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ADDRESSING THE ISSUE OF TURMERIC ADULTERATION: STRATEGIES FOR THE PREVENTION AND MANAGEMENT OF LEAD POISONING

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ABSTRACT

Turmeric is of huge importance in Indian food and traditional medicine that's why it is also called as golden spice. It not only increases the taste of food but pharmacologically it helps to eliminate or reduce pain, oxidative stress and inflammation. Turmeric contains a chemical constituent known as curcumin which have scientifically proven analgesic, anti-inflammatory and antioxidant properties. Turmeric as a spice provides many health benefits and very useful ingredient of Ayurvedic medicines but if we came to know that this yellow spice is harmful, then what will happen and what can we do. Recent research says that, the levels of lead in samples of turmeric taken from different countries of the Asian continent were found 1,000 µg/g. This much level is too much high and responsible thing behind it was found Lead chromate. It is very shocking that although Lead chromate, a yellow colour pigment is not a food ingredient but it is used in food items (turmeric) to increase the colour appearance. According to the Indian standards, the lead level in turmeric (whole and powdered) cannot be more than 10 µg/g. Recent report of World health organization tells that people lead exposure makes a man sick. More than 0.15 crores deaths occurred all over the world due to lead exposure in the year 2021. Mostly the reason of death was found problem in the heart. In this article, we will go over some of the facts of turmeric adulteration, where lead comes from, analysis of lead and, the dangers of lead poisoning and lead chromate. The approaches for preventing and treating lead poisoning have also been covered.

KEYWORDS: Turmeric, turmeric adulteration, lead, lead chromate, heavy metals, Analysis of lead in food, prevention of lead poisoning, treatment of lead poisoning, sources of lead.

INTRODUCTION

Turmeric samples were found to contain lead levels in turmeric samples were more than 1,000 μg/g, according to study that was published in the Journal Science of the Total Environment. The study tells that lead chromate is the responsible factor behind this. The Food Safety and Standards Authority of India has said that the lead content in turmeric, whether it is in its complete form or in powdered form, must not exceed 10 μg/g. This level of lead is not only dangerous for children but adults too, and the consumption of turmeric in such alarming quantities will make the condition even worse.[1]

Turmeric, also referred to as Indian saffron or golden spice, is a daily dietary component in numerous households. *Zingiber officinale*, commonly known as turmeric, is a member of the Zingiberaceae family. Its characteristic yellow-orange colour is attributed to curcumin, a natural polyphenol pigment present in turmeric. Turmeric has been utilised as a natural medicine in various countries for millennia, attributed to the analgesic, antioxidant, and anti-inflammatory properties of curcumin. Recent clinical trials have initiated investigations into the efficacy of turmeric and curcumin in addressing various conditions, including cancers and COVID-19. India serves as the leading producer, exporter, and consumer of turmeric globally. India accounts for 80% of the global turmeric supply, primarily sourced from the southern states of Andhra Pradesh, Tamil Nadu, and Karnataka. Turmeric is also cultivated to a lesser extent in neighbouring countries such as Bangladesh, Pakistan, Sri Lanka, and Nepal. The adulteration of turmeric and other spices poses a significant public health threat worldwide, particularly in nations with inadequate regulatory frameworks and extensive informal food sectors. Spices are susceptible to adulteration due to their high value and frequent sale in processed forms. For example,[2]

Table 1: Adulterants of turmeric.

Adulterant	What it is?
Metanil yellow	An azo dye incorporated into turmeric is suspected to have carcinogenic effects.
Lead chromate	Exhibit significant and well-documented toxic effects resulting from exposure to chromium and lead.

1. Heavy metals

The Indian Pharmacopoeia defines heavy metals as metallic contaminants that, if present in pharmaceutical medicines, have the potential to be hazardous. Lead (Pb), Mercury (Hg), Arsenic (As), Cadmium (Cd), Bismuth (Bi), Antimony (Sb), Tin (Sn), Silver (Ag), Copper (Cu), and Molybdenum (Mo) are among the heavy metals that are frequently tested for. Typically, pharmaceutical compounds have 20 parts per million (ppm) limits for heavy metals. In order to protect patients from potential injury, this restriction guarantees that the levels of metallic contaminants including lead, mercury, arsenic, and cadmium are kept under control.[3]

2. Lead

Lead is an element which is naturally occurring and hazardous as well. Their enormous utilisation has resulted in considerable environmental pollution and serious health issues due to human exposure worldwide. Significant causes of environmental pollution encompass mining, smelting, manufacturing, recycling operations, and the utilisation of lead in various products.[4]

2.1 Properties of Lead

- Lead has a melting point of 327.462 degrees Celsius and a boiling temperature of 1749 degrees Celsius; its atomic number is 82, and its mass is 207.2.
- Its symbol is Pb. Lead (Pb) is an incredibly malleable, white, shiny metal that has a rather smooth texture.
- The metal is not only an excellent electrical conductor, but it also has exceptional resistance to corrosion.
- Powdered metal, when ignited in air, creates a flame that is bluish-white in colour.
- When lead and fluorine are combined at normal temperature, the result is lead fluoride.
- A corrosion-resistant paint and pipe material, it has a long history of use dating back to antiquity.
- As an integral component of lead-acid batteries, it finds usage in automobile batteries, electrical equipment soldering, and electrolysis electrodes.[5]

2.2 Methods of Analysis

2.2.1 Determination of lead in foods by atomic absorption spectrophotometer

Let us examine the principle underlying the determination of lead in foods using atomic absorption spectrophotometry.

a. The test portions are subjected to drying followed by ashing at 450°C with a gradual temperature increase of approximately 50°C per hour.
b. Next, 6N HCl (1+1) is added, and the solution is drained until it is dry.
c. The leftover material is mixed with 0.1N HNO_3, and flame and graphite methods are used to find the concentration of the analytes.

2.2.2 Determination of lead in food using microwave assisted digestion by inductively coupled plasma-mass spectrometer (ICP-MS)

Let us examine the theory underlying the assessment of lead in food using microwave-assisted digestion utilising inductively coupled plasma mass spectrometry.

a. In a digestion vessel subjected to high pressure, a food sample undergoes treatment with acid through microwave heating.
b. The analytical solution is now directed towards nebulisation, with the aerosol being transported to a high-frequency inductively coupled argon plasma.
c. The elevated temperature of the plasma facilitates the drying of the aerosol while also serving to atomise and ionise the components.
d. The ions are extracted from the plasma through the use of sampler and skimmer cones, subsequently directed to a mass spectrometer. Here, separation occurs based on the mass-to-charge ratio, and the quantity of analyte is quantified using pulse-count and/or analogue detection methods against calibrated reference standards.

2.2.3 Determination of Lead in food

Let us discuss the underlying premise.

a. The sample is incinerated using an oven and the ash obtained is neutralised by adding ammonia in the presence of citrate.
b. While cyanide complexes with a number of interfering substances, lead is separated in chloroform as lead dithizonate.
c. After being agitated once more with diluted nitric acid, the chloroform layer is disposed of.

d. After buffering the aqueous phase between pH 9.5 and 10.0, dithizone in chloroform is used to extract lead again.
e. The absorption of colour generated is measured at 510 nm and compared with a suitable reference.[6]

Table 2: Acceptable limit of Lead in turmeric whole and powder.[7]

Name of metal contaminant	Article of food	Parts per Million (mg/kg or mg/L)
Lead	Turmeric whole and powder	10

3. Health hazards of Lead

- Lead is a particularly problematic toxicant that can cause damage to almost all of the body's systems, including the circulatory, endocrine, renal, immunological, reproductive, and neural systems.
- One of the negative, long-lasting, and irreversible consequences of lead exposure during the early stages of life is that it impedes the development of the brain, which ultimately leads to a lower intelligence level (IQ).
- The consumption of turmeric has been linked to the development of lead poisoning.
- According to the findings of investigations into the supply chain for turmeric, it is a common practice to add lead chromate to turmeric roots in order to improve their appearance and to make it easier to sell roots of lower quality.[2]

4. Lead poisoning

The World Health Organisation says that lead exposure can lead to many health issues and can affect many body systems of young children and women of reproductive age, as per the risk. Lead is distributed throughout the liver, kidneys, brain, and skeletal system. It is placed within the dental structures and skeletal system, where it has the efficiency to gather slowly as time passes. The assessment of human exposure of lead is conducted by determination of lead levels in blood. In 2021, lead exposure was associated to more than 0.15 crores deaths globally, mostly due to cardiovascular consequences. In the course of pregnancy, lead collects in bone and is released into the blood circulation, show a potential source of exposure for the growing embryo. Any degree of exposure to lead is recognised as having detrimental effects.[4]

The majority of organs in both adults and children are harmed by lead toxicity. It's important to understand the therapy. The primary treatment is to prevent exposure to lead. Because lead cannot be totally removed from the body, medical therapies and dietary supplements may assist remove lead from organ tissues and lessen the amount of lead that accumulates in organs. Immovable bone deposits raise serious pregnancy concerns even if lead accumulation in bones may not be the main source of issues. Nephropathy and renal inefficiency result from these damages to renal tubular cells. Low levels of lead (5g/dL) cause endothelial inflammation and hypertension. The effects of lead in teeth, saliva, hair, and nails are unknown because their levels are much lower than those in blood. Lead damages proteins and enzymes by causing ionic disturbance and oxidative stress. Ca, Zn, and Fe can lower lead levels but not remove them. Vitamins and flavonoids are also employed as antioxidants. Ongoing monitoring of blood lead levels and prompt detection of lead poisoning can prevent significant adverse outcomes. Avoiding direct exposure and ensuring adequate intake effectively reduces tissue Pb^{2+} accumulation.[5]

5. Lead chromate

Lead chromate which is also written as Lead (II) chromate, is a solid compound that has the formula $PbCrO_4$. It is a solid that goes down very slowly in water and is a bright yellow colored compound. It's used as a colour.

5.1 Structure

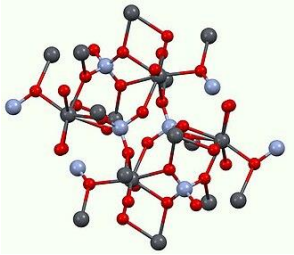

Fig 1: Structure of lead chromate (Courtesy: www.en/wikipedia.org).

5.2 Preparation

By reacting sodium chromate with lead salts, Lead chromate is prepared. Lead salts like lead nitrate or by adding lead oxide to chromic acid. Lead sulfochromate pigments are synthesised by adding a portion of chromate to sulphate, results in mixed lead-chromate-sulfate compositions. In some cases, molybdate substitutes chromate.

5.3 Reaction

The process of heating in a hydroxide solution yields chrome red, a pigment characterised by its red or orange hue, composed of lead oxide (PbO) and chromium trioxide (CrO_3). In a hydroxide solution, lead chromate gradually dissolves, resulting in the formation of a plumbite complex.

$$PbCrO_4 + 4OH^- \rightarrow [Pb(OH)_4]^{2-} + CrO_4^{2-}$$

5.4 Safety hazards

- Although lead chromate comprises both lead and chromium, it does not exhibit acute lethality due to its remarkably low solubility.
- The lethal dose for rats is merely 5,000 mg/kg. The production of lead chromate necessitates meticulous attention and caution.
- Lead chromate is subject to stringent regulations in developed nations.
- The inhalation of particles represents one of the most significant threats.
- During the 1800s, this product was utilised to bestow a vivid yellow hue upon certain varieties of confectionery.
- This substance is employed unlawfully to intensify the hue of specific spices, notably turmeric.
- In contrast to various other pigments derived from lead, lead chromate continues to find extensive application, particularly in the realm of road marking paint.[8]

6. Sources of lead

- Plumbing systems that contain lead pipes, solders, and fittings have the potential to pollute drinking water with lead.
- When lead-containing materials are burned, such as when leaded paint, plastic cables, recycling, or smelting, lead particles are generated. Inhaling these lead particles can be harmful.
- Consuming dust, soil, water, or food that has been contaminated.

6.1 Health effects in children

Lead does not show any symptom at low or minimum level. Because young children have a higher absorption power than adults (by a factor of four to five), they are considered to be an easy target for lead poisoning overall.

- After entering into the body, lead is distributed to many organs i.e. the kidneys, liver, brain and bones.
- Lead is deposited in bones and teeth. Lead deposits in the bone may be released into the bloodstream during pregnancy, which could have an impact on the developing baby.
- The brain and central nervous system are harmed by elevated levels of lead, which can cause coma, convulsions, and even death.
- Children who suffer from severe lead poisoning may exhibit behavioural problems and intellectual incapacity.
- Children are more susceptible to lead absorption, particularly when there is a calcium or iron deficiency. Children's brain development can be impacted by lead, which can lead to poor IQ, poor focus, and inappropriate behaviour.
- Increased lead level can result in anaemia (low haemoglobin count), hypertension (high blood pressure), renal dysfunction (improper function of kidneys), immunotoxicity (toxicity of foreign substances on the immune system) and reproductive organ toxicity (adverse effects of certain substances on the organs of reproductive system which affect fertility, development of foetus and total reproductive health).
- There is no known safe level of lead in blood, although even a concentration of 3.5 µg/dL can cause cognitive impairment, behavioural problems, and poor learning skills in children.

6.2 Burden of disease

Being sick is more likely after being exposed to lead. According to the Institute for Health Metrics and Evaluation, lead exposure was associated with more than 0.15 crores deaths globally in 2021, most of which were caused by cardiovascular complications. In addition, it was estimated that lead exposure would account for around 0.33 crores of disability-adjusted life years (DALYs) worldwide in 2021.[4]

6.3 Treatment of lead accumulation in human beings

When compared to other treatments, chelation stands out as crucial and highly effective. In cases of acute exposure, this intervention entails giving chelating agents, which bind to Pb^{2+} and allow its elimination from tissues through the urine system. The most powerful chelator now available is calcium disodium ethylene diamine tetraacetic acid, most commonly known as $CaNa_2$ EDTA. Oral chelating agents such as succinimer (2,3 meso dimercaptosuccinic acid or DMSA) are preferred in moderate, asymptomatic instances. They quickly reduce lead levels in the blood, brain, and kidneys by forming stable complexes with water.

The administration involves a dosage of 350 mg/m^2, administered three times daily over a span of five days. The frequency is then reduced to two instances per day for a period of 14 days. DMSA significantly decreases oxidative stress and apoptosis resulting from lead exposure, functioning as an antioxidant. Given that Pb^{2+} is detrimental and serves no purpose within the human organism, it must be entirely eradicated. This can be achieved solely through the substitution of the current Pb^{2+} ions with Ca^{2+} ions, which offer beneficial properties. This occurs as Pb^{2+} ions substitute for Ca^{2+} ions in critical locations, resulting in significant damage. Only chelation therapy is suitable for this condition. Introduced into clinical practice in 1950 as an antidote for lead toxicity, extensive research has been conducted on the early chelating agent known as EDTA. Chelation therapy is pursued for its efficacy in significantly

reducing blood lead levels, facilitating the removal of Pb^{2+} ions from the body through urinary excretion. Nonetheless, given that chelating agents can induce side effects, their application is confined to instances of significant heavy metal overexposure.[5]

CONCLUSION

It is deeply concerning that lead poisoning is occurring due to food on a global scale. Lead poisoning can occur as a result of adulteration of lead chromate in turmeric, despite turmeric's widespread use as a spice and medicine to treat or prevent many diseases, particularly in south Asian countries like India, Pakistan, Banladesh, Sri Lanka and Nepal. To make the low-quality turmeric look more appealing, it is contaminated with lead chromate. The Food Safety and Standards Authority of India has set a lead acceptability limit of 10 mg/kg for both whole and powdered turmeric in India. When this limit is crossed, it is no longer deemed safe for human consumption. Although lead deposited inside the body can be reduced, it cannot be eradicated entirely. Therefore, chelation therapy is the gold standard for treating food poisoning, and prevention is key to keeping lead poisoning at bay. Eliminating lead exposure begins with sealing off potential entry points. For the sake of people's physical and mental well-being, it is critical that they be informed about the dangers of lead poisoning and adulteration.

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