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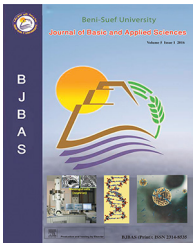

Review Article

Impact of toxic heavy metals and pesticide residues in herbal products

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ARTICLE INFO

Article history:
Received 18 April 2015
Accepted 19 October 2015
Available online 27 February 2016

Keywords:
Herbal medicine
Heavy metals
Pesticides residues
Analytical methods

ABSTRACT

Medicinal plants have a long history of use in therapy throughout the world and still make an important part of traditional medicine. The World Health Organization (WHO) estimates that 65%–80% of the world's populations depend on the herbal products as their primary form of health care. This review is conducted to provide a general idea about chemical contaminants such as heavy metals and pesticide residues as major common contaminants of the herbal medicine, which impose serious health risks to human health. Additionally, we aim to provide different analytical methods for analysis of heavy metals and pesticide residues in the herbal medicine.

1. Introduction

1.1. *Importance of herbal medicine*

Greater attention has been paid to the herbal medicine even in developed countries. Herbal medicine has been used and trusted globally for thousands of years for their easy accessibility and restricted side effects (Padmavathi, 2013). Traditional medicines that are utilized by 80% of the population have compounds derived from herbal plants (Arunkumar and Muthuselvam, 2009). The medicinal values of these plants are usually due to the presence of phytochemical content as stated by Essien et al. (2012) and the most important of these phytochemicals include alkaloids, tannins, flavonoids and phenolic compounds.

The goals of using plants as sources of therapeutic agents include:

- Isolation of active principles for direct use as drugs, e.g., digoxin, digitoxin, morphine etc.
- Production of bioactive compounds of novel or known structures as lead compounds for production of patentable entities of higher activity and/or lower toxicity, e.g., oxycodone, taxotere, and verapamil, which are based, respectively, on morphine, taxol, and khellin.
- The usage of the agents as pharmacologic tools, e.g., lysergic acid diethylamide, mescaline, and yohimbine.
- The usage of the whole plant or part of it as a herbal remedy, e.g., peppermint oil, echinacea, garlic and *Ginkgo biloba* (Fabricant and Farnsworth, 2001).

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http://dx.doi.org/10.1016/j.bjbas.2015.10.001

Table 1 – Examples for medicinal plants and their therapeutic uses.

Medicinal plants	Therapeutic uses
Garlic (*Allium sativum* L.)	Antiviral, antifungal, expectorant, anti-septic, anti-histamine (Hannan et al., 2011).
Artemisia (*Artemisia herba-alba*)	Antihelminthic and antimalaria drug (Mohamed et al., 2010).
Ginger (*Zingiber officinale*)	Act as analgesic, anti-inflammatory and hypoglycemic (Ojewole, 2006).
Ginkgo (*Ginkgo biloba* L.)	Antitussive (Mahadevan and Park, 2008)
Guava (*Psidium guajava*)	Potent anti-diarrheal, antihypertensive, hepatoprotective, hypoglycemic and antimutagenic activities (Nwinyi et al., 2008).
Eucalyptus (*Eucalyptus camaldulensis*)	Antibacterial, antifungal, analgesic and anti-inflammatory effects and antioxidative activities (Cheng et al., 2009).
Thyme (*Thymus vulgaris*)	Act as antispasmodic and anti oxidant, anthelmintic and has late been recommended as substitute as cancer prevention agent (Monira et al., 2012).

Medicinal plants are a source for a wide variety of natural antioxidants and are used for the treatment of diseases throughout the world (Rafieian-Kopaie and Baradaran, 2013). Medicinal plants, or their extracts, have been used in the prevention and treatment of several chronic diseases such as cardiovascular diseases, inflammatory diseases, arthritis, diabetes, and others as reported by Juhás et al. (2008).

The problems of high cost of synthetic drugs, residual effects on livestock products, adverse effects and development of drug resistance have led the researchers to find safe, potent, unconventional and economic natural drug sources as stated by Adedeji et al. (2008) (Table 1).

1.2. *Sources of toxic chemicals in the medicinal herbal products*

Medicinal plants may be easily contaminated by absorbing heavy metals from soil, water and air. Usually soil is subjected to contamination through atmospheric deposition of heavy metals from point sources including different industrial activities. Additional sources of these elements for plants are rainfall, atmospheric dusts and plant protection agents (Maobe et al., 2012).

Toxic elements from wastewater may contaminate agricultural soils, water supplies and environment and hence human food chain. The crops become contaminated and accumulate unfavorable levels of metallic elements within them. The up-take of metals by roots mainly depends on metal and soil characteristics and plant species etc. Thus, metal mobility in plants is very important to determine the effect of soil contamination on plant–metal uptake (Sobukola and Dairo, 2007).

Elevated levels of heavy metals in plants are reported from the areas having long-term uses of treated or untreated wastewater, plants growing along heavy traffic ways and previous dumpsites (Nwachukwu et al., 2010).

After collection and transformation of herbs into dosage form, the heavy metals confined in plants finally enter the human body and may disturb the normal functions of central nervous system, liver, lungs, heart, kidney and brain, leading to hypertension, abdominal pain, skin eruptions, intestinal ulcer and different types of cancers (Khan et al., 2008).

The storage and transportation conditions leading to the loss of the active ingredients, production of metabolites with no activity and the production of toxic metabolites play an important role in herbal contamination. Mites, nematode worms, insects, and beetles can also destroy herbal drugs during storage (Kunle et al., 2012).

Herbal drugs are accountable to contain pesticide remainders, which gather from agricultural practice, such as spraying, handling of soils during farming, and administering fumigants throughout storage (Kunle et al., 2012).

1.3. *Effects of toxic chemicals on human health*

1.3.1. *Heavy metals*

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic at low concentrations. Metals are widely distributed throughout nature and occur freely in soil and water. Heavy metals in herbal preparations may not be a result of accidental contamination but may be introduced for supposed therapeutic properties; for example, mercury was used to treat syphilis until the introduction of penicillin, while arsenic-derived compounds are still used for treatment of some forms of malignancy.

Among the heavy metals mercury, lead, arsenic and cadmium are toxic metals and have mutagenic effects even at very low concentration. Several cases of human disease, malfunction and malformation of organs due to metal toxicity have been reported. Along with human beings, animals and plants are also affected by toxic levels of heavy metals (Sathiavelu et al., 2012).

The effects of toxicity vary between metals; for example, while lead poisoning typically may cause abdominal pain, vomiting, severe anemia, hemoglobulinuria and the stools have dark color owing to the presence of lead sulfide, mercury poisoning may cause peripheral neuropathy, psychological disturbances and arrhythmias may develop due to the toxic effect of mercury on the myocardium. Late, marked renal impairment occurs due to its nephrotoxic action leading to death.

The specific identification of metals is required for accurate diagnosis due to considerable overlap between the clinical syndromes associated with heavy metal poisoning (Ibrahim et al., 2006) (Table 2).

1.3.2. *Pesticide residues*

Pesticides are chemical compounds used to control or eradicate pests. According to their activity, they are grouped as insecticides, fungicides, nematocides, herbicides, rodenticides, and others (Britt, 2000).

According to chemical structure, they are grouped as organochlorine pesticides (OCPs) [hexachlorocyclohexanes (HCH),