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Review Article

# PHYTONCIDE: NATURE'S ANTIDOTE FOR HUMANITY

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## ABSTRACT

Nature is considered as a mighty healer for human beings since ages. It is undoubtful that Plants offers a plentiful reservoir of medicinal compounds. Among these, secondary metabolites are the phytochemicals produced as a result of protection against pathogens, herbivorous animals, and other environmental stress factors. Phytoncides are Volatile Organic Compounds (VOC's) produced by the plants in order to protect themselves from bacteria, fungi, insects and other organisms and are released into the air, thereby forming a protective environment around the plant. These phytoncides which are mostly of isoprene origin has exhibited various pharmacological activities. Researches have found that forest bathing or prolonged exposure to forest volatile oils can have a profound impact on both physical and mental well being of humans. Since these chemicals act mainly by stimulating olfactory receptors and interacting with nasal mucous membranes, they can be considered similar to aromatherapy. Aromatherapy basically works through olfactory system as well as through dermal absorption. Both share some general health benefits like enhancing immunity by increasing NK cell activity and reducing the mental stress. Recently, many expert scientists around the world has developed new concepts like forest medicine and forest therapy, which may open up ways for in depth study of this topic.

## INTRODUCTION

It has been ages since humans have recognized the importance of plants and its benefits in health. Ancient literatures has documented the relationship between humans and plants. Plants have been worshiped as a part of many religions and cultures. Considering the immense utility of plants, they have been protected in the name of sanctity. Each God has been associated with a particular plant, thereby its conservation is ensured [1].

It is distinct that our lives depend completely on plants and their products. Chemical products obtained from plants possess an abundant source of medicinal value. Phytochemicals, especially the secondary metabolites provides a wide range of medicinal source because of its incredible health benefits. The secondary metabolites are organic compounds produced by the plant cells through metabolic pathways derived from primary metabolic pathways [2].

Plants produce the chemicals to protect themselves from environmental hazards such as pollution, stress, drought, UV rays exposure or any other attack from micro organisms. Researches have found out that human beings can make use of these phytochemicals as these possess exceptional therapeutic value.

Among these chemicals, terpenes and terpenoids (primary constituent of essential oils of many types of plants and flowers[3]) are important mediators of ecological interaction. They have shown a myriad of pharmacological actions and have been widely utilized in traditional medicines. Higher amount of terpenes are produced by trees in warmer weather So these can be considered as phytoncides. Phytoncides play an important role in plant immunity and in the relationships between organisms within an ecosystem[4].

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Hence a better understanding of phytoncides is significant so as to make use of these organic chemicals for benefiting human health. The purpose of this review is to provide an overview of the importance of phytoncides in human health.

**Exploring the Term Phytoncides: Definition and Etymology**

Phytoncides are antimicrobial allelochemic volatile organic compounds derived from Plants. The word comes from two Greek words: *"Phyto"* meaning *"plants"* and "*cide"* (formed from the Latin word *"caedere"*) meaning "to kill" or "to exterminate" and the word was coined in 1928 by Boris Petrovich Tokin, a soviet biochemist at Moscow State University. He has found out that some plants give off very active substances that help to prevent from rotting or being eaten by some insects and animals[5]. According to Tokin's definition, phytoncides are by nature antibacterial, antifungal and protistocidal substances produced by plants as an immunity factor, overlooking the interactions of organisms in biocenes[6], i.e., they are biologically active substance of plant origin that kills or inhibits growth and development of bacteria, microscopic fungi, protozoa[7].

**Chemical Nature of Phytoncides**

Phytoncides belong to a larger group of substances called VOC (Volatile Organic Compound). Approximately 4,00,000 known aromatic and medicinal plants have essential oils[7]. Among these, there are hundreds of different VOCs that involve many metabolic processes and are produced by flowers, roots and vegetative parts of plants. The VOCs belong to the chemical family of isoprenoids which include terpenes such as limonene and pinene. All VOCs are phytoncides and not all phytoncides are VOCs[8]. There are phytochemicals other than volatile oils which can be considered as phytoncides. Phenolic compounds like flavanoids, tannins, lignins; alkaloids even though non-volatile, can be kept under the category of Phytoncides.

**Volatile Oils and its Properties**

The volatile odorous principles which mainly come under the category of plant secondary metabolites when exposed to air at normal room temperature exhibits volatile principles are called volatile oils/ ether oils. They are also known as essential oils as essential oils as they are representative of essence of major active constituents /secondary metabolites. The main source of these components includes terpenes (Mono/ sesquiterpines) and their oxygen derivatives. Majority of the plants do contain these essential oils stored in specialized secretory cells/tissues while some plants does not have natural secretion of volatile oils, but are formed following decomposition of various other phytochemical constituents such as glycosides. A typical example includes mustard seeds which are basically odourless, but when crushed and added to water, an odour is evolved. This is due to formation of a chemical constituent Allyl isothiocynate formed by decomposition of a glycoside singrin by another enzyme Myrosine. The intermingling of the cells that contain these two constituents are made possible by crushing the seed.

The characteristic of volatile oils, while volatile oils are insoluble in water, are easily soluble in ether, chloroform and moderately soluble in alcohol. Numerous proximate principles of plant and animal tissues including camphor, fixed oils, lipids, resins and alkaloids (in their free state) are dissolved by them.[8] Volatile oils which are basically colorless oils undergoes oxidation and becomes darker when exposed to air and sunshine. They do not saponify with alkalies and do not leave permanent grease on filter paper like most of the fixed oils do. Most of them are optically active with a high refractive index, possess distinctive smell and are lighter than water (with the exception of clove oil) [9].

**Examples of Plants with Volatile Oil**

Around 87 families and 2000 species are rich in producing volatile oils. Commonly found in entire plant or in any part of members of family like lamiaceae, rutaceae, piperaceae, zingiberaceae, apiaceae, myrtaceae.

They are secreted in special structures of plants like:

- The oil tubes or ducts of fruits of apiaceae.
- Internal lysigenous or schizogenous passages or glands (pinaceae and rutaceae), trichomes of several plants, etc.
- Glands (asteraceae and lamiaceae)
- Modified parenchyma cells (lauraceae and piperaceae)

In conifers, volatile oils may occur in the tissues; in the rose they appear in appreciable quantities only in the petals; in cinnamon, only in the bark and in the leaves; in fruits of apiaceae, only in the pericarp, for mints – it occurs in the glands of the stems and leaves; and in orange – volatile oils are different in petals and fruit, also they are present in plants having resin and gums.

**How Volatile Oil is produced From Plants**

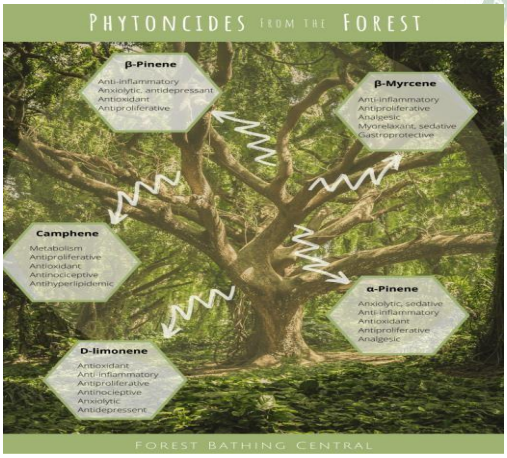
Plants can create certain volatile organic compounds (VOCs) continuously while others do so in reaction to stress or stimuli. For instance, a tree may create a chemical that is poisonous to the herbivore mammal and renders it inedible when it begins to graze on its leaves. Other trees of the same species will detect the increased release of volatile organic compounds (VOCs) as a cue to start manufacturing materials within the system and defend themselves against herbivores. Plants that release VOCs when herbivorous mites are present are another example.

Hydrolysis of certain glycosides, the breakdown of cell wall's resinogeneous layer or protoplasm can all produce volatile oils[10].

**Phytoncides and its Significance in Human Health**

Over the last 2 decades, researches have been carried out to find out the impact of phytocides on human health. A new concept emerged in Japan as a result of a National Health Programme for Forest Bathing or Shinrin – yoku which has been introduced in 1982 by the Forest Agency of Japan for the stress management of their workers. Shinrin – yoku is a short leisurely visit to a forest field, which has a similar effect to Aromatherapy. The main purpose was to ensure relaxation and inhalation of volatile substances (Phytoncides such as alpha-pinene and limonene etc)[11]. Since 2004, studies have been executed to investigate the effect of forest bathing on human health. Some of the recent studies have revealed novel connections between effects of phytoncides on the immune, nervous and endocrine systems[12]. This can be attributed to the action of terpenoids, namely α-pinene and β-pinene, which are the important bioactive compounds derived from Essential oils of various plant species.

The pharmacological activities of few phytoncides are depicted in the below image [13].




Prolonged exposure to phytoncides led to increased activity of natural killer cells and and levels of intra cellular anti cancer protein such as perforin, GRN and GrA/B while simultaneously reducing the number of T cells in the blood stream. It was further observed that phytoncides affects the levels of adrenaline and noradrenaline significantly reducing their concentrations in urine. Reduction in stress hormone levels might contribute partially to increased NK activity[14]. They can increase the activity of parasympathetic nerve and reduce the activity of sympathetic nerve showing relaxing effects [15].

In short, inhalation of these forest volatile oils/ phytoncides shows few pharmacological actions like:

- Antimicrobial effects on antibiotic resistant bacterial strains.
- Anti-tussive, muco-active, bronchodialation, and antispasmodic activities on respiratory system.
- Non–olfactory – mediated psychopharmacological effects on arousal, activation, memory loss, dementia, cognitive performance, anxiety, quality of life, quality of sleep.
- Antioxidant effect
- Antinociceptive, anti inflammatory, and cytotoxic activity.
- Anti-nausea and spasmolytic effects on the intestine [16].

**Probable Mode of Action of Phytoncides**

Since the phytoncides are odoriferous substances, its action can be explained mainly based on nasal pathway, i.e., olfactory perception. These are volatile oils, which get evaporated easily which makes them inconvenient to use internally. These compounds are inhaled through nose, where they pass the blood brain barrier and affect the central nervous system, autonomic nervous system and endocrine system. Odours induce perception, emotional learning, cognitive, behavioral and other associated emotions. Thus, the olfactory efferent is wired to the brain to produce a sequence of psychological – emotional responses resulting in emotions, memory processing and mind body interactions[17].

Phytoncides acts on the autonomous nervous system by activating it and thereby decreasing stress by stimulation of olfactory bulb. Through this process, the parasympathetic nervous system has been shown to be dominant over sympathetic nervous system. Reduction in cortisol has been associated with increased NK cell activity. Hence, reduction in cortisol in relation to increased PNS activity led to NK cell activation and increased downstream effector molecules perforin, granulysin and granzymes A/B [18].

**DISCUSSION**

The current review highlights on the importance of phytoncides, their chemical nature, distribution and occurrence in plant parts, its health benefits in human beings and probable mode of action. It is well known that a forest walk/forest bathing helps in stress– relieving and enhances the mood. Even though the actual pharmacodynamics and pharmacokinetics of the phytoncides in human body is not properly studied, as volatile oil compounds, phytoncides can cross the blood brain barrier after inhalation, thereby affecting the central nervous system by eliciting hormonal changes. Several studies have been carried out for assessing the effects of forest bathing on immune functioning. i.e., Phytoncides such as α-pinene increase NK cell activation thereby inhibiting growth of grafted cancer. Apart from these therapeutic benefits, these VOC's can contribute to the mental and emotional well being of a person. This

review focuses on the significance of a harmony between human beings and plants so as to promote a nature connected lifestyle which in turn add up immunity.

## CONCLUSION

Even though there are a number of studies indicating the physiological and psychological health benefits of inhaling phytoncides, it cannot be solely attributed to forest volatile oils in the atmosphere. It is obvious that a forest bath or an exposure to these phytocides has an impact on overall immunity of the individual and has shown reduction in stress related diseases. But large scale trials providing strong evidence to establish the efficacy and identify optimal dosages are yet to be done. In order to validate and understand the full potential of phytoncides, a thorough large study has to be conducted so that these terpene based forest volatile oils can be made use of in healing humans. If the pharmacokinetic and pharmacodynamic action of these phytoncides have been assessed and documented properly, it will be a benchmark in the field of pharmacotherapeutics. Additionally, this can be included as a part of personal as well as community regimen for the prevention as well as treating the diseases.

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