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POST - HARVEST PATHOLOGY OF MEDICINAL PLANTS: AN APPRAISAL

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The growth of fungi on medicinal plants is quite certain during storage, if not dried to the extent of discouraging their growth after harvest. If such improperly dried plants are stored, transported to distant places or used for preparing Ayurvedic, Yunani or Homoeopathic medicine, there seems every possibility of contamination of toxic metabolites secreted by the storage fungi, some of them proving hazardous for the human health. These fungi may also decompose the active principle of the medicinal plants, alter their pH, texture, colour and ultimately adversily affect the salability. Notable storage fungi belong to the species of *Aspergillus, Penicillium, Fusarium, Paecilomyces, Alternaria, Curvularia, Cladosporium, Periconia, Drechslera, Helminthosporium* and others. Therefore, proper scientific drying of medicinal plants is imperative before their storage and utilization.

Keywords : Medicinal plants; Storage Fungi.

Introduction

The post-harvest pathology of herbs being used for medicine is a discipline of Botany and more relevant to the Ayurvedic and Unani practice which begins after the extraction of the seed, plucking up of the flowers and fruits, procuring the root, stem and leaves and collection of the bark, latex and gum. Thus, the post- harvest pathology of these differs from that of the grain, vegetable and fruits. The former one is harvested after maturity possessing distinct indications while the latter two are generally prematurely harvested for consumption. The method and style of procuring and storing medicinal plants are entirely changed due to serious considerations to protect their active principle from loss by drying and decay by microbes.

In general, the post-harvest pathology of medicinal plants concentrates on several factors resulting in the decomposition of the active principles of the herbs and their contamination with microbial toxins, some of them proving hazardous for human health[1-3]. Such herbs automatically lose their salability and also it will be a serious offence to sell such decayed herbs to the ignorant buyers. No doubt, insects too, destroy the medicinal herbs especially in storage, but this entomological aspect is entirely different from the mycological aspect being deliberated and discussed presently.

Parts of the plants being used as herbal medicine - Different parts of the plants are used as Ayurvedic, Unani, Homoeopathic and Herbo-mineral medicines. These are roots, stems, leaves, flowers, fruits, seeds and bark of the stem, root, latex and gum (Table 1).

Peep at the grocer's shop - The common man, Ayurvedic physicians and Hakims visiting to the grocer's shop are well aware with saddest plight of the storage of the medicinal herbs. These are stored in jute bags or tin container which might be broken at many points, in the dark room for longer period without caring for their damage by insects or by microbes about whom grocers themselves are totally ignorant. At the time of purchase of such stored medicinal herbs, their off-coloration, discoloration, mouldiness and blackening are easily visible to the naked eye besides altered and abnoxious odour and deviated taste that seem common symptoms as observed in chilli[4-6] being extensively used in the preparation of herbal medicines.

Today there is craze of using medicinal herbs for the manufacture of soap, shampoo, face cream, body lotion and several other cosmetics. Mushroom growth of companies manufacturing medicines both Ayurvedic and Homoeopathic and other products boasting forcefully of their products containing herbal extract in them, has undoubtedly raised their unlimited demand and are being sold as hot cake today. But the burning question is how far the herbs being incorporated in the manufacture of any

Table 1. Parts of the plants being commonly used as herbal medicines.

Parts	Vernacular Name	Botanical Name	Family
Root	Khas	*Vitiviera zizanioides*	Poaceae
	Ashwagandha	*Withania somnifera*	Solanaceae
	Satavar	*Asparagus racemosus*	Liliacease
	Safed musali	*Asparagus adscendens*	Liliaceae
	Atis	*Aconitum heterophyllum*	Ranunculaceae
	Sarpagandha	*Rauwolfia serpentina*	Apocyanaceae
	Punarnava	*Boerhanvia diffusa*	Nyctaginaceae
	Jatamansi	*Nardoschys jatamansi*	Valerianaceae
	Akarkara	*Anacyclus pyrethrum*	Berbidaceae
	Bala	*Sida rhombifolia*	Malvaceac
	Atibala	*Sida acuta*	Malvaceae
	Daruhaldi	*Berberis aristata*	Berbidaceae
	Vidarikand	*Pueraria tuberosa*	Leguminosae
	Mulhati	*Glycyrrhiza glabra*	Leguminosae
	Sonth	*Zingiber officinale*	Zingiberaceae
Stem	Haldi	*Curcuma longa*	Zingiberaceae
	Chandan	*Santalum album*	Santalaceae
	Giloy (guruch)	*Tinospora cordifolia*	Menispermaceae
	Nagarmotha	*Cyperus rotundus*	Cyperaceae
	Chirayata	*Swertia chirayata*	Gentianaceae
Bark of stem	Sahijan	*Moringa indica*	Moringaceae
	Arjun	*Terminalia arjuna*	Combretaceae
	Sita ashok	*Saraca indica*	Leguminosae
	Pipal	*Ficus religiosa*	Moraceae
Gum	Guggul	*Commiphora mukul*	Burseraceae
	Gond	*Acacia arabica*	Mimosaceae
	Hing	*Ferula alliacea*	Apiaceae
Leaf	Gurmar	*Gymnema sylvestre*	Asclepiadaceae
	Bel	*Aegle marmelos*	Rutaceae
	Tejpat	*Cinnamomum zeylanicum*	Lauraceae
	Adusa (vakas)	*Adhatoda vasica*	Acanthaceae
	Sanay	*Crotalaria angustifolia*	Leguminosae
Flower	Gulab (petal)	*Rosa sinensis*	Rosaceae
	Long (flower bud)	*Eugenia caryophylata*	Myrtaceae
	Kesar (stigma)	*Crocus sativus*	Iridaceae
	Javitri	*Myristica fragrans*	Myristicaceae
	Nagkesar	*Mesua ferrea*	Guttiferae
Fruits	Jaiphal	*Myristica fragrans*	Myristicaceae
	Bel	*Aegle marmelos*	Rutaceae
	Gokharu	*Tribulus terrestris*	Zygophyllaceae
	Amla	*Emblica officinales*	Euphorbiaceae
	Harar	*Terminalia chebula*	Combretaceae
	Bahera	*Terminalia bellirica*	Combretaceae
	Saunf	*Foeniculum vulgare*	Apiaceae
	Jeera	*Cuminuim cyminum*	Apiaceae
	Ajwain	*Trachyspermum ammi*	Apiaceae
	Kali mirch	*Piper nigrum*	Piperaceae

Seed	Pipalli	*Piper longum*	Piperaceae
	Munakka(draksha)	*Vitis vinifera*	Vitaceae
	Indrajau	*Holarrhena antidysentrica*	Apocyanaceae
	Talmakhana	*Astracantha longifolia*	Acanthaceae
	Kaunch	*Mucuna prurita*	Papilionaceae
	Chiraungi	*Buchanania latifolia*	Anacardiaceae
	Badam	*Prunus amygdalus*	Rosaceae
	Nirgundi	*Vitex negundo*	Vitaceae
	Bavachi	*Psoralea corylifolia*	Papilionaceae
	Til	*Sesamum indicum*	Pedaliaceae
	Ilaichi (chhoti)	*Elettaria cardamomum*	Zingiberaceae
	Ilaichi (bari)	*Amomum aromaticum*	Cannaceae

Table 2. Common storage fungi observed in association with stored herbs showing various symptoms of their deterioration and decay.

Major symptoms of decay	Fungi
A. Blackening of roots and stems	*Cladosporium oxysporum, C. cladosporioides, C.herbarum, Curvularia lunata, C. pallescens, C. tetramera, Alternaria alternata, A.tenuissima, A.dianthicola, Memnoniella echinata, Drechslera australiensis, D.biseptata, Nigrospora sphaerica, Periconia lateralis, Stachybotrys atra*
B. Off-coloration of fruits and seeds and mouldiness	*Rhizopus nigricans* *Syncephalastrum racemosum*
C. Mycelium inside the fruits and seed	*Aspergillus chevalieri, A. ruber, A. nidulans, Chaetomium globosum, C.nigricolor, C.pulchellum, Microascus sp, Alternaria alternata, A.tenuissima, A.longipes, Aspergillus candidus, A. flavus, A.sydowi, A.niger, A.tamarii, A.terreus, Cladosporium chlorocephallum, C.herbarum, Curvularia lunata, Curvularia pallescens, Penicillium citrinum, p. oxallicum, P.nigricans, P.rubrum, P.notatum, Paecilomyces varioti, Fusarium moniliforme, F.roseum, F.poae, Verticillium luteo-album,*

kind of pharmaceutical product, is indeed, safe? The answer, in no case, be affirmative due to the facts that large number of storage fungi have been observed in association with these herbs (Table 2). It is worthnoting that the stored hot spices harbour very less number of storage fungi[7] probably due to containing good amount of aromatics in them discouraging the growth of mycoflora. Such spices are *Piper nigrum, Myristica fragrans, Eugenia caryophyllata, Amomum aromaticum, Elettaria cardamomum* and some others. The mycelium of *Aspergillus flavus, A. tamari* and a few others has been found internally in seed of *Myristica fragrans,* a highly fragrant and popular item used in the pharmaceutical preparations and as spices.

Role of fungi in deterioration of the medicinal herbs - The mycoflora coming over the surface of the medicinal herbs grow luxuriantly provided the suitable conditions such as the high moisture content of the herbs and high relative humidity of the store house or godowns at temperature range of 28-35°C prevail even for nearly one month. The rainy season and even untimely rain in any season, except the chilly winter, create inclemency of storage. In tropics, grievous loss of plant products have been recorded earlier. Johnson[8] recorded 1-2% loss of food grain due to microbial spoilage at global level. The estimate of loss by now for undeveloped and under developed countries might have gone to many folds. The result of storage of herbs does not seem better than this plight.

The off-coloration, in fact, seems due to dissolution of cuticle over the surface of the stem, leaf, fruit and seed by extracellular cutinolytic enzyme[9] and growth of fungi[4-6]. Such off - coloration has earlier been reported in many spices such as *Foeniculum vulgare, Cuminum cyminum* and *Trachyspermum ammi*[7] and *Coriandrum sativum*[5]. Most perceptible discoloration

coupled with spore dust formation inside has been observed in stored chilli fruit throughout our country. The discoloration is due to enzymatic dissolution of pigment globules present in the cells of pericarp containing capsorubin, capsanthin, carotene and xanthophylls[4].

The reserved food of the seed in the form of carbohydrates, proteins and lipids are desired substrates for the growth of mycoflora besides degradation of the active principles of the medicinal herbs side by side secreting mycotoxins in them. Recently, contamination of the seed of *Psoralia corylifolia, Strychnos nuxvomica, Mucuna pruriens, Butea monosperma, Tribulus terrestris;* fruits of *Piper longum, Terminalia chebula, T. belarica, T. catappa, Emblica officinale, Myristica fragrans;* stem and leaf of *Andrographis paniculata;* root of *Rauwolfia serpentina, Vetiviera zizanioides, Asparagus racemosus;* bark of *Holarrhena antidysentrica* and some others by mycotoxins has been communicated[10-20]. The screening of the medicinal herbs and crude drug yielding plants for identifying the mycotoxins seems a very scanty documentation in comparison to their world wide use. Still the scenario presented to us is very dismal.

Among the notable mycotoxins detected in the medicinal herb and crude medicines are Aflatoxins G_1, G_2, B_1, B_2 produced by *Aspergillus flavus,* Citrinin produced by *Penicillium citrinum,* Ochratoxins produced by *Aspergillus ochraceus,* Zearalenone produced by *Fusarium moniliforme* and *F. graminearum.* Aflatoxins have been reported to inflict dysfunction and diseases of liver, kidney and digestive system, reduction in total count of RBC and WBC and cause chromosomal abnormilities. As the dimension of utilization of herbs is widening with monstrous speed, there appears dire need to tackle the gigantic problem mentioned ahead not confined to the herbs only but detected in the pharmaceutical preparations too[3].

The increase in the acidity of the seed due to enzymic hydrolysis of fat into fatty acid and protein into amino acids have been reported[19,20]. Thus, this lowering of the pH may alter the efficacy of the pharmaceutical preparations of the herbs.

How to avoid the contamination of the mycotoxins in the herbs and herbal medicines? - What we have acquired from the erudite documentation and our experience, indicate that the drying of the plant product to reduce the moisture level to below ten per cent is the cheapest and prevalent convenient method. 14 % moisture level has been reported to damage sorghum[21] and rice[22] seed considerably. It has been suggested to reduce the moisture content of the medicinal herbs to below eight per cent[3]. Christensen and Kaufmann[23] in their comprehensive review of storage fungi stated that these fungi could grow in the seed in equilibrium with relative humidity of the storage between 70-90% which is generally prevalent in the rains in tropics including major part of our country.

The above statements point out that the medicinal herbs after the harvest, should be thoroughly dried conveniently and at cheapest rate. The sun drying is the most suitable technique. But some of the Ayurvedic physicians are of opinion that the parts of the plants to be used directly for preparing Ayurvedic medicines, should first be spread on the floor away from the direct sunlight and after considerable air drying, should be spread in the sun for one or two days depending upon the duration of sunshine and thickness of the parts of the plants, probably due to loss of some vital chemicals especially volatile ones by direct sunlight. Moreover, the aromatics such as terpenes, pinene, cymene, dipentene, phyllandrene, terpenolene, decylcaldehyde, ester of acetic acid and decyclic acid, cedrol, citronellol, geraniol, menthol, myrtenol, eugenol, thymol and many others are volatiles and there is apprehension of their loss at high temperature of the sun and its long duration. After drying, the moisture level must be determined and be reduced to less than ten per cent. Drying of the rhizome of turmeric, ginger; stem of *Tinospora* and root of *Asparagus* really create problems, rather it is unthinkable by plain drying in the sun. The ginger and turmeric are first boiled and then dried in the sun. *Asparagus* root is also boiled and the bark is peeled off and then dried. For drying *Tinospora* stem, it is wise to crush it with light weight hammer made of wood or iron. During normal drying of the fruit of *Emblica officinale,* soft rotting starts due to *Aspergillus flavus* and by the time of complete drying, decay of the whole lot is apprehended, therefore, vapour cooking of the fruit and removal of the seed from the cooked fruit followed by sun drying is quite easy job. *Cyperus rotundus* should also be treated like *Tinospora.* We cannot dry fleshy leaf of *Aloe vera* due to copious mucilage. The leaf extract by air and sun drying can be used. Undoubtedly the drying of the medicinal herbs is a technical matter which must be taught to the producers of the medicinal plants.

As regards storage and transport, these should be packaged dry in polyethylene pockets or bags or polyethylene lined airtight sacs and stored at relatively low temperature preferable in cold storage especially of those herbs containing aromatics. Grocers should package small amount of herbs, say 50, 100, and 200 g or so for storing as well as disposing the crowd of customers quickly and conveniently. This has earlier been suggested[24] for

saling of quite dry and consumable chilli fruit efficiently to the customers in petty shops of grocers.

There seems general tendency of convenience and easy handling with quick disposal to the customers. And, for such purpose, many herbs are made to powder form and packaged in small pockets. It is not unscientific if used within a short period.

Attempting detoxification of the mycotoxins - As the mycotoxins have been reported to be stable even up to 250°C[25], these cannot be removed from the herbs even during the preparation of decoction at boiling point of water. In Ayurvedic pharmacology high temperature is only applied in the preparation of Kshar and Bhasma. The cooking under pressure has been noticed to reduce the amount of aflatoxin but not eliminating completely. Other methods of detoxification of mycotoxins from the food materials and herbal drugs attempted so far[26-28] cannot be conceived as convenient, practical, satisfactory and less expensive.

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