

**CRUDE DRUG ADULTERATION: A CONCISE REVIEW****Salman Ahmed\* and Muhammad Mohtasheemul Hasan**

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**ABSTRACT**

The adulteration and substitution of crude drug is a burning problem. No doubt, substitution is helpful in places where unavailability of particular crude drug and or unwanted adverse effects of desired crude drug are there and have a choice of other drug with similar pharmacological effect and less unwanted after effects. But in most cases, it is unacceptable because the conversion of authentic drug into substandard drug may cause variety of adverse effects from mild and moderate to severe life threatening reactions. So, understanding of all the ways of adulteration and substitution is necessary to rectify this illegal act and maximizing consumers' safety. At the end of this review, Botanical Adulterant Program of American Botanical Council is also highlighted.

**KEYWORDS:** Adulteration, crude drug, substitution.

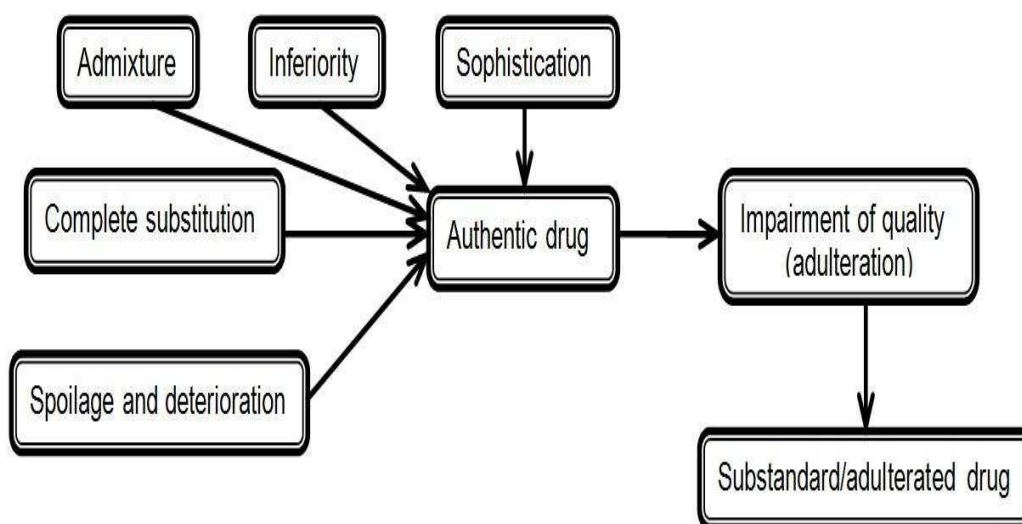
**INTRODUCTION**

The adulteration more precisely defined as crude drug appears at first sight to be genuine as its morphological similarity and sometimes chemically indistinguishable. It is deliberate or accidental substitution of a crude drug partially or completely with other substances which are either free or inferior in therapeutic or chemical properties. Substitution of the herbs is the need of the hour when required medicinal plants becoming red listed. The most essential criteria for substitution is the pharmacological activity rather than morphology or constituents. Substitution of herbs achieved many goals though basic was to provide similar therapeutic effect as that of original drug. It provided a greater scope for the physician to utilize herbs that are easily available, cost effective and most appropriate for the clinical condition. The adverse reaction of the drug in which required drug have unwanted adverse

reaction along with therapeutic effects. e.g., abortifacient effect of any drug is limited in pregnancy, substitution with other crude drug is preferable.<sup>[1]</sup> As Traditional Chinese Medicine became part of China's national public healthcare system in the mid-1950s, local species of important herbal drugs were reasonably substituted for the official source plant with the knowledge that the substitute was less potent. For example, in the 1985 *Pharmacopoeia of the People's Republic of China*, with respect to the official source plant for the herb *jin yin hua* is *Lonicera japonica* (Caprifoliaceae, Japanese honeysuckle flowers). Three species, *Lonicera hypoglauca*, *Lonicera confusa*, and *Lonicera dasystyla*, are listed as interchangeable substitutes for *Lonicera japonica*. An additional 9 species are acknowledged to be acceptable as local substitutes in specific regions. In this example, when the official species are unavailable, local substitutes are acceptable.

The unwanted aspect of substitution lies under sub standard conditions. Which sometimes become life threatening. Adulteration caused a variety of adverse effects from mild (allergic reactions, fatigue, gastrointestinal upset, mood disturbances or muscle weakness, nausea, pain, and respiratory complaints) to moderate (confusion, convulsions, dermatitis, lethargy or seizures, leucopenia, sensory disturbances, vomiting) to severe (carcinomas, cerebral oedema, coma, intracerebral haemorrhage, poisoning, metabolic acidosis, multi-organ failure, nephrotoxicity, perinatal stroke, renal or liver failure or death) life threatening effects.<sup>[2]</sup> One of the example is Ginger Jake Epidemic. It was an attempt to make fluid extract of ginger more palatable as a way to attain a cheap drunk during the prohibition of alcohol in the United States during the 1920s by systematically adding plasticizers such as dibutyl phthalate and ethylene glycol (antifreeze) to the illegal beverage disguised as a medicinal —fluid extract. Finally, tri-ortho-cresyl phosphate (TOCP) was added to the extract to smooth out the taste. It was the toxic compound in the ginger extract. Symptoms of TOCP poisoning, following initial gastrointestinal problems, had a latency period of 10-20 days. The proceeding neurotoxicity included pain and paraesthesia of the lower extremities, then progressive muscle weakness usually developing into paralysis of the lower extremities. The symptoms were the result of axonal degeneration in peripheral nerves and degeneration of anterior horn cells from the spinal cord. From February to March 1930, thousands of victims become died as a result of toxic reactions.<sup>[3]</sup> When natural constituents are below than required minimum standard is known as Inferiority. It can be avoiding by careful selection of plant material. Destruction of drug constituents contains two types. Spoilage is produced by microbial or other pest infestation. It makes a product unfit for consumption. It can be avoid

by careful drying and storage conditions. Whereas, deterioration is a destruction of valuable drug constituents by bad treatment or aging or deliberate extraction of constituents and sale the residue as original drug. Addition of material other than drug consist of three types. Admixture is the addition of one article to another through accident or carelessness. Inclusion of soil / stones on an underground part (roots, rhizome) by carelessness / ignorance and accidental and co-collection of two similar species are examples. Sophistication is the deliberate addition of spurious / inferior material with intends to defraud. For example, addition of yellow colored starch powder in *Zingiber officinale* (ginger) powder and *Carica papaya* seeds in *Piper nigrum* (black pepper) fruit. Complete substitution is the addition of an entirely different article in place of that which is required. Supply of cheap cotton seed oil in place of pure olive oil is one of the example.<sup>[1]</sup>



**Figure-1: Factors creating adulteration in authentic crude drug.**

### CRITERIA FOR DESIRABLE SUBSTITUTION<sup>[1]</sup>

Drug should exhibit similar chemical constituents and therapeutic effects.

#### a. Substitution with totally different drug

- *Clerodendron indicum* and *Solanum xanthocarpam* (Yellow-berried Nightshade) have shown antihistaminic activity and employed in diseases related to respiratory system.
- The chemical constituents of *Tribulus terretris* (Chota Gokhru) Family: Zygophyllaceae and *Pedaliium murex* (Large Caltrops / Bara Gokhru) Family: Pedaliaceae are different. *Tribulus terretris* contains chlorogenin, diosgenin, rutin, rhamnase, and alkaloids. Whereas, *Pedaliium murex* possesses ursolic acid, vanillin, flavonoids and alkaloids. But both species are proved as nephroprotective, diuretic and hepatoprotective effect.

**b. Substitution of species belonging to same family**

The chemical constituents of *Datura metel* (black datura) and *Datura stramonium* (thorn apple) Family: Solanaceae are alkaloids as scopolamine, atropine, hyoscyamin. These alkaloids are proved as bronchodilator and inhibitor of mucus membrane secretions in respiratory tract. So, both species are beneficial in the disease of respiratory tract.

**c. Substitution of different parts of plant**

The roots of *Sida cordifolia* considered as official drug. Root contains sitoindoside and acyl steryl glycoside. Whole plant contains alkaloids, hydrocarbons, fatty acids and ephedrine. Various plants extracts exhibit antibacterial, antioxidant, hypoglycemic, hepato-protective and cardio tonic activities. Roots and aerial parts both are equally effective in above mentioned conditions.

**REASONS OF ADULTERATION<sup>[4]</sup>****a. Confusion in Vernacular names**

Same vernacular name of different species and different vernacular names of same species creates confusion and invites adulteration (Table-1). In Ayurveda, Parpatta refers to *Fumaria parviflora*. In Siddha, 'Parpadagam' refers to *Mollugo pentaphylla*. Owing to the similarity in the names in traditional systems of medicine, these two herbs are often interchanged or adulterated or substituted (Table-1).

**b. Lack of knowledge about authentic source**

Nagakesar is one of the important drugs in Ayurveda. The authentic source is *Mesua ferrea*. However, market samples are adulterated with flowers of *Calophyll uminophyllum* because suppliers are unaware of it. Authentic flowers can be easily identified by the presence of two-celled ovary whereas in case of spurious flowers they are single celled.

**c. Similarity in morphology**

*Mucuna pruriensis* adulterated with other similar Papilionaceae seeds having similarity in morphology. *Mucuna utilis* (sold as white variety) and *Mucuna deeringiana* (sold as bigger variety) are popular adulterants. Apart from this *Mucuna cochinchinensis*, *Canavalia virosa* and *Canavalia ensiformis* are also sold in Indian markets. Authentic seeds are up to 1 cm in length with shining mosaic pattern of black and brown color on their surface. *Mucuna deeringiana* and *Mucuna utilis* are bigger (1.5-2 cm) in size. While *Mucuna deeringiana* is dull black and *Mucuna utilis* is white or buff colored.

**Table-1: Examples of same vernacular names for different species and Different vernacular names of same species of African and Nigerian plants<sup>[5, 6]</sup>**

Language	Vernacular name	Scientific name	Family
<b>Same vernacular name of different species</b>			
Digo	Kibombo	<i>Dissotis rotundifolia</i> (Smith) Triana.	Melastomataceae
		<i>Rauvolfia mombasiana</i> Stapf.	Apocynaceae
	Kamata	<i>Aerangis thomsonii</i> (Rolfe) Schltr.	Orchidaceae
		<i>Culcasia scadens</i> P.Beauv.	Araceae
Kamba	Kawata	<i>Rubia cordifolia</i> L.	Rubiaceae
		<i>Stapelia semota</i> N.E.Br.	Asclepiadaceae
Kipsigis	Lemeiywet	<i>Ozoroa incano</i>	Anacardiaceae
		<i>Syzygium guineense</i> (Willd.) de Candolle.	Myrtaceae
Ngoni	Mambahuru	<i>Hydnora africana</i> Thunb.	Moraceae
		<i>Cissus rotundifolia</i> Vahl.	Vitaceae
-----	Indian plum	<i>Flacourtia indica</i> (Burm. f.) Merr.	Salicaceae
		<i>Ziziphus mauritiana</i> Lam.	Rhamnaceae
Luo	Ochol	<i>Diospyros abyssinica</i> (Hiern) F. White	Ebenaceae
		<i>Lepisanthes senegalensis</i> (Poir.) Leenh.	Sapindaceae
		<i>Mystroxydon aethiopicum</i> (Thunb.) Loes.	Celastraceae
		<i>Pseudospondias microcarpa</i> Engl.	Anacardiaceae
Swahili	Mgunga	<i>Schrebera alata</i> (Hochst.) Welw.	Oleaceae
		<i>Acacia etbaica</i> Schweinf.	Mimosoideae
		<i>Acacia nilotica</i> (L.) Del.	
		<i>Acacia robusta</i> Burch.	
		<i>Acacia senegal</i> (L.) Willd.	
		<i>Acacia seyal</i> Del.	
<i>Acacia stuhlmannii</i> Taub.			
		<i>Acacia tortilis</i> (Forssk.) Hayne.	
<b>Different vernacular names of same species</b>			
Digo	Mungwene ; Masalansi	<i>Uvaria acuminata</i> Oliv.	Annonaceae
Shambaa	Mnkande; Mvugve; Mvungunya	<i>Kigelia africana</i> (Lam.) Beneth.	Bignoniaceae
Digo	Mserere; Msettette; Mtambaajongoo; Mvuma	<i>Hoslundia opposita</i> Vahl.	Labiatae
Shambaa	Mshwee; Mshwelele		

#### d. Lack of authentic plant

*Hypericum perforatum* is cultivated and sold in European markets. In India, availability of this species is very limited. However, the abundant Indo-Nepal species *Hypericum patulum*,

sold in the name of *Hypericum perforatum*. Market sample is a whole plant with flowers and it is easy to identify them taxonomically. Anatomically, transverse section of *Hypericum perforatum* stem has compressed thin phloem, hollow pith and absence of calcium oxalate crystals. Whereas *Hypericum patulum* as broader phloem, partially hollow pith and presence of calcium oxalate crystals.

#### e. Similarity in Color

It is well known that with course of time, drug materials get changed to or substituted with other plant species. 'Ratanjot' is a recent day example. In the past, roots of *Ventilago madraspatana* were collected from Western Ghats, as the only source of 'Ratanjot'. However, that has not been practiced now. It is clearly known that *Arnebia euchroma* var. *euchromais* the present source. Similarity is in yielding a red dye, *Arnebia euchroma* substitutes *Ventilago madraspatana*. Recently *Ventilago madraspatana* is not found in market. Whatever is available in the market, in the name of Ratanjot is originated from *Arnebia euchroma*.

#### f. Careless Collections

Some of the herbal adulterations are due to the carelessness of herbal collectors and suppliers. *Parmelia perlata* is used in Ayurveda, Unani and Siddha. It is also used as grocery. Market samples showed it to be admixed with other species (*Parmelia perforata* and *Parmelia cirrhata*). Sometimes, *Usnea* sp. is also mixed with them.

### TYPES OF ADULTERATION<sup>[4]</sup>

#### a. Substitution with inferior commercial verities

It is the use of morphologically resemble, different inferior commercial verities (may or may not have any chemical or therapeutic potential as that of original natural drug).

Example are

- Arabian senna (*Cassia angustifolia*), dog senna (*Cassia obovata*) and ovaram senna (*Cassia auriculata*) have been used to adulterate Senna (*Cassia senna*).
- Japanese ginger (*Zingiber mioga*) have been used to adulterate medicinal ginger (*Zingiber officinale*).
- *Capsicum annum* have been used to adulterate *Capsicum minimum*.
- *Piper nigrum* fruit is adulterated by *Carica papaya* seeds.

**b. Substitution with artificially manufactured drug**

Artificially manufactured substances use as a substitute of the original drug. Artificial sugar for honey, yellow colored paraffin wax for bees wax, compressed Chicory in place of coffee and properly cut and shaved basswood for nutmeg (Jaifal) are examples.

**c. Substitution by exhausted drugs**

Same plant material is mixed with drug having no active medicinal components as they have already been extracted out.

**Examples**

- **Volatile oil containing drugs :** *Foeniculum vulgare* (fruit / fennel) , *Syzygium aromaticum* (flowering buds / clove) , *Coriandrum sativum* (fruit / coriander) , *Carum carvi* (fruit / caraway / siahjeera) , *Cascara sagrada*(Sacred Bark / jamal gota) and *Zingiber officinale* (roots / ginger).
- **Coloring matter containing drugs:** In case of loss of coloring material during exhaustion the residue is recolored with artificial dye. Examples: *Rosa macdub* (Red rose petal) and *Crocus sativus* (stigma of flowers / saffron), *Camellia sinensis* (leaves / tea).

**d. Substitution by superficially similar but cheaper natural substances**

Adulterated product has no relation with genuine material, may or may not have any therapeutic or chemical component. As *Ailanthus altissima* (*Ailanthus*) are substituted for *Atropa belladonna* (*Belladonna*), *Cassia acutifolia* (*senna*) , *Mentha longifolia* (*mint*) etc.; Leaves of *Phytolacca americana* (*pokeweed*) and *Scopolia japonica*, (*Japanese belladonna*) for *Atropa belladonna* (*Belladonna*); Leaves of *Xanthium strumarium* for *stramonium* and dandelion *Anethum sowa* (*Indian dill*) with *Anethum graveolens* (*European dill*) or *Carum carvi* (*caraway*).

**e. Substitution by addition of worthless or heavy materials****Examples**

- Large mass of stone mixed with *Glycyrrhiza glabra* (*liquorice root*).
- Pieces of lime stone mixed with *Ferula assa-foetida* (*Asafoetida*).
- Lead shot mixed with pieces of *Papaver somniferum* (*opium*).

**f. Addition of synthetic principles**

It is the use of synthetic chemicals to enhance the natural character. Addition of benzyl benzoate to peru balsam, citral to citrus oils and lemon oil to orange oil are examples. Many herbal products contain undisclosed prescription or over-the-counter drugs and heavy metals. In 1998, the California Department of Health reported that 32 percent of Asian patent medicines sold in that state contained undeclared pharmaceuticals or heavy metals. The drugs most frequently found were ephedrine, chlorpheniramine, methyltestosterone, and phenacetin; 10 to 15 percent contained lead, mercury, or arsenic. The FDA and other investigators have also reported the presence of prescription drugs, including glyburide, sildenafil, colchicine, adrenal steroids, alprazolam, phenylbutazone, and fenfluramine, in products claiming to contain only natural ingredients. For example, PC-SPES is a patented herbal preparation marketed to “enhance prostate health,” but commonly used to treat prostate cancer. Reports of its effectiveness have appeared in major medical journals. After chemical analysis of PC-SPES revealed the presence of diethylstilbestrol, indomethacin, warfarin, or a combination of these drugs, the product was removed from the market. In 2002, the Japanese Ministry of Health, Labor and Welfare reported that the use of certain imported Chinese dietary supplements was associated with hepatic failure and hyperthyroidism. These products proved to be adulterated with *N*-nitroso-fenfluramine, fenfluramine, and thyroid extracts. As of September 2002, a total of 622 patients were known to have become ill, with 148 requiring hospitalization; 3 deaths have occurred. The offending products were recalled, and the ministry required manufacturers to perform chemical analyses on all imported dietary supplements.<sup>[7]</sup>

**AHP-NCNPR Botanical Adulterants Program**

The American Botanical Council (ABC), the American Herbal Pharmacopoeia (AHP), and the University of Mississippi's National Center for Natural Products Research (NCNPR)—have initiated a large-scale program to educate members of the herbal and dietary supplement industry about ingredient and product adulteration. Responsible parties in the herbal and dietary supplement community have become increasingly concerned about the suspected and confirmed practice of adulteration of numerous ingredients. The existence of adulteration raises questions about the identity and quality of some popular herbal ingredients sold in dietary supplements in the United States and in other botanical products (e.g., medicines, cosmetics, etc.) in global markets. The ABC-AHP-NCNPR Botanical Adulterants Program will focus on both accidental adulteration that occurs as a result of poor quality-control



procedures, as well as the intentional adulteration of plant-based products for financial gain. This industry-funded program aspires to serve as a self-regulatory mechanism for industry to address adulteration problems through education rather than federal regulation. The ABC-AHP-NCNPR Botanical Adulterants Program is a long-term, multi-party coalition of herb quality and identity experts in university research groups, third-party analytical laboratories, government agencies, trade associations, and industry companies to examine the extent of suspected adulteration of herbal materials, particularly adulteration that is economically motive. The intention is to confirm the extent of adulteration in the United States and global markets, determine which official or unofficial analytical methods are currently available to help detect the presence or absence of a suspected or known adulterant, and to provide comment and guidance on the relative strengths and/or weaknesses of differing analytical methods. The results of this investigation will be published in a series of reports (white papers) and will be made available on the ABC website.<sup>[8]</sup>

## CONCLUSION

After understanding the ways of adulteration, more research and information required to rectify and minimize the illegal act adulteration, for improving consumers' safety. For this purpose we can take help from scientific literature, expert opinion, pharmacology, kinetics/dynamics, interactions, adverse effects, toxicology and dosing. The numerous reports of adverse effects and deaths associated with botanical health products, the distribution and widespread sale of adulterated products, and the marked increase in misleading promotional claims on the Internet demand prompt action to protect the public health. For this reason, vigorous and concerted action is needed to educate the public and government about the critical need for new regulatory safeguard and for the government funding to implement them. In this regard the ABC-AHP-NCNPR Botanical Adulterants Program is highly appreciated and off course will play an important role to remove out that bug, adulteration from our planet.

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