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Role of Secondary Metabolites of Tulsi (*Ocimum sanctum)* in combating lead induced stress.

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Abstract:

Tulsi or *Ocimum sanctum* is a medicinal plant that is widely used for its medicinal properties. It is used in ayurveda for treatment of cancer, infertility, bacterial infection. It is also considered to be a natural immunity booster, stress reducing plant. Tulsi or *Ocimum sanctum* is a brilliant healing and health benefitting plant. They contain a various number of secondary metabolites which protects the plant from microbial attacks and abiotic stresses such as metal stress. Tulsi or *Ocimum sanctum* has a large number of secondary metabolites such as phenols, tannins and flavonoids. Metal stress is a primary problem in plants which acts as a barrier in their growth. Lead is one such metal found in *Ocimum sanctum* and is a heavy metal that has no role in the metabolism of plant. However, it has the ability to pile up in different parts of the plant preventing its growth. In this paper we are going to read about the role of the secondary metabolites in *Ocimum sanctum* and how it helps in combating metal induced stress specifically lead induced stress.

1. Introduction

Stress in plants is defined as external factors that adversely affect a plant's development, growth, or production. [1]. Plants respond to stress in a variety of ways, altering their gene expression, cellular metabolism, growth rates, crop yields, etc. Typically, certain sudden alterations in the environment cause stress in plants [2]. Plant stress can be divided into two categories: abiotic stress and biotic stress. Abiotic stress is imposed on plants by their environment and can be either physical or chemical, unlike biotic stress, which is a biological entity such as diseases, insects, etc. that crop plants are subjected to [3].

Metal stress is one of the most important factors of abiotic stress. Metals have been employed by the living world for a very long time. Even in trace amounts, some of these metals affect plant life and the

metabolic processes that take place within it. While important elements like Mn, Mo, Zn, Cu, and Co, which are classified as micronutrients, also prove to be harmful at large quantities, non-nutrient metals like Hg, Pb, Cd, Ni, Ba, and Cr are poisonous even at very low amounts. Heavy metals are defined as metals with a density of 5 g/cm3 or more. Of the 90 elements found in nature, 53 are considered heavy metals, only a few are biologically important [4]. The most prevalent heavy toxic heavy metal in the environment is lead. Its important physico-chemical properties allow its use to be traced back to historical times. It is an important but harmful environmental chemical that is widely distributed throughout the world [*5*]. It is difficult to give up using it because of its significant qualities, including softness, malleability, ductility, weak conductivity, and resilience to corrosion. Because of its non-biodegradable makeup and ongoing use, its concentration in the environment increases with corresponding risks [*6*]. Lead toxicity manifests visually as chlorosis, rapid suppression of root growth, stunted plant growth, and blackening of the root system. Lead hinders photosynthesis and interferes with the actions of enzymes, water balance, and mineral nutrition [*7*].

Several naturally occurring enzymes in cells produce metabolites, which are the intermediate byproducts of metabolism. Examples include antibiotics and pigments. Metabolites are the typical nomenclature for small molecules. Metabolites have a variety of roles, including those related to energy, structure, signaling, catalysis, defense, and interactions with other organisms. Plant metabolites are of two types: primary metabolite and secondary metabolites. Primary metabolites are the chemical substances created throughout the processes of growth and development. Additionally, they take part in photosynthesis and respiration, which are the two main metabolic processes. The growth phase is when the major metabolites are produced. They are referred to as central metabolites and they keep the body's physiological processes running smoothly. They are the by-products of the anabolic metabolism that the cells use as building blocks to create vital macromolecules. Some of the main industrially produced metabolites are amino acids, vitamins, and organic acids. The principal metabolite that is most commonly produced on an industrial basis is alcohol. Secondary metabolites are those that are not necessary for the basic metabolic activities. They may be significant in other ways as well, such as

the environment. Because they are produced through the same metabolic pathways as main metabolites do, secondary metabolites are regarded as the byproducts of primary metabolites. Antibiotics, poisons, pheromones, enzyme inhibitors, etc. are a few examples.

The therapeutically significant essential oils are abundant in the medicinal plants, as are secondary metabolites (which have the potential to be drug sources). Alkaloids, flavonoids, phenolics, essential oils, tannins, and saponins are a few of the most significant bioactive phytochemical components found in plants [*8*]. Plants retain the secondary metabolites in their leaves, roots, and other organs. The secondary metabolites are of significant importance because of their potential commercial, pharmacological, and medicinal usefulness, despite the fact that metabolic origin and role in the plant are obscure [*9*]. *Ocimum sanctum* (OS) has an extensive list of therapeutic incentives, including being anti-inflammatory, anti-diabetic, anti-ulcer, anti-cancer, antibacterial, and antifungal. Herbal therapy heavily relies on the phytochemicals found in Ocimum, including its alkaloids, flavonoids, phenolics, essential oils, tannins, and saponins [*10*].

The formation of secondary metabolites is induced by the start of stress through a variety of cellular and molecular interactions and signaling pathways that are involved in the stress responses [*11*]. Researchers' interest in these bioactive compounds has grown as a result of the variety of uses and the recognition of biological features of secondary metabolites [*12*]. Abiotic stress signals, such as toxic metals, can activate genes involved in the creation of secondary metabolites [*13*]. Recognizing how plants respond to metal toxicity by adjusting the synthesis of various secondary metabolites is crucial [*14*].

2.1: Plant Profile

For its numerous therapeutic benefits, *Ocimum sanctum L.* (also known as *Ocimum tenuiflorum*, or Tulsi) has been utilized in Ayurveda for thousands of years. One of the holiest and most revered of the numerous healing and health-giving plants of the orient is Tulsi, the Queen of plants and the fabled "Incomparable One" of India [*15*].

Ocimum sanctum (Family Labiatae) is a 75 cm tall, numerously branched, upright, sturdy, and scented herb. This tiny plant

can be found all over India and is grown there as well as worshipped in Hindu temples and homes. This is also known as India's Holy Basil in English, Vishnu-Priya, Tulsi in Sanskrit, and Kala Tulsi in Hindi. This plant's roots, seeds, and leaves have all been utilized in traditional Ayurvedic treatment. The taxonomic position of Ocimum sanctum is:

Systematic position Kingdom: Plantae

Family: Lamiaceae

Genus: Ocimum

Species: tenuiflorum

Scientific Name: *Ocimum tenuiflorum L.*

Syn.- *Ocimum sanctum L.*

There are numerous compounds in holy basil's stem and leaves, including as saponins, flavonoids, triterpenoids, and tannins, that may have biological impacts [*16*]. Tulsi or *Ocimum sanctum* (OS) extracts are used in ayurvedic remedies for malaria, distinct poisonings, headaches, stomach problems, inflammation, and common colds. *Ocimum sanctum* L. is traditionally consumed as fresh leaf, dried powder, or herbal tea. Recent research employing these extracts suggests they have anti-inflammatory, antioxidant, immune-modulating, and stress-reducing qualities [*17*]. Additionally, it has been claimed to have anti-carcinogenic and radioprotective properties. *Ocimum sanctum* L. has been credited with a number of therapeutic qualities [*18*].

2.2: Abiotic Stress (Lead Stress)

As a result of many activities, such as industrialization and urbanization, heavy metal contamination of soil and water, including lead, silver, and cadmium, is growing daily. Lead (Pb) is an example of a potential heavy metal that can collect in many areas of a plant but is neither a necessary element nor plays any part in cell metabolism. The PH, particle size, cation exchange capacity, root exudation, and various other physical and chemical characteristics all play a major role in controlling lead uptake [*19]*

Because of their function in absorbing light and converting it into food through the process of photosynthesis, leaves are regarded as one of the most crucial plant organs. Until the testa is broken by the growing radicle, the testa in seeds prevents lead from entering the interior tissues. Lead is absorbed fairly quickly when the testa is ruptured, with notable outliers occurring in the radicle and hypocotyl meristematic zones. Lead circulates through the vascular tissues of cotyledons and tends to collect in specific locations in the distal regions [*20*].

Tulsi has been found to protect against the harmful effects of heavy metals like lead, arsenic, cadmium, chromium, and mercury as well as the toxic effects of radiation in addition to guarding against toxic compounds [*21l*].

2.3: Plant metabolism

The complex of chemical and physical mechanisms that comprise photosynthesis, respiration, and the synthesis and breakdown of organic compounds are referred to as plant metabolism.

Primary metabolites are substances that directly contribute to a plant's growth and development. The main example of primary metabolites are fats, carbohydrates, proteins, vitamins and nucleic acid fragments.

Secondary metabolites are compounds produced via other metabolic pathways and, while they are significant, are not absolutely necessary for a plant to operate. The example of secondary metabolites is divided into three major groups: [*22*]

1. Flavonoids and allied phenolic and polyphenolic compounds,
2. Terpenoids,
3. Nitrogen-containing alkaloids and sulphur-containing compounds.

The plant is a rich source of bioactive phytochemicals like alkaloids, flavonoids, terpenoids, phenolics, tannins, and saponins as well as essential oil. This plant's polyphenols and flavonoids are mostly responsible for imparting a variety of medicinal benefits, including antioxidant potential [*23*].

Events may have occurred during the course of evolution that caused the terpenoid and phenylpropanoid pathways in certain Ocimum species to diverge. The presence of an active terpenoid pathway in species that are abundant in phenylpropanoids and vice versa is interesting to notice. This shows that every species descended from a common ancestor that contained functional genes for both pathways. However, the ultimate chemical makeup of each species was defined by the varied expression and control of pathway genes [*24].* In order to direct metabolic flow towards the terpenoid or phenylpropanoid pathway, gene expression is crucial. In instance, terpene-rich *O. basilicum var*. SD showed enhanced expression of terpenoid pathway terminal enzymes and decreased expression of phenylpropanoid entry point enzymes such phenylalanine ammonia-lyase (PAL). However, it was discovered that the general phenylpropanoid pathway enzymes PAL and 4-coumarate-CoA ligase

(4CL) expressed at much higher levels in *O. basilicum var*, which had a higher phenylpropanoid content. Data from *O. tenuiflorum* and *O. basilicum* next-generation sequencing were used to support these findings. *O. tenuiflorum*, a phenylpropanoid-rich plant, exhibits substantially higher expression of the enzymes involved in the general phenylpropanoid pathway.

2.4: Mechanism of combating lead induced stress by *Ocimum sanctum*:

Abiotic stress has dramatic adverse effects on plants by altering the metabolic activity of cells by overproducing amount of reactive oxygen species (ROS) in plants [*25*]. Reactive oxygen species (ROS) in plants play dual roles in many biological processes, involving growth, programmed cell death, cell cycle, hormone signaling, and cell responses and development. They also have a perilous nature *[26]*. Understanding the physiological and molecular mechanisms governing plant tolerance to specific heavy metals as well as their genetic roots is crucial to the development of plants as phytoremediation agents [*27*].

Ocimum sanctum has created three fundamental methods for surviving lead-induced stress and growing on contaminated and metalliferous soils.

1. Plants that effectively store huge amounts of metals in their roots and keep metal out of their aerial parts throughout a range of soil metal concentrations are known as metal excluders.

2. Metal indicators: These plants accumulate metals in their above-ground tissues, and the metal concentrations in their tissues typically correspond to the soil's metal concentrations.

3. Plant species that can concentrate metals to levels significantly higher than those found in the soil or in surrounding non accumulating species are known as metal accumulators [*28*].

Secondary metabolites also have an eminent role in combating lead stress in *Ocimum sanctum*. The secondary metabolites help to make the plant of medicinal use and hence it helps in the reduction of lead stress.

2.5: Future aspects:

Secondary metabolites, which have strong physiological effects on people and are found in medicinal plants, are a rich source of these compounds. The ancient medical system known as "Ayurveda" makes reference to Ocimum sanctum and its extracts because of their historical

relevance as a source of medications. It is remarkably clear that Tulsi leaves and juice efficiently lessen a wide range of illnesses, including cancer, cardiovascular disorders, digestive disorders, respiratory disorders, kidney-related issues, and respiratory disorders. It also acts as a mosquito repellent. The lifespan of human life may be increased via the conservation and sustainable use of such plant resources, which can also make a significant difference in the fight against drug-resistant bacteria. The general populace in developing nations is very concerned about the rising expense of medications and their negative effects [29].

Consequently, new avenues for pharmacological research that concentrate on natural remedies are opened, and societal trends are shifted in favour of natural treatments [*30*]. Ocimum sanctum is widespread throughout the Indian subcontinent, and because it is so accessible, its immunomodulatory qualities may be researched to give people extra immunity at a very low cost [*31*]. Future research on Tulsi's neuroprotective and regenerative capabilities will shed new light on how it affects the development of Parkinson's and Alzheimer's illnesses. More research on unidentified chemicals that have an effect on scent should be done on holy basil. Further research should be done on the biopesticide effects of O sanctum as well as the creation of new Tulsi-based medications [*32*].

2.6: Current research:

It was determined that conventional medication is secure and offers a wide range of therapeutic uses. *Ocimum sanctum* is one of the significant herbs with a variety of pharmacological qualities among the many therapeutic plants. *Ocimum sanctum L.* has a significant biological potential, according to scientific study. So, it can be said that *Ocimum sanctum L.*, often known as Tulsi, is a traditionally used and clinically effective therapeutic herb [*33*].

3: Conclusion:

Lead is not a necessary element for plants, despite the fact that it accumulates in many plant tissues and has a deleterious impact on a number of physiological functions. These physiological functions include gene expression, mineral nutrition, respiration, photosynthesis, and membrane structure and characteristics.

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