MEDICINAL PLANTS: THE MEDICAL, FOOD, AND NUTRITIONAL BIOCHEMISTRY AND USES

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Abstract

This article focuses on the medical, food, and nutritional biochemistry and uses of medicinal plants. Medicinal plants are used with the intention of health maintenance, to be administered for specific conditions, or both, whether in modern or in traditional medicines. Many phytochemicals with established or potential biological activity have been identified in plants. The compounds found in plants (phytochemicals) are of several kinds, but most are in four main biochemical classes: terpenes, alkaloids, glycosides, and polyphenols. Medicinal plants are used widely in non-industrialized societies and developing countries in Africa, Asia, and Southern America, mainly because they are thought to be very effective, cheaper than modern medicines, and readily available. Plants, including many currently used as culinary spices and herbs, have been used as medicines, not certainly effectively, from ancient times. Polyphenols of many classes are widely spread in plants. Plants having phytoestrogens, a type of polyphenols, have been administered for decades for gynecological conditions, such as fertility, menopausal, and menstrual problems; among these plants are *Pueraria mirifica*, anise, kudzu, angelica, and fennel. The astringent rind of the pomegranate, having polyphenols known as punicalagins, is commonly used as a medicine. Angelica, having phytoestrogens, has been used for gynaecological disorders for long. Nicotine, an alkaloid, from tobacco directly binds to Nicotinic acetylcholine receptors in the body, accounting for its pharmacological effects. Cardiac glycosides are powerful drugs from the medicinal plants including lily of the valley and foxglove; they include digitoxin and digoxin which support heart beating, and work as diuretics. Terpenoids and terpenes of many kinds are contained in many medicinal plants, and also in resinous plants such as conifers; they are strongly aromatic. A number of the terpenoids and terpenes have medicinal uses: for instance, thymol (an antiseptic) was once used as an anti-worm medicine (vermifuge). In most of the developing countries, especially in the rural areas, local traditional medicine, inclusive of herbalism, is the lone source of health care for individuals, while in the developed countries, alternative medicine including dietary supplements is aggressively marketed using claims of traditional medicine.

Keywords: Medicinal Plants, Biochemistry, Food Plants, Phytochemicals

1. Introduction

Medicinal plants (medicinal herbs) have been discovered for decades and used in traditional medicine practices ever since prehistoric times. Plants synthesize hundreds of chemical and biochemical compounds for functions including defense against insects, herbivorous mammals, fungi, and diseases. Numerous phytochemicals with established or potential biological activity have been identified in plants. However, as a single plant has widely diverse phytochemicals, the effect of using a whole plant as medicine is not certain. Further, the pharmacological actions and phytochemical contents, if any, of several plants with medicinal potential remain untapped unassessed by rigorous scientific research to categorically define safety and efficacy (Ahn, 2017).

The earliest historical records of medicinal plants (herbs) are found from the Sumerian civilization, where hundreds of medicinal plants, opium inclusive, are listed on the clay tablets. Ebers Papyrus from the ancient Egypt, c. 1550 BC, defines over 850 plant medicines. Dioscorides, a Greek physician, who worked in the Roman army, acknowledged and documented over a thousand recipes for medicines with over 600 medicinal plants in the *De materia medica*, c. 60 AD; this preformed and laid the foundation for the basis of pharmacopoeias for 1500 years. Drug related research makes use of the ethnobotany to search for the pharmacologically active natural substances, and has in this manner discovered hundreds of beneficial compounds. These include the popular drugs aspirin, opium, digoxin, and quinine. The compounds found in plants (phytochemicals) are of several kinds, but most are in four main biochemical classes: terpenes, alkaloids, glycosides, and polyphenols.

Medicinal plants are used widely in non-industrialized societies and developing countries in Africa, Asia, and Southern America, mainly because they are thought to be very effective, cheaper than modern medicines, and readily available. The annual value of the global export of the thousands of plants with suspected medicinal characteristics and properties was projected to be 2.2 billion USD in 2012. In the year 2017, the potential global market for the botanical medicines and extracts was projected at several hundred billion dollars (Ahn, 2017). In many nations, there is little or no regulations of traditional medicine practices, but the WHO coordinates a network to encourage rational and safe use. Medicinal plants face both specific threat of over-collection to meet the market demand and the general threats, such as habitat destruction and climate change (Ahn, 2017).

Plants, including many presently used as spices and culinary herbs, have been used as medicines, not essentially effectively, from prehistoric times. Spices are partly used to counter food spoilage microorganism (bacteria), especially in hot climates (Tapsell *et al.*, 2006; Billing and Sherman, 1998), and especially in meat dishes that spoil more readily (Sherman and Hash, 2001), most of the extracts including sugar alcohols do not contribute to tooth day (Awuchi, 2017). Angiosperms (flowering plants) were known to be the original source of many plant medicines. Human settlements are usually surrounded by weeds often used as herbal medicines, such as dandelion, chickweed, and nettle (Stepp, 2004; Stepp and Moerman, 2001). Humans were not alone, as is, in utilizing herbs as medicines: a number of animals such as sheep, non-human primates, and monarch butterflies ingest medicinal plants when ill (Sumner, 2000). Plant samples from ancient burial sites are amongst the lines of evidence and indication that Paleolithic folks had knowledge of herbal medicine. For example, a 60000-year-old burial site of Neanderthal, "Shanidar IV", in northern part of Iraq has yielded large quantities of pollen from

eight species of plant, seven of which are currently used as herbal remedies (Solecki, 1975). A mushroom was spotted in the *Ötzi the Iceman's* personal effects, whose body in the Ötztal Alps was frozen for over 5,000 years. The mushroom was most likely used against whipworm (Capasso, 1998).

In prehistoric Sumeria, medicinal plants (in hundreds) including opium and myrrh are enlisted on clay tablets. The prehistoric Egyptian Ebers Papyrus enlists over 800 medicinal plants such as aloe, juniper, mandrake, cannabis, castor bean, and garlic. From ancient times to present, Ayurvedic medicines as documented in the Sushruta Samhita, the Atharva Veda, and the Rig Veda, have used hundreds of pharmacological active spices and herbs such as turmeric, which contains curcumin (Aggarwal *et al.,* 2007*;* Girish and Shridhari, 2007). The pharmacopoeia of the Chinese, the *Shennong Ben Cao Jing* record plant medicines such as chaulmoogra for ephedra, leprosy, and hemp (Sumner, 2000). This was extended in the Tang Dynasty *Yaoxing Lun* (Wu, 2005). In the 4th century BC, an Aristotle's pupil Theophrastus composed the first systematic botany text, known as *Historia plantarum* (Grene, 2004). In about 60 AD, Pedanius Dioscorides, a Greek physician, working for the Roman army, acknowledged over 1000 recipes for medicines with over 600 medicinal plants in the *De materia medica*. The book remained an authoritative reference on herbalism for more than 1500 years, into the 17th century.

The place and roles of plants in medicine were radically altered in the nineteenth century by the application and use of chemical analyses. Alkaloids were extracted and isolated from succession of medicinal plants, beginning with morphinefrom the poppy, and soon followed by strychnos and ipecacuanha, quinine from the cinchona tree, and several others. As chemistry advanced, more classes of pharmacologically active compounds and substances were discovered in the medicinal plants (Atanasov *et al.,* 2015). Commercial extraction of the purified alkaloids including morphine from the medicinal plants started at Merck in 1826. The synthesis of substance first discovered in medicinal plant started with salicylic acid in 1853 (Atanasov *et al.,* 2015). Around the end of the nineteenth century, the mood of pharmacy swung against the medicinal plants, as enzymes frequently modified the active ingredients once whole plants were dried, and glycosides and alkaloids purified from plant materials started to be preferred. The drug discovery from medicinal plants continued to be important throughout the 20th century and into 21st, with significant anti-cancer drugs from yew and the Madagascar periwinkle (Atanasov *et al.,* 2015).

This paper critically focused on the medical, food, and nutritional biochemistry and uses of medicinal plants. It also gives insight on the pharmacological and biochemical applications of the components, such as terpenes, alkaloids, glycosides, and polyphenols, in medicinal plants.

1.1. Contextualization of medicinal plants

Medicinal plants are plants used with the intention health maintenance, to be administered for some specific conditions, or both, whether in traditional medicine or in modern medicine (Ahn, 2017; Smith-Hall *et al.,* 2012). In 2002, the Food and Agriculture Organization of the UN estimated that more than 50,000 medicinal plants are used all over the world (Schippmann *et al.,* 2002).In 2016, The Royal Botanic Gardens, Kew conservatively estimated that 17,810 plant species have medicinal use, out of about 30,000 plants for which a use of whichever kind is documented (Royal Botanic Gardens, 2016).

In modern medicine, about one quarter of the drugs prescriptions for patients are derived from medicinal plants, and are rigorously tested (Smith-Hall *et al.*, 2012). In other systems of medicine, the medicinal plants may be the majority of what are usually informal attempted treatments, not scientifically tested (Tilburt and Kaptchuk, 2008). The WHO estimated, without reliable data, that some 80% of the population of the world depend mostly on traditional medicine (which include but not limited to plant); perhaps some 2 billion individuals are mainly reliant on medicinal plants (Smith-Hall *et al.*, 2012). The use of plant materials including natural health products or herbal products with supposed health benefits, is growing in developed countries (Ekor, 2013). This brings associated risks of toxicity and some other effects on the human health, in spite of the safe image of natural products and herbal remedies (Ekor, 2013). Herbal medicines have been in usage since long before the existence of modern medicine; there was and usually still is little or no existing knowledge of the pharmacological and biochemical basis of their actions and mechanisms, if any exist, or of their safety, if need be; there are always need for dose related safety concerns of medicinal plants and herbal medicines, as well as the active biomolecules and compounds present in them. In 1991, the WHO formulated a policy on traditional medicine, and ever since then has published the guidelines for them, with series of monographs on the widely used herbal medicines (Singh, 2016; Cravotto *et al.*, 2010) and medicinal plants.

Medicinal plants often provide three major kinds of benefits: financial benefits to individuals who harvest, process, and sale or distribute them; health benefits to the individuals who consume them as medicines; and society-wide benefits, such as taxation income, job opportunities, and a healthier labour force (Smith-Hall *et al.*, 2012). Nevertheless, development of plants or plant extracts with potential medicinal uses and applications is dulled by weak scientific evidence, insufficient financing, and poor practices in process of drug development (Ahn, 2017).

1.2. Phytochemicals

All plants produce chemical substances and compounds which give them evolutionary advantages, such as defense against herbivores or, in the instance of salicylic acid, as hormone in plant defenses (United States Department of Agriculture, 2017; Hayat and Ahmad, 2007). These phytochemicals have the potential for use as drugs, and also the contents and known pharmacological activities of these biochemical substances in medicinal plants formed the scientific basis for their uses and applications in modern medicine, if scientifically proved (Ahn, 2017). For example, daffodils (*Narcissus*) have nine groups of alkaloids including the galantamine, licensed for medicinal use against Alzheimer's disease. Alkaloids are bitter-tasting and often toxic (in the science of nutrition and toxicology, bitterness depicts toxicity), and concentrated in the plant parts, such as the stem, which are most likely to be consumed by herbivores; they can also protect against parasites (Bastida *et al.*, 2006; Birks, 2006). Modern knowledge and information on medicinal plants are being systematized in Medicinal Plant Transcriptomics Database, which as at 2011 provided a sequence reference for transcriptome of some thirty species (Soejarto, 2011). The main classes of pharmacologically active phytochemicals are explained below, with examples of the medicinal plants which contain them.

1.2.1. Polyphenols

Polyphenols of many classes are widespread in plants, playing diverse roles in their defense mechanisms against predators and plant diseases. They include astringent tannins and hormone-mimicking phytoestrogens (Elumalai and Eswariah, 2012; Da Silva *et al.* 2013). Plants containing phytoestrogens have been successfully administered for centuries for gynecological conditions and disorders, such as fertility, menopausal, and menstrual problems (Muller-Schwarze, 2006). Some of these plants are *Pueraria mirifica*, anise, kudzu, angelica, and fennel. Many polyphenolic extracts, such as extracts from grape seeds, bark of maritime pine or olives, are sold and advertised as dietary supplements and cosmetics with little or no proof or legal health claims based on scientific evidence for beneficial health effects (European Food Safety Authority, 2010). In Ayurveda, the astringent rind of pomegranate containing polyphenols known as punicalagins, is used as medicine (Jindal and Sharma, 2004). Angelica, which contains phytoestrogens, has long been used to remedy gynaecological disorders.

1.2.2. Alkaloids

Alkaloids are bitter-tasting chemicals which are often toxic and very widespread in nature, found in many medicinal plants (Aniszewski, 2007). There are many classes with different modes and mechanisms of action as drugs, both pharmaceutical and recreational. Medicines of different classes include scopolamine, hyoscyamine, and atropine (all from nightshade), caffeine (*Coffea*), cocaine (*Coca*), the traditional medicine berberine (from the plants such as *Mahonia* and *Berberis*), ephedrine (*Ephedra*), morphine (opium poppy), quinidine and quinine (*Cinchona*), nicotine (tobacco), reserpine (*Rauwolfia serpentina*), vincristine (*Catharanthus roseus*), and vincamine (*Vincaminor*) (Elumalai and Eswariah, 2012; Gremigni *et al.*, 2003). The opium poppy *Papaver somniferum* is a source of the alkaloids codeine and morphine. Deadly nightshade, *Atropa belladonna*, gives tropane alkaloids including scopolamine, hyoscyamine, and atropine. The alkaloid nicotine from tobacco directly binds to the Nicotinic acetylcholine receptors of the body, accounting for its pharmacological and biochemical effects.

1.2.3. Glycosides

The cardiac glycosides are powerful and potent drugs from medicinal plants which include lily of the valley and foxglove. They include digitoxin and digoxin which support heart beating, and act as diuretics. The anthraquinone glycosides are detected in medicinal plants such ascascara, Alexandrian senna, and rhubarb (Wang *et al.*, 2013; Chan and Lin, 2009). Plant-based laxatives produced from such plants include senna, *Aloe*, and rhubarb. *Senna alexandrina*, which contains anthraquinone glycosides, has been used often as a laxative for ages. The foxglove, *Digitalis purpurea*, has digoxin, a cardiac glycoside. The plants were used on heart conditions long before the identification of the glycoside. Digoxin is used to treat heart failure, atrial fibrillation, and atrial flutter.

1.2.4. Terpenes

Terpenes and terpenoids of several kinds are found in various medicinal plants (Wiart, 2014), and in resinous plants like the conifers. They serve to repel herbivores and are strongly aromatic. Their scent makes them useful and suitable in essential oils, whether for aromatherapy or for perfumes such as lavender and rose (Singsaas, 2000). Some have medicinal uses: for

instance, thymol, an antiseptic, was once used as vermifuge (medicine for anti-worm). The essential oil of *Thymus vulgaris* (common thyme), contains the monoterpene thymol, an antifungal and antiseptic. Thymol is one the several terpenes found in plants.

2. Medicinal plants in practice

2.1. Cultivation of medicinal plants

Medicinal plants require intensive management. Different species require their own distinct cultivation conditions. The WHO recommends the use of rotation to minimize problems with plant diseases and pests. Cultivation may be traditional or can use conservation agriculture practices, or state of the art agricultural equipment to conserve water and to maintain the organic matter in the soil, for instance with no-till farming systems (World Health Organization, 2003). In many aromatic and medicinal plants, plant characteristics often vary widely with cropping strategy and type of soil, so care is essentially required to obtain satisfactory yields (Carrubba and Scalenghe, 2012).

2.2. Preparation of medicinal plants

Medicinal plants are usually tough and fibrous, requiring some preparation to make them more convenient to administer. According to Institute for Traditional Medicine, popular methods for the preparation of herbal medicines are powdering, extraction with alcohol, and decoction, in each case yielding mixture of substances. Powdering involves drying of the plant materials followed by crushing it to yield powder which can be compressed to form tablets. Decoction involves crushing followed by boiling the plant materials in water to produce liquid extract. The extraction with alcohol involves soaking of the plant material in distilled spirit or cold wine to form a tincture (Dharmananda, 1997).

Traditional poultices were prepared by boiling medicinal plants and wrapping them in a cloth, and then externally applying the resulting parcel to the affected parts of the body (Mount, 2015).

When modern medicine identifies a drug in medicinal plant, commercial quantities of the drug can either be extracted from plant material or synthesized, yielding a pure medicinal chemical. Extraction may be practical when the chemical compound in question is complex (Pezzuto, 1997).

2.3. Uses of medicinal plants

Plant medicines are extensively used worldwide. In most of the developing countries, especially in the rural areas, local traditional medicines, such as herbalism, are the major source of health care for the people, while in the developed countries, alternative medicines including the use of dietary supplements are marketed aggressively with the claims of traditional medicine. As at 2015, most products produced from medicinal plants have not been tested for their efficacy and safety, and products marketed in developed nations and provided in the undeveloped countries by the traditional healers were not of even quality, sometimes containing dangerous contaminants (Chan, 2015). Traditional Chinese medicine uses a wide variety of plants, amongst other materials and techniques. The researchers from the Kew Gardens found 104 species used for managing diabetes in Central America, in which seven were identified in at least three different studies (Giovannini, 2017; Giovannini *et al*., 2016). The Yanomami of Brazilian

Amazon, assisted by many researchers, have described 101 species of plant used for traditional medicines (Milliken, 2015; Yanomami *et al.,* 2014).

Drugs derived from plants including cannabis, opiates, and cocaine have both recreational and medical uses and applications. Different countries have at several times made use of illicit drugs, partly on the basis of risks involved in using psychoactive drugs (The Economist, 2010).

2.4. The effectiveness of medicinal plants

The cinchona tree bark contains the alkaloid quinine, traditionally used against malaria. The bark of the willow trees contains salicylic acid, an active metabolite of aspirin, which has been used for decades to reduce fever and relieve pain.

Plant medicines have often not been properly tested scientifically, but have been in use informally for centuries. By 2007, many clinical trials had demonstrated potential useful activities in nearly 16 percent of herbal medicines; there was very limited in vivo or in vitro evidence for approximately half of the medicines; there was only phytochemicals evidence for about 20%; 0.5% were toxic or allergenic; and about 12% had basically not been studied scientifically. The UK Cancer Research cautions that there is no sufficient or reliable evidence for effectiveness of herbal remedies for cancer treatment.

A phylogenetic study in 2012 built a family tree down to the genus level with 20,000 species to make comparison among the medicinal plants of three study regions, Nepal, the South African Cape, and New Zealand. The study discovered that the species traditionally used to treat the same kinds of conditions belonged to the same plants groups in all the three regions, giving strong phylogenetic signal (Saslis-Lagoudakis *et al.,* 2012). Since many plants that yield pharmacological and pharmaceutical drugs belong to these groups, and the groups were used independently in three different regions of the world, the results were taken to mean:

(a) That undefined pharmaceutical activity is associated with the use in traditional medicine,
(b) That the use of phylogenetic groups for medicines in a region may predict their use in other regions, and
(c) That these groups of plants do have potentials for medicinal usefulness (Saslis-Lagoudakis *et al.,* 2012).

2.5. Regulations for medicinal plants

The World Health Organization (WHO) is coordinating a network known as International Regulatory Cooperation for Herbal Medicines (IRCHM) with the aim to improve the quality of medical and pharmaceutical products produced from medicinal plants and also the claims made for these products. In 2015, only around 20 percent of countries of the world had well-functioning regulatory agencies in place, while 30 percent had none, and around 50 percent had limited capacity for regulation. In India, where the Ayurveda has been practiced for centuries, the herbal remedies are the responsibilities of the government department, AYUSH, under Ministry of Health & Family Welfare (Kala and Sajwan, 2007).

The WHO has set out strategies for traditional medicines with four main objectives:

a) to increase their affordability and availability;
b) to integrate them as part of the policies into national healthcare systems;
c) to promote their rational and therapeutically sound usage; and

d) to provide guidance and knowledge on their safety, quality, and efficacy (World Health Organization, 2013).

WHO notes in the strategy that nations are experiencing seven major challenges to such implementation, which include in developing and enforcing policy; in quality and safety, especially in the assessment of the products and the qualification of practitioners; in integration; in research and development; in controlling advertising; in the sharing of information; and in education and training (World Health Organization, 2013).

2.6. Drug discovery

The pharmaceutical industries have roots in the apothecary shops of the Europe in the 1800s, where some pharmacists provided local traditional medicines and medicinal remedies to customers, which included extracts such as morphine, strychnine, and quinine. Therapeutically important drugs like taxol (from Pacific yew, *Taxus brevifolia*) and camptothecin (from *Camptotheca acuminata*, used in the traditional Chinese medicine) were derived from medicinal plants (Heinrich and Bremner, 2006). The Vinca alkaloids vinblastine and vincristine, used as drugs for anti-cancer, were discovered in 1950s from a Madagascar periwinkle, *Catharanthus roseus* (Moudi *et al.,* 2013).

Hundreds of chemical compounds have been identified with ethnobotany, investigating the plants used by the indigenous peoples for the possibility of medical applications (Fabricant and Farnsworth, 2001). Some important phytochemicals, including resveratrol, curcumin, epigallocatechin gallate, andgenistein are pan-assay interference compounds, which means that *in vitro* studies of their activities often provide unreliable data, as well as insufficient evidence. Consequently, phytochemicals have often proven unsuitable as the lead compounds in drug discovery (Baell and Walters, 2014; Dahlin and Walters, 2014). Within 1999 to 2012 in the US, despite many hundred applications for new status of drugs, only two botanical drug candidates were with sufficient evidence of medicinal values to be approved by the US Food and Drug Administration (Ahn, 2017).

The pharmaceutical industry has remained absolutely interested in mining the traditional uses of the medicinal plants in its efforts of drug discovery. Among the 1073 small-molecule drugs approved within 1981 to 2010, more than half were either inspired by or derived directly from natural substances (Newman and Cragg, 2012).

2.7. Safety concerns of medicinal plants

Plant medicines can raise safety concerns and cause adverse effects and even death in extreme cases, whether by the side-effects of their active compounds (substances), by overdose, by inappropriate prescription, or by adulteration (or contamination). Many such effects are well known, while several others remain to be scientifically explored. The Thornapple Datura stramonium is used for asthma remedy, because of its content of the alkaloid atropine, but it is as well a powerful and potential fatal hallucinogen. There is no reason whatsoever to presume that as a product comes from nature it is safe: the existence of powerful natural poisons such as nicotine and atropine indicates this to be incorrect. Further, the high standards and quality applied to the conventional medicines do not often apply to the plant medicines, and dose often vary extensively depending on the growth conditions of the plants: for instance, older plants may be far more toxic than young plants (Talalay, 2001; Vickers, 2007), and also plants grown on

toxic and contaminated environments usually contain more toxic substances than the plants grown in organic and agricultural safe environment.

The extracts of pharmacologically active plants can interact with the conventional drugs, both because they can provide increased dose of related compounds, and because some phytochemicals delay and interfere with the body systems that metabolize drugs in the liver including cytochrome P450 system, causing the drugs to last longer in the body and also have a more powerful and potential cumulative effect (Nekvindová and Anzenbacher, 2007).Plant medicines may be dangerous during pregnancy (Born and Barron, 2005). Since plants usually contain several different substances, plant extracts can have complex effects on human body.

List of the herbs with some known adverse effects;

The list in Table 1 is a list of herbs and herbal treatments with the known or anticipated adverse effects, either alone or by interaction with other drugs or herbs. Table 2 shows herbs with adverse effects. The herbs not included in this list do not imply they are free of adverse effects. Generally, the effectiveness and safety of alternative medicines have not been proven scientifically and remain unknown to a large extent. Beyond the adverse effects from the herbs themselves, inappropriate formulation, adulteration, or lack of understanding of drug and plant interactions have led to the adverse reactions that may be life threatening or lethal.

The list is dynamic and comprehensive and may not satisfy particular standards for extensiveness. Most of the adverse effects indicated in this list are associated with just a small percentage of cases; as a result, they should be understood and taken as potential risks instead of as certainties.

Table 1: Herbs, treatments, and constituents with known or suspected adverse effects

Name	Other common names	Scientific name	Adverse effects
Aconite	Aconitum, monkshood, wolfsbane	*Aconitum* spp.	Heart palpitations and arrhythmias, abdominal pain, respiratory system paralysis, hypotension, nausea, vomiting, death
Aloe vera juice	medicinal aloe	*Aloe vera*	Potentially carcinogenic, abdominal pain, diarrhea, with others may potentiate antiarrhythmic agents and cardiac glycosides
Anthranoid laxatives			Potentially carcinogenic, abdominal pain, diarrhea, with others may potentiate antiarrhythmic agents and cardiac glycosides.
Areca nut	betel nut	*Areca catechu*	The deterioration of psychosis in the patients with preexisting psychiatric disorders, identified carcinogen contributing to cancer of the stomach, esophagus, pharynx, and mouth when

			chewed.
Aristolochic acid (in herbs in the genus *Aristolochia* such as *Aristolochiaser pentaria, Aristolochiareticulata* and in Chinese herbs like *Aristolochia fangchi* & *Aristolochia manshuriensis* (banned in China; *Stephaniatetrandra* & *Magnolia officinalis* do not have aristolochic acid).			Kidney toxicity associated with kidney failure; connected with the development of cancer, especially of the urinary tract, called carcinogen
Atractylate		*Atractylis gummifera*	Nausea, vomiting, liver damage, epigastric and abdominal pain, headache, diarrhoea, anxiety, and convulsions, usually followed by coma, among others.
Ayurvedic Herbo-mineral (Rasashastra) Medicines			Contamination with heavy metals
Bitter orange			Fainting, stroke, death, arrhythmia, heart attack
Broom	wood waxen, broom flower, dyer's broom, dyer's whin, furze, green broom, dyer's greenwood, dyer's weed, greenweed	*Genista tinctoria*	Uterotonic properties, diarrhea, nausea, and vomiting contraindicated for pregnancy as well as breast feeding
Buckthorn bark & berry	alder buckthorn	*Rhamnus frangula*	diarrhea, abdominal pain, potentially carcinogenic, with others may potentiate antiarrhythmic agents and cardiac glycosides
Bark of Cascara Sagrada	bearberry	*Rhamnus purshiana*	diarrhea, abdominal pain, potentially carcinogenic, with others may potentiate antiarrhythmic agents and cardiac glycosides
Chaparral	creosote bush,	*Larrea*	Liver damage, Hypotension in cancer

	larreastat, gobernadora	*divaricate, Larrea tridentata*	patients, kidney problems
Chinese herbal mixtures			Powerful heavy metal poisoning
Coltsfoot	Foalswort, coughwort, farfarae folium leaf	*Tussilago farfara*	Cancer, liver damage
Comfrey	comphrey, blackwort, slippery root, common comfrey	*Symphytum officinale*	Cancer, liver damage
Country mallow	silky white mallow, heartleaf	*Sida cordifolia*	Heart attack, stroke, death, heart arrhythmia
Dan Shen	tan shen, red sage, Chinese sage	*Salvia miltiorrhiza*	Potentiates warfarin activities, leading to excessive anticoagulation & bleeding
Dong quai	female ginseng	*Angelica sinensis*	Can induce uterine contractions; contraindicated when nursing or pregnant
European Mistletoe	common mistletoe	*Viscum album*	Gastrointestinal bleeding, toxic to cardio and the central nervous systems
Ephedra	ma huang	*Ephedra sinica*	Palpitations and agitation, hypertension, nervousness, tremors and seizures, irregular heart rate, insomnia, paranoid psychoses, strokes, heart attacks, and death, kidney stones
Flavonoids (conta in in many medicinal plants)	Citrin, Vitamin P	Bioflavonoids, flavonoids	Kidney damage, hemolytic anemia
Germander		*Teucrium*	Liver damage
Ginger		*Zingiber officinale*	Can alter the time of bleeding
Ginkgo	Gingko	*Ginkgo biloba*	Bleeding
American Ginseng	North American Ginseng, Canadian Ginseng, American Ginseng, Ginseng, Ginseng Root, Ontario Ginseng, Panax quinquefolium, Occidental Ginseng, Panax quinquefolius, Sang, Shang, Shi Yang Seng, Red Berry, Wisconsin	*Panax quinquefolius*	Chronotropic and hypertensive activities may increase the levels of digoxin, diarrhea, rapid heartbeat, hypertension or hypotension, itching, insomnia, headaches, nervousness, vaginal bleeding, breast tenderness. Very rarely Stevens–Johnson syndrome, severe allergy, liver damage, May lower blood sugar in combination with diabetes medicines. Possible birth defects, worsen hormone sensitive conditions such as ovarian cancer,

	Ginseng, RenShen		endometriosis, uterine fibroids, breast cancer, and uterine cancer. Insomnia.
Goldenseal	yellow puccoon, orangeroot	*Hydrastis canadensis*	Uterotonic effect
Greater celandine	celandine	*Chelidonium majus*	Cause liver damage
Guarana		*Paullinia cupana*	Insomnia and agitation
Guar gum	guaran		Obstruction of gastrointestinal tract
Gugulipid	guggal, Mukul myrrh tree, guggul	*Commiphora mukul*	Nausea, hiccups, headache, diminished effectiveness of other cardiovascular medications like propranolol and diltiazem
Hawthorn	may, mayblossom, maythorn, quickthorn, whitethorn, common hawthorn, motherdie, haw	*Crataegus monogyna*	Increases coronary dilation effects of sodium nitrate, adenosine, epinephrine, theophylline, caffeine, and papaverine, increase barbiturate-induced sleeping times, potentiates digitalis activity
Horse chestnut	Conker, conker tree	*Aesculus hippocastanum*	allergic reaction, anaphylaxis, and liver toxicity
Kava	kava-kava	*Piper methysticum*	Chronic use might cause reversible dry skin condition, potentates CNS sedatives
Khat	Qat	*Catha edulis*	Causes chronic liver dysfunctions
Liquorice root		*Glycyrrhizaglabra*	Hypertension, arrhythmias, edema, hypokalemia
Lobelia	pukeweed, vomit wort, asthma weed	*Lobelia inflata*	Toxicity, coma, death, rapid heartbeat, hypotension
Milk thistle	Marian thistle	*Silybum marianum*	Allergy, mild laxative
Pennyroyal		*Mentha pulegium*	May damage liver

Peony	Bai Shao, common peony, coral peony, Cortex Moutan, Chi Shao, Chinese peony, European peony, Mu Dan PI, peony flower, Jiu Chao Bai Shao, Moutan, peony root, piney, Shao Yao, tree peony, radix peony, red peony, Shakuyaku, UdSaleeb, Udsalam, White Peony Udsalap	Radix Paeoniae, Radix Paeoniae Rubra, Radix Paeoniae Alba, Paeonia, Paeonia alba, Paeonia lactiflora, Paeonia officinalis; Paeonia suffruticosa, Paeonia mascula; Paeonia obovata; Paeonia veitchii, Paeoniae Radix, Paeoniae Flos	May slow clotting; contraindicated for individuals with bleeding disorders; before and after surgery. Contraindicated when pregnant or nursing. Can induce uterine contractions.
Pyrrolizidine alkaloids (contained in senecio, coltsfoot, comfrey, borage, etc.)			Liver damage
Reserpine		*Rauvolfia serpentina*	Sedation, mental depression, nasal congestion, inability to complete tasks, mild diarrhea, increased gastric secretion
Safrole		*Sassafras albidum*	Can cause liver damage
Saw palmetto		*Serenoa repens*	headaches, diarrhea, gynecomastia, rare and mild gastrointestinal upset, ventricular rupture and death in a patient, paroxysmal atrial fibrillation
Senna	Egyptian senna	*Senna alexandrina*	liver damage, abdominal pain, can potentiate antiarrhythmic agents and cardiac glycosides, diarrhea, potentially carcinogenic

St John's wort	Klamath weed, Tipton's weed	*Hypericum perforatum*	Allergic reactions, fatigue, dry mouth, photosensitization, GI disturbances, dizziness, confusion
Valerian	garden heliotrope, all-heal, garden valerian	*Valeriana officinalis*	palpitations, insomnia, over sedation, overstimulation, drowsiness, GI upset, headache
Vasambu	sweet flag	*Acorus calamus*	Nausea and vomiting
Yohimbe	yohimbine	*Pausinystalia johimbe*	hypotension, heart problems, death, rapid heart rate, hypertension

Table 2: Herbs with adverse drug interactions

Name	Other names	Scientific name	Drugs	Adverse effects
Cinchona bark		*Cinchona pubescens*	Warfarin	Likely additive
Chamomile			Blood thinners	
Devil's Claw	wood spider, grapple plant	*Harpagophytum*	Warfarin	Additive effect
Ephedra		*Ephedra*	Caffeine, decongestants, stimulants	Additive effect
Feverfew	featherfew	*Tanacetum parthenium*	Aspirin	Additive effect
Garlic		*Allium sativum*	Warfarin	Additive effect
Ginger		*Zingiber officinale*	Warfarin	Causes iris bleeding, additive effect
Ginkgo	gingko	*Ginkgo biloba*	Ticlopidine, clopidogrel, dipyridamole, vitamin E, Aspirin, warfarin, garlic	With aspirin - retards absorption of aspirin
Ginseng		*Panax ginseng*	Warfarin	
Papaya extract		*Carica papaya*	Warfarin	Possibly additive, purpura, damage to GI tract mucous membrane
Kava	kava-kava	*Piper methysticum*	Antipsychotics, alcohol, sedatives, sleeping pills	
Milkvetch		*Astragalus*	May interact with medications which suppress immune system, such as cyclophosphamide.	May affect blood pressure and blood sugar levels.

Pineapple enzyme		*Ananas comosus*	Bromelain	Diarrhea, increased tendency for bleeding if simultaneously used with anticoagulants and the inhibitors of thrombocytic aggregation owing to modulation of arachidonate cascade
Psyllium seed		*Plantago* spp	Coumarin derivates	Retard drug absorption
St John's wort	Klamath weed, Tipton's weed	*Hypericum perforatum*	Warfarin, antidepressants, protease inhibitors for HIV, birth control, some asthma medications, and many other medications	

Herbal plants associated with allergic reactions

- Yarrow
- Wild carrot
- Vitex agnus-castus
- Tansy
- Rosemary
- Pulsatilla
- Plantain
- Pilewort
- Parsley
- Motherwort
- Milk thistle
- Meadowsweet
- Lady's slipper
- Juniper
- Hydrocotyle
- Hydrangea
- Hops
- Holy Thistle
- Guaiacum
- Gravel root
- Fucus
- Feverfew
- Euphorbia
- Elecampane
- Dandelion
- Cowslip
- Cinnamon
- Celery
- Cassia
- Boneset
- Asafoetida
- Artichoke
- Arnica
- Apricot
- Aniseed
- Angelica

2.8. Threats

Where medicinal plants are rather harvested from the wild than being cultivated, they are subject to both specific and general threats. A specific threat is excess collection to meet the rising demand for medicines. General threats are climate change, global warming, and habitat loss to development as well as agriculture (Kling, 2016). A case in point was pressure on the wild populations of the Pacific yew shortly after news of effectiveness of taxol was publicized. The threat from over-collection can be addressed by the cultivation of many medicinal plants, or by the system of certification to make the wild harvesting sustainable (Kling, 2016).There have been wide criticisms on herbal medicine and dietary supplement products as having insufficient scientific evidence or standards to confirm their safety, contents, and presumed efficacy (Barrett, 2013; Zhang *et al.*, 2012). A study in 2013 found that one out of every three of herbal products sampled have no trace of the herbs listed on the labels, and other products were

merely adulterated with unpublicized fillers including potential allergens (Newmaster *et al.*, 2013; O'Connor, 2013).

3. Conclusion

Plants synthesize hundreds of chemical and biochemical compounds for functions including defense against insects, herbivorous mammals, fungi, and diseases. Numerous phytochemicals with established or potential biological activity have been identified in plants. The pharmacological actions and phytochemical contents, if any, of several plants with medicinal potential remain untapped unassessed by rigorous scientific research to categorically define safety and efficacy. The compounds found in plants (phytochemicals) are of several kinds, but most are in four main biochemical classes: terpenes, alkaloids, glycosides, and polyphenols. Medicinal plants are used widely in non-industrialized societies and developing countries in Africa, Asia, and Southern America, mainly because they are thought to be very effective, cheaper than modern medicines, and readily available. Medicinal plants face both specific threat of over-collection to meet the market demand and the general threats, such as habitat destruction and climate change. Plants, including many currently used as culinary herbs as well as spices, have been used as medications, not necessarily effectively, from ancient times. Flowering plants, known as Angiosperms, were the original source of many plant medicines. Human settlements are usually surrounded by weeds used for herbal medicines, such as chickweed, nettle, and dandelion. Humans were not alone in usage of herbs as medicines: many animals such as monarch butterflies, sheep, and non-human primates ingest medicinal plants when they fall ill. The place of plant in medicine was drastically altered in the nineteenth century by application of chemical analysis. Alkaloids were isolated from a succession of medicinal plants, starting with morphine from the poppy. All plants produce chemical compounds which give them an evolutionary advantage, such as defending against herbivores or, in the example of salicylic acid, as a hormone in plant defenses. Polyphenols of several classes are widespread in plants. Plants containing phytoestrogens, a type of polyphenols, have been administered for centuries for gynecological disorders, such as fertility, menstrual, and menopausal problems; among these plants are *Pueraria mirifica*, kudzu, angelica, fennel, and anise. The astringent rind of the pomegranate, containing polyphenols called punicalagins, is used as a medicine. Angelica, containing phytoestrogens, has long been used for gynaecological disorders. Alkaloids are bitter-tasting chemicals, very widespread in nature, and often toxic, found in many medicinal plants. The alkaloid nicotine from tobacco binds directly to the body's Nicotinic acetylcholine receptors, accounting for its pharmacological effects. The cardiac glycosides are powerful drugs from medicinal plants including foxglove and lily of the valley. They include digoxin and digitoxin which support the beating of the heart, and act as diuretics. Terpenes and terpenoids of many kinds are found in a variety of medicinal plants, and in resinous plants such as the conifers; they are strongly aromatic. Some of the terpenes and terpenoids have medicinal uses: for example, thymol is an antiseptic and was once used as a vermifuge (anti-worm medicine). In many medicinal and aromatic plants, plant characteristics vary widely with soil type and cropping strategy. Plant medicines are in wide use around the world. In most of the developing world, especially in rural areas, local traditional medicine, including herbalism, is the only source of health care for people, while in the developed world, alternative medicine including use of dietary supplements is marketed aggressively using the claims of traditional medicine.

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