Microbial contamination of raw materials: A major reason for the decline of India's share in the global herbal market

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Contamination of raw materials of herbal drugs by microorganisms is one of the major reasons for decline of India's share in the global herbal market. The qualitative and quantitative effects of microbial and mycotoxin contamination of raw materials of herbal drugs as well as possible strategies for their safe preservation have been discussed here.

The global market of medicinal plants has been growing at a fast pace of 7% annually, capitalizing on the growing awareness of herbal and aromatic plants worldwide. Herb-exporting countries will receive more revenues following the widening market for herbal products in developed countries. Two of the largest producers of raw materials of herbal medicines are China and India. Despite its inherent strength in ayurveda and other ethnic systems of medicine, India accounts for only a small portion of the world trade in medicinal and aromatic plants, which is dominated by China. While China holds handsome 40% share in the US$ 60 billion world trade in medicinal plants, India accounts for just US$ 100 million. Ironically, India has a comparatively small share of this ever-growing global herbal market.

Microbial contamination of herbal raw materials of India

In India, the unscientific methods of collection, storage, transportation and congenial climatic conditions make the raw materials of herbal drugs prone to fungal infestations. The raw materials are collected using unscientific methods and are commonly exposed to many microbial contaminants. The raw materials are often deteriorated by microorganisms before harvesting, and during handling and storage. There are reports on aflatoxin-contaminated herbal raw materials imported from India. Due to detection of aflatoxin B_1 in the black pepper procured from India, some foreign pharmaceutical firms have decided to re-evaluate the suitability of Indian black pepper samples for formulation of phytomedicines[1]. In Egypt, different medicinal plant samples imported from India were reported to be contaminated by different toxigenic strains of fungi[2]. Some of the samples have been reported to contain aflatoxin B_1 by more than 20 μg/kg, beyond the tolerance level fixed by WHO. Such drugs would certainly be rejected in the global market.

Despite several reports on fungal contamination and aflatoxin production on foodstuff, limited researches have been carried out on microbial contamination of drug-plant samples. Roy and Chaurasia[3] reported the contamination of some raw materials by aflatoxins up to a level of 20 ppb. Appreciable amount of mycotoxins in stored drugs of important medicinal plants, e.g. rhizomes of *Asparagus racemosus* (0.16 μg/g), *Atropa belladona* (0.27 μg/g), *Withania somnifera* (0.68 μg/g), *Plumbago zeylanica* (1.13 μg/g), fruits of *Terminalia chebula* (1.19 μg/g) and seeds of *Mucuna pruriens* (1.16 μg/g) has been reported[4]. Deokule and Kabnoorkar[5] reported fungal association on punarnava and decrease of alkaloid content. Recently, Singh *et al.*[6] have reported mould and aflatoxin contamination in stored raw materials of six medicinal plants, viz. *Adhatoda vasica*, *A. racemosus*, *Evolvulus alsinoides*, *Glycyrrhiza glabra*, *P. zeylanica* and *T. chebula*. Maximum number of fungal isolates was detected from *A. racemosus*. A perusal of different reports on fungal and mycotoxin contamination of raw materials indicates that there is no uniformity in association of fungal species with the raw materials. This may be because of presence of specific secondary metabolites in different raw materials, which may be fungitoxic in nature to some of the fungal species and provide chemical resistance against them.

Qualitative and quantitative effects of microbial contamination

Fungal contamination has been reported to affect the chemical composition of the raw materials and thereby decrease the medicinal potency of herbal drugs[7]. The fungal enzymes, during host–pathogen interaction, result in degradation of alkaloids and their conversion into simpler forms. There may be a risk of mycotoxicoses in patients after oral administration of fungal and mycotoxin-contaminated drug samples. The toxins elaborated by these fungi elicit a wide spectrum of toxic effects when the contaminated materials are ingested. The most prominent toxins are aflatoxins, zearalenone, ochratoxin and patulin, which are known to cause hazards to the liver, nervous system, muscular system, respiratory organs as well as digestive and genital systems.

Need of quality control

Microbial contamination of raw materials of herbal drugs is a major impediment preventing India from becoming a herbal giant. Therefore, fungal contamination of drugs, especially raw materials, should be prevented during manufacturing. Plant materials used for medical purposes should be carefully stored and the growth of toxigenic fungi should be inhibited. India can be a major player in the global herbal market if its raw materials are free from microbial contaminations. Since aflatoxins are extremely thermostable, the best remedy is to check production of aflatoxins by antiaflatoxigenic chemicals, which do not affect taste and odour of raw materials and are also non-mammalian toxic in nature.

It is advisable to treat plant drugs with non-toxic chemicals at various stages of storage and processing. However, it would not be proper to treat herbal raw materials with synthetic chemicals because of their adverse effects on the human systems. Recently, some of the products of higher plant origin were successfully used as botanical antimicrobials against different

agricultural pests. They have merit over the synthetic antimicrobials due their biodegradable nature and non-mammalian toxicity. Among traditional plant-based antimicrobials of Indian origin, the neem tree (*Azadirachta indica*) represents an outstanding example. In addition, the fungitoxic components of traditionally used plants, viz. *Acacia nilotica*[8] and *Lawsonia inermis*[9] have been recommended to be efficacious like many synthetic antimicrobials. Hence, the traditionally used medicinal plants and their components should be tested for their efficacy in protecting herbal raw materials as botanical preservatives. The essential oil of *Cinnamomum camphora* has been recently recorded for protection of raw materials from fungal as well as aflatoxin B_1 contamination[6]. Such products of higher plant origin should be screened against microorganisms of herbal raw materials and their safety profile as botanical preservative should be recorded, so that the taste and odour of the treated raw materials are not adversely affected. The mode of their practical application should also be worked out. Some of these antimicrobials of plant origin, viz. gallic acid, eugenol, carvacrol, thymol, carvone, gingerol, allicin, carnosol, rosmanol, carnosic acid and thujone are products of different spices which have been traditionally used as food items by humans for a long time. Hence there would be no or least chance of any adverse effects on human systems if such plant products are recommended in post-harvest processing of raw materials. In addition to the antimicrobial nature, these products also possess antioxidant properties[10]. Therefore, the storage of herbal raw materials in association with the scented plant chemicals of traditionally used herbs possessing antimicrobial, antiaflatoxigenic and antioxidant efficacy may enhance the shelf-life of the raw materials by inhibiting fungal and mycotoxin contamination as well as checking their usual deterioration due to lipid peroxidation. There is a need for a large-scale screening programme so as to recommend the antifungals and antioxidants of traditionally used plants in processing and storage technologies of herbal raw materials.

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Special plantation drive – Towards livelihood security in Bundelkhand, Uttar Pradesh

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The Bundelkhand region comprises seven districts, viz. Jhansi, Lalitpur, Jalaun, Hamirpur, Banda, Mahoba and Chitrakoot of Uttar Pradesh (UP) and six districts, viz. Datia, Tikamgarh, Chhatarpur, Panna, Damoh and Sagar and Lahar, and Bhander Tahsils (of Bhind and Gwalior districts) of Madhya Pradesh (MP). It is located between 23°8′–26°30′N lat. and 78°11′–81°30′E long. with a total area of 71,619 km^2. Out of 108 poorest districts notified by the Planning Commission, Government of India, nine districts come under this region. The region has been named after Bundelas, who settled first at Mau in Banda with the capital in Mahoni later in Orcha, during the 16th century BC. This region is bounded on all the four sides by rivers, viz. the Yamuna, the Narmada, the Chambal and the Tons, and is the meeting place of many cultures, viz. Biraj, Bhojpuri, Tribal and Malwi. The soils of this region are mainly derived from gneisses, type red and black. This undulating relief receives average annual rainfall of 1000 mm of which 90% is during monsoon. In general, the rainfall pattern of this region is erratic and uncertain. The average temperatures range from 22.9°C to 26.7°C during winter, and 41.8°C to 43.9°C during summer. Since no industry is available in this region, more than 80% of the population is dependent on rainfed agriculture and livestock for livelihood. Although agriculture is the mainstay of the people, only 20% of the net sown area is irrigated[1]. Four years of continuous drought and acute water and power shortage in this region ending self-sufficient agri-livelihoods, has resulted in large-scale migration[2] up to 36.95%. The change in land-use pattern, dependency of people on forests, and scarcity of natural resources in this region has caused exploitation of dense forest. Under these circumstances, it is difficult to sustain livelihood without resource enrichment.

Against this background, a special plantation drive in Bundelkhand has evolved and field activities are in full swing to make this region green. Nature also favoured this drive by showering more than 700 mm rainfall during June–July. This special drive is operational in seven districts under Bundelkhand region, covering an area of 29,418 km^2 (12.21% of UP), which also includes 12 lakh ha of degraded forest area. This will benefit 8.2 million people of the region (4.95% of total UP). Lower rainfall than the average in several years followed by one or two years of excess rainfall in this region[1] clearly emphasize the importance of water storage during good receiving year like in 2008. Since the land is undulating, it needs to be protected from erosion and resulting silting of tanks. The special plantation drive is a good initia-