.24, 17.65%), and fat (0.58, 0.71%) and lower water content (80.15, 79.86%) respectively were noted. The concentration of heavy metals in both fish muscles and the water body also varied significantly with the seasons. In the fish muscles, the highest content of Zn (0.409 mg/kg dry weight) and Cd (4.140 mg/kg dry weight) was recorded in winter, however, the highest concentration of Co (0.318 mg/kg dry weight) and Pb (1.96 mg/kg dry weight) was observed in spring and summer respectively. On the other hand, the water samples collected in autumn showed the maximum concentration of Cd (1.385 mg/L), Co (0.762 mg/L) and Pb (0.18 mg/L) however, the maximum concentration of Zn (0.0041 mg/L) was recorded in winter. With the exception of Cd, the accumulation of the studied heavy metals in fish muscles was within the safe limits for seafood recommended by various organizations.


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## 1. Introduction

Al-Ahsa, about 60 km inland from the Persian Gulf, is a traditional oasis region within the Eastern Province and is home to the largest oasis in the world. Natural freshwater springs have surfaced at oases in the region for millennia, encouraging

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human habitation and agricultural production (especially date palm cultivation). The Al-Ahsa oasis is important since there are few freshwater resources in Saudi Arabia. Sources of freshwater in the country can be divided into (a) natural sources of water: such as springs, seasonal streams, pools, wetlands and marshes; (b) artificial sources of water: such as agricultural drainage and treated effluent outflows, wells, dams and irrigation canals fed by water pumped from deep underground aquifers in order to supply agricultural irrigation projects and expanding human demand, (NCWCD, 2005). Whether natural or artificial in origin, these freshwater wetlands attract and support a diverse assemblage of plants and animals and are important centres of endemism (NCWCD, 2005) but they are also highly vulnerable biological sites in the arid landscape of Saudi Arabia. A sparse fish fauna would be expected in Saudi Arabia in view of its arid environment and their distribution is related to the availability of freshwater dispersal routes (NCWCD, 2005). Nile tilapia (*O. niloticus*) is, however, one of the most important fish species in the freshwater habitats of Saudi Arabia.

The pollution of freshwater sources by sewage, industrial waste, oil and agricultural fertilizers and pesticides, endangers the existence of both flora and fauna. Fish are often considered as an important bioindicator for aquatic ecosystems, because they obtain a high trophic level, and because they have the inherent potential to accumulate heavy metals in their muscles (Rahman et al., 2012). Therefore and because fish are an important source of balanced protein in the human diet, the present study was carried out to determine the chemical composition of Nile tilapia, *O. niloticus* and to evaluate the bioaccumulation of some heavy metals in this fish species collected from the two main drainage canals of Al-Ahsa, Saudi Arabia relevant to their environment.

## 2. Materials and methods

### 2.1. Sample collection

Samples of water and Nile tilapia, *O. niloticus*, were collected from one canal only of the two main drainage canals in Al-Ahsa during each of the four seasons (spring, summer, autumn, and winter in 2012) whereas there is no fish was recorded or collected from the other canal. The water samples were transported in plastic bottles while the collected fish were immediately packed in polythene bags fitted with oxygen and transferred to the laboratory.

### 2.2. Tissue sampling

Fish were killed by a blow on their head, an incision was made along one side of the dorsal fin and the skin was carefully and quickly peeled down, avoiding tissue squeezing. A sample of white muscle was removed from the dorso-lateral side just behind the head and taken for further processing and analysis.

### 2.3. Determination of fish body composition

The proximate chemical composition (Love, 1980) of the white muscle (i.e. moisture, protein, lipids and ash) was determined according to the standard analytical procedures of AOAC (1995).

### 2.4. Determination of heavy metals in fish muscles

The contents of Zinc (Zn), Cadmium (Cd) Cobalt (Co) and Lead (Pb) was determined in both the fish muscles and the water samples using an Atomic Absorption Spectrophotometer (Model AA-680/ Shimadzu) according to the method described by AOAC (1995).

### 2.5. Statistical analysis

Data collected were subjected to statistical analysis using a one way Analysis of Variance (ANOVA). The average values (mean ± standard deviation) were compared by using Fisher's Least Significant Differences test (LSD-test), as described by Snedecor and Cochran (1989).

## 3. Results

### 3.1. Chemical composition of fish muscles

The chemical composition of muscles of *O. niloticus* (as a percentage based on the fresh weight) is shown in Table 1. Overall, significant differences ($p < 0.05$) were observed in the chemical composition of fish muscles between the four seasons. The highest moisture content (82.43%) was observed in summer followed by spring, albeit without a significant difference. The lowest average moisture content was observed in fish muscles in winter (79.86%) followed by autumn, with these values being significantly less than those obtained in summer and spring.

Analysis of fish muscles showed that the highest protein value was achieved in the samples collected in winter (17.65%), which were close to autumn values (17.24%). There was a significant decrease in the protein content of fish muscles in spring (16.00%) and summer (15.68%), however, with the latter representing the lowest protein value recorded in this study.

The lipid content of fish muscles also differed significantly ($p < 0.05$) between the various fish samples. The highest value (0.71%) was observed in the fish collected in winter, whereas the lowest level (0.37%) was found in spring fish samples.

**Table 1** Muscle composition of Nile tilapia (*O. niloticus*) collected from drainage canals in Al-Ahsa, Saudi Arabia.

| Season of Collection | Moisture% | Protein% | Fat% | Ash% |
|---|---|---|---|---|
| Spring | $82.21 \pm 0.34^{a}$ | $16.00 \pm 0.58$ | $0.37 \pm 0.12$ | $1.07 \pm 0.16^{b}$ |
| Summer | $82.43 \pm 1.59^{a}$ | $15.68 \pm 0.37^{b}$ | $0.51 \pm 0.09^{bc}$ | $1.02 \pm 0.11^{b}$ |
| Autumn | $80.15 \pm 1.85^{b}$ | $17.24 \pm 0.38^{a}$ | $0.58 \pm 0.13^{ab}$ | $1.30 \pm 0.07^{a}$ |
| Winter | $79.86 \pm 1.06^{b}$ | $17.65 \pm 0.21^{a}$ | $0.71 \pm 0.04^{a}$ | $1.23 \pm 0.15^{a}$ |

Each reading represents (Mean ± SD: Percentage based on the fresh weight).
Different letters in the same column means that there was significant difference at $p < 0.05$.