# Assessment of Health Risk of Food Dye Colors

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## Abstract

The purpose of this research is to assess heavy metals of food dye colors. Different food dye colors such as red, orange, green, yellow and chocolate colors were collected from local market. The metal contents (Na, Cl, S, Al, Si, Ca, P, Fe, Br, Cu, Sr, K, Sn, Mg and Zn) of food dyes was determined by Energy Dispersive X–ray Fluorescence Spectrometer and their measured data were analyzed by calculating health risk methods. The concentration of metal contents in food dyes was compared with Food and Agriculture Organization/ World Health Organization (FAO/WHO) safe limits. The concentration values of sodium (Na), potassium (K) and magnesium (Mg) were evidently higher than safe limits. The concentration values of sodium (Na) and potassium (K) in the S–5 (Chocolate) were larger than safe limits but S–1 (Red), S–2 (Orange) and S–3 (Green) were lower than safe limit. Chocolate color (S–5) was more dangerous than other colors. And then, the heavy metal concentrations of Fe, Cu and Zn in food dyes were compared with the daily intake values Food and Drug Administration (FDA). The average daily intake (ADI) and hazard quotient (HQ) value of iron (Fe) were higher than copper (Cu) and zinc (Zn) in ingestion pathways. The HQ value of iron was greater than one for child. HI value of child was greater than that of adult.

Keywards: Heavy Metals, Hzard Quotient(HQ),Hazard Index(HI)

## Introduction

Food coloring or food dyes is a type of dye to make food look more appealing and are either made from natural or synthetic (or artificial) sources. Natural colors are extracted from natural matter such as plants, trees, and insects. Food dyes are chemical substances that were to enhance the appearance of food by giving it artificial food color. People have added colorings food for centuries. Synthetic color in basic foodstuffs such as candy, ice–cream, cheese, jellies, jams, sports drinks, and baked goods are used. In fact, artificial food dyes consumption has increased especially, children are the biggest consumers. Consumers have been made that artificial food dyes cause serious side effect such as hyperactivity in children, as well as cancer and allergies. Most allergic reactions are not life–threatening. However, if we have symptom of an allergy, it may be beneficial to remove artificial food dyes from our diet. Both the natural food dyes and the artificial food dyes have their own distinct properties as well as the limitation and they are used in different food products for different purposes. Artificial food dyes are made up of

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chemical compounds that can be harmful to humans, especially those who work in their production.

## Measurement Methods

**Sample Collection**

In this present work, the five food dyes were collected from local market and they were manufactured by Shanghai Dyestuffs Research Institute Co., Ltd. The names of these samples are S–1 (Red), S–2 (Orange), S–3 (Green), S–4 (Yellow) and S–5 (Chocolate).

Theory of Health Risk Assessment

Human health risk assessment is a process used to estimate the health effects. The risk assessment process is made up of four basic steps: hazard identification, exposure assessment, toxicity (dose–response) assessment, and risk characterization. Hazard Identification basically aims to investigate chemicals that are present at food dyes. In the present work, Fe, Cu and Zn were identified as possible hazards for the community. The purpose of exposure assessment is to measure the intensity, frequency, and duration of human exposures to an environmental contaminant. In the study, exposure assessment was carried out by measuring the average daily intake (ADI) of heavy metals earlier identified through ingestion by adult and child. Dose–response assessment estimates the toxicity due to exposure levels of chemicals.

**Ingestion of Heavy Metals**

$$ADI_{ing} = \frac{C.IR.EF.ED.CF}{BW.AT} \quad (1)$$

Where, $ADI_{ing}$, C, IR, EF, ED, BW, AT and CF are the average daily intake of heavy metals ingested from dusts in mg/kg/day, the concentration of heavy metals in mg/kg for dusts, the ingestion rate in mg/day, the exposure frequency in days/year, the exposure duration in years, the body weight of the exposed individual in kg, the time period over which the dose is averaged in days and the conversion factor in kg/mg.

**Non–Carcinogenic Risk Assessment**

Non– carcinogenic hazard is characterized by a term called hazard quotient (HQ). HQ is expressed as the probability of an individual suffering an adverse effect. It is defined as the quotient of ADI or dose divided by the toxicity threshold value, which is referred to as the chronic reference dose (RFD) in mg/kg–day of a specific heavy metal as shown in equation,

$$HQ = \frac{ADI}{RFD} \quad (2)$$

For a number of heavy metals, the non–carcinogenic effect to the pollution is a result of a summation of all the HQs due to individual heavy metals. This is called the Hazard Index (HI).

The mathematical representation of the parameter

$$HI = \sum_{k=1}^{n} HQ_k = \sum_{k=1}^{n} \frac{ADI_k}{RFD_k} \quad (3)$$

Where, $HQ_k$, $ADI_k$, $RFD_k$ are values of heavy metal k. If the HI value is less than one, the exposed population is unlikely to experience adverse health effects. If the HI value exceeds one, then there may be concern for potential non–carcinogenic effects.

## Results

In this research work, sodium (Na), chlorine (Cl), sulfur (S), aluminum (Al), silicon (Si), calcium (Ca), phosphorus (P), iron (Fe), bromine (Br), copper (Cu), strontium (Sr), potassium (K), tin (Sn), magnesium (Mg) and zinc (Zn) content in collected food dyes were determined by using EDXRF method. The concentrations of elements contained in food dyes compared with the FAO/ WHO safe limits and expressed in Table 1 and Figure 1. Average Daily Intake (ADI) (mg/kg–day) values in food dyes for non–carcinogenic for adult and child are shown in Table 2 and Figure 2. Hazard Quotient (HQ) values in food dyes for non–carcinogenic risk for adult and child are shown in Table 3 and Figure 3. Hazard Index (HI) values in food dyes for non–carcinogenic risk for adult and child are shown in Table 4 and Figure 4.

Table 1 Compare of Concentrations of Elements Values in Samples and (FAO/WHO, 2002 Safe Limits

| Elements | Concentrations of Elements | | | | | FAO/ WHO Safe Limits |
|---|---|---|---|---|---|---|
| | S-1 Red | S-2 Orange | S-3 Green | S-4 Yellow | S-5 Chocolate | |
| Na | 53.1 | 65.9 | 60.5 | 56.8 | 25.1 | 4.7 |
| Cl | 28.4 | 5.71 | 26.5 | 29.8 | 18.5 | NG |
| S | 16.0 | 25.9 | 11.3 | 12.5 | 13.5 | NG |
| Al | 0.501 | 0.598 | 0.567 | 0.603 | 0.344 | NG |
| Si | 0.109 | 0.190 | 0.123 | 0.106 | 0.0714 | NG |
| Ca | 0.0570 | 0.412 | 0.112 | 0.0599 | 3.39 | 9.4 |
| P | 0.0518 | 0.0675 | 0.0421 | 0.0475 | 0.0445 | 7.6 |
| Fe | 0.0038 | 0.0400 | 0.0083 | 0.0149 | 0.533 | 7.8 |
| Br | 0.0027 | 0.0014 | 0.0064 | 0.0055 | 0.238 | NG |
| Cu | 0.0011 | 0.0006 | 0.0010 | 0.0017 | 0.132 | 0.51 |
| Sr | 0.0008 | 0.0063 | 0.0040 | 0.0012 | 0.096 | 5.3 |
| K | 1.34 | 0.0304 | 0.0267 | ND | 37.6 | 12.5 |
| Sn | ND | 0.0018 | 0.0025 | 0.0027 | 0.233 | NG |
| Mg | 0.446 | 1.15 | 0.850 | ND | ND | 0.96 |
| Zn | ND | 0.0012 | 0.0010 | ND | 0.0766 | 34 |

NG= Not mentioned in the FAO/WHO Guideline ND= Not Detected

Table 2 Average Daily Intake (ADI) (mg/kg-day) Values in Differen Colors of Food Dyes for Adult and Child

| Elements | Average Daily Intake (ADI) Values in Ingestion Pathway | | Daily intake Values (FDA) |
|---|---|---|---|
| | Adult | Child | |
| Fe | 0.0017 | 0.012 | 18 mg |
| Cu | 0.0004 | 0.0027 | 2 mg |
| Zn | 0.00038 | 0.0026 | 15 mg |

Table 3 Hazard Quotient (HQ) Values in Different Colors of Food Dyes for Adult and Child

| Receptor Pathways | | Hazard Quotient (HQ) Values for Heavy Metals | | |
|---|---|---|---|---|
| | | Fe | Cu | Zn |
| Ingestion | Adult | 0.243 | 0.01 | 0.0013 |
| | Child | 1.714 | 0.068 | 0.0087 |

Table 4 Hazard Index (HI) Values in Different Colors of Food Dyes for Adult and Child

| Receptor Pathways | Hazard Index (HI) Values for Heavy Metals | |
|---|---|---|
| | Adult | Child |
| Ingestion | 0.25 | 1.79 |

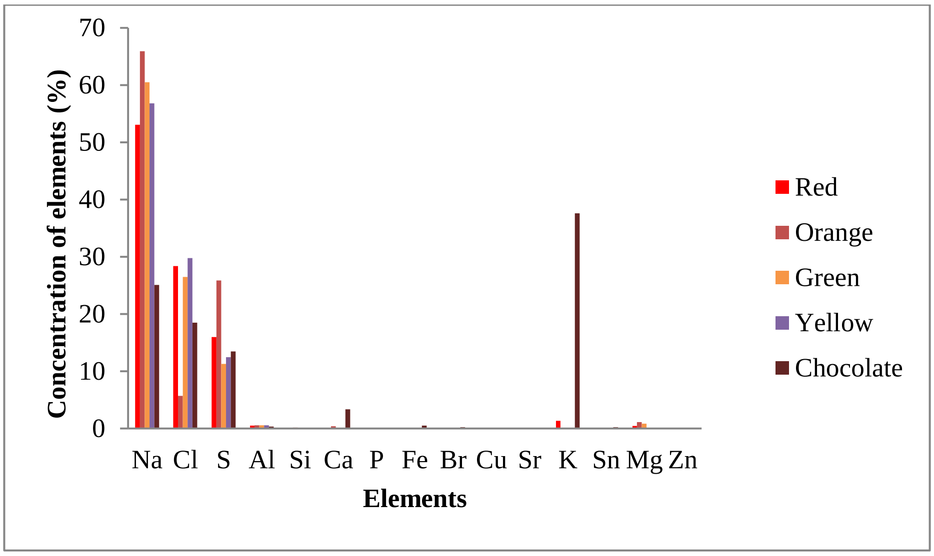


Figure 1 Concentration of Elements Contained in Different Colors of Food Dyes

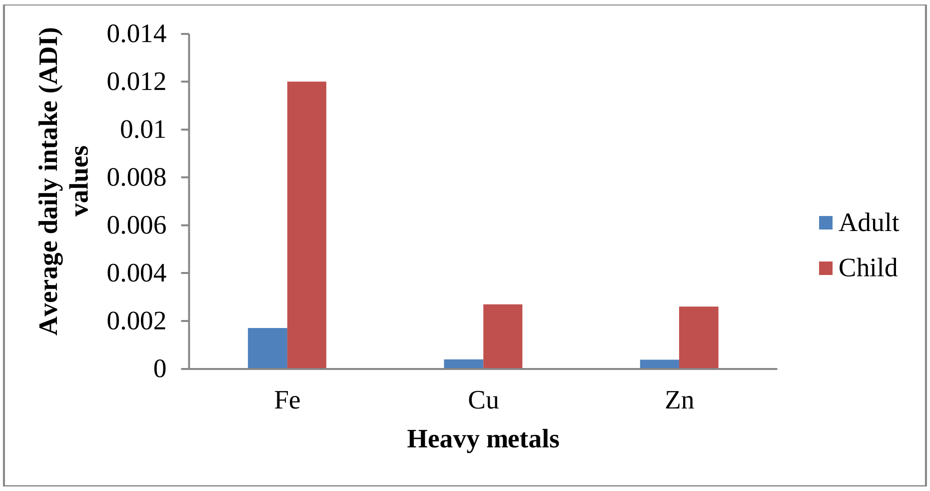


Figure 2 Average Daily Intake (ADI) Values in Different Colors of Food Dyes for Adult and Child

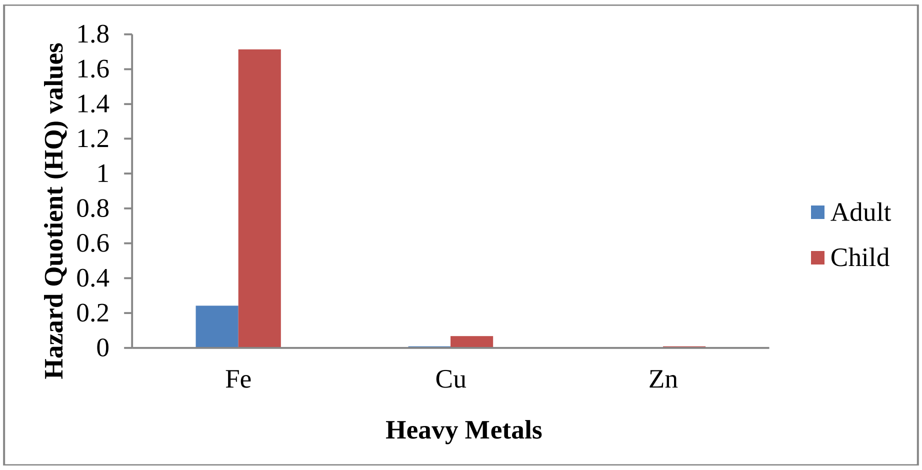


Figure 3 Hazard Quotient (HQ) Values in Different Colors of Food Dyes for Adult and Child

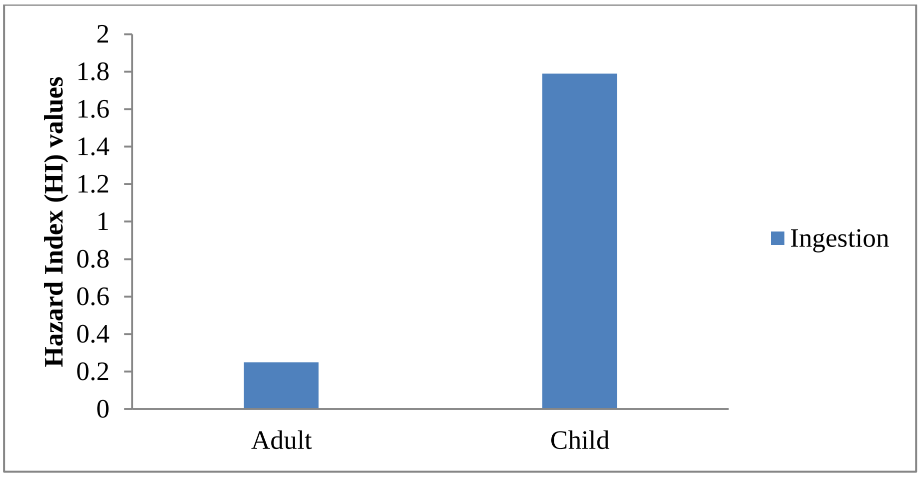


Figure 4 Hazard Index (HI) Values in Different Colors of Food Dyes for Adult and Child

## Discussion

According to Figure 1, the concentration values of sodium in all samples were evidently higher than safe limit. The concentration values of sodium (Na) and potassium (K) in the S–5 (Chocolate) were higher than safe limits but S–1 (Red), S–2 (Orange) and S–3 (Green) were lower than safe limit. Chocolate color (S–5) was more dangerous than other colors. Sodium is essential to human health, but too much sodium is poisonous. Sodium poisoning can cause seizures, coma and death. Potassium plays an important role in the physical fluid system of human and it assists nerve functions. Concentration value of magnesium (Mg) in the S–2 (Orange) was larger than safe limit but S–1 (Red) and S–3 (Green) were lower than the safe limit. Some metals are essential for life. All living organisms require varying amounts of metals but become toxic at higher concentration. Excessive intake of Fe, Cu and Zn may cause carcinogenic effects on human health, even though they are essential for human life. Iron may cause conjunctivitis, choroid its, and retinitis if it contacts and remains in the tissues. A more common problem for humans is iron deficiency, which leads to anaemia. Cu had been associated with liver damage. Zn may cause impairment of growth and reproduction. According to Figure 2, the value of average daily intake of iron contained in food dyes is higher than copper and zinc for adult and child. According to Figure 3, for non– carcinogenic risk effect of adult and child, the HQ values of Cu and Zn were less than one but Fe was greater than one for child in ingestion pathway. HQ values are less than one; there is no obvious risk to the population. According to Figure 4, the HI value of a child was twice greater than that of an adult.

## Conclusion

The concentrations of elements contained in these samples were compared with (FAO/WHO) safe limits. The concentration values of sodium (Na), potassium (K) and magnesium (Mg) were evidently higher than FAO/WHO safe limits. The concentration values of sodium (Na) and potassium (K) in the S–5 (Chocolate) were larger than safe limits. Chocolate color (S–5) was more dangerous than other colors. The average daily intake (ADI) value and hazard quotient (HQ) value of iron (Fe) were found higher than other metals such as copper (Cu) and zinc (Zn) in food dyes in ingestion pathways. And then, the heavy metal concentrations of Fe, Cu and Zn in food dyes were compared with the daily intake values (FDA). The HQ value of iron was greater than one for a child. HI value of a child was greater than that of an adult. Food dyes is hazard drop the health for child. If the large amount of food dyes is used daily, the side effects will occur. Based on the results of this research, it can be concluded that consumers need to be careful to protect the side effects of food dyes.

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