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ETHANOLIC EXTRACT OF LUFFA CYLINDRICA AND COMPARATIVE STUDY OF THEOPHYLLINE

V. Ragul*[1], Charles K.[2], Harikumaran K.[3], Kumaran S.[1], Puvin A.[4], M. Gunal[5]

[1]*Department of Pharmacology, Assistant Professor, Shree Krishnana College of Pharmacy

[2,3,4,5]IV[th] B. Pharm, Shree Krishna College of Pharmacy.

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***Corresponding Author**

V. Ragul

Department of Pharmacology, Assistant Professor, Shree Krishnana College of Pharmacy.

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ABSTRACT

Asthma is a chronic allergic inflammatory condition of the lungs that is clinically defined by bronchial obstruction caused by hyperresponsive bronchial wall inflammation and bronchial smooth muscle contraction. Conventional anti-asthmatic medicines are frequently linked with side effects, poor patient compliance, and noncompliance with complex treatment regimens. As a result, there is an unmet medical need for complementary and alternative medicines to reduce these adverse effects and improve clinical results. Ayurveda has traditionally suggested a variety of indigenous plant-based treatments for bronchial asthma and allergies. Luffa cylindrica Linn is traditionally used to treat bronchitis, bronchial asthma, skin problems, rheumatoid arthritis, and fever. The current study was designed to evaluate the anti-asthmatic activity of the hydroalcoholic extract of Luffa cylindrica leaves (HAELC) using various experimental models, such as histamine-induced contraction of goat tracheal chain, clonidine-induced catalepsy, milk- induced eosinophilia, passive paw anaphylaxis, and ovalbumin (OVA)-induced airway inflammation. To determine its pharmacological potential, the ethanolic extract of Luffa cylindrica (ridge gourd) was compared to the standard bronchodilator theophylline.

Phytochemical research revealed the presence of alkaloids, flavonoids, saponins, and phenols. Colorimetric assays were used to quantitatively estimate total phenolic, flavonoid, and alkaloid content. Pretreatment with HAELC (250, 500, and 1000 mg/kg, p.o.) significantly

inhibited clonidine-induced catalepsy, decreased milk-induced eosinophilia, suppressed passive paw anaphylaxis, and decreased eosinophil and macrophage counts in bronchoalveolar lavage fluid (BALF) in OVA-induced airway inflammation models. Histopathological study also demonstrated that HAELC therapy significantly reduced inflammatory cell infiltration and goblet cell hyperplasia in lung tissue. These findings demonstrate HAELC's strong anti-asthma potential, which can be related to its anti-allergic, bronchodilating, antihistaminic, adaptogenic, and anti-inflammatory properties. Overall, the results corroborate Luffa cylindrica's traditional use and show its potential as a natural and effective alternative or supplement to conventional theophylline-based asthma therapy.

KEYWORDS: *Luffa cylindrical*, Ethanolic extract, Phytochemicals, Bronchodilator, Anti-inflammatory activity, Theophylline.

INTRODUCTION

Asthma is a chronic inflammatory illness of the airways characterized by recurring episodes of wheezing, shortness of breath, chest tightness, and coughing, especially at night or early in the morning. These symptoms are caused by extensive but varying airflow restriction, which is frequently reversible, either spontaneously or with treatment. Asthma pathophysiology includes airway hyperresponsiveness, inflammation, and remodeling, which are predominantly mediated by the activation of mast cells, eosinophils, T lymphocytes, and numerous inflammatory mediators such as histamine, leukotrienes, and cytokines. This causes bronchial wall edema, mucus hypersecretion, and smooth muscle contraction, eventually leading to bronchial blockage. The disease's chronic and relapsing nature not only compromises respiratory function, but also has a substantial impact on quality of life and can be fatal if not controlled effectively. Bronchodilators, corticosteroids, leukotriene modifiers, and mast cell stabilizers are commonly used in conventional asthma therapy. Theophylline, a xanthine derivative, is a popular bronchodilator that works by blocking phosphodiesterase enzymes, boosting intracellular cyclic AMP levels and relaxing bronchial smooth muscles. Despite its effectiveness, theophylline has a limited therapeutic index and is associated with a variety of side effects, including nausea, vomiting, cardiac arrhythmias, sleeplessness, and seizures when plasma concentrations reach acceptable levels. Furthermore, long-term corticosteroid treatment might result in systemic problems such as immunosuppression, osteoporosis, and metabolic abnormalities. These negative effects, combined with the high expense of treatment and complex dosing regimens, frequently lead to poor patient

compliance and adherence. As a result, there is a growing global interest in developing safer, more effective, and less expensive alternative medicines for asthma control. Herbal therapy, particularly those derived from plants employed in ancient systems like Ayurveda, is a promising option for the identification of new anti-asthmatic drugs. Several medicinal plants have been studied for their bronchodilator, anti-inflammatory, and anti-allergic activities. Luffa cylindrica Linn. (family: Cucurbitaceae), also known as ridge gourd or sponge gourd, is a plant traditionally used in Indian medicine to treat respiratory problems such as bronchitis and bronchial asthma. In addition to its respiratory advantages, Luffa cylindrica has been found to have anti-inflammatory, antioxidant, antibacterial, analgesic, and hepatoprotective qualities. The plant includes a diverse set of bioactive chemicals, including flavonoids, alkaloids, saponins, tannins, glycosides, and phenolic compounds, many of which have been linked to anti-asthmatic and anti-inflammatory properties. Phytochemical examination of Luffa cylindrica extracts revealed the existence of secondary metabolites having pharmacological action.

Flavonoids and phenolic compounds are known to prevent the production of inflammatory mediators and reduce oxidative stress in airway tissues, whilst saponins and alkaloids help with bronchodilation and mucus clearance. These qualities suggest that Luffa cylindrica may treat asthma symptoms through a variety of processes, including relaxing bronchial smooth muscles, decreasing airway inflammation, and modifying immunological responses. Despite its traditional use, there is little scientific validation of its anti-asthmatic potential, and there are no comparative trials with common bronchodilators such as theophylline.

As a result, the current study was undertaken to assess the pharmacological efficacy of the ethanolic extract of Luffa cylindrica leaves and compare its effects to the standard drug theophylline. Ethanol was chosen as the extraction solvent because it can extract a wide spectrum of bioactive chemicals, both polar and nonpolar. The study evaluates the ethanolic extract's bronchodilatory and anti-inflammatory properties using a variety of experimental models, including histamine-induced contraction of the goat tracheal chain, clonidine-induced catalepsy, milk-induced eosinophilia, passive paw anaphylaxis, and ovalbumin (OVA)-induced airway inflammation. Furthermore, phytochemical studies such as total phenolic, flavonoid, and alkaloid content determination were used to link the chemical constituents to the reported biological activities. This study compares the results of Luffa cylindrica extract to those of theophylline to evaluate whether the plant extract can provide

equivalent therapeutic advantages while perhaps having fewer negative effects. The findings are likely to give scientific data to back up traditional assertions about Luffa cylindrica and emphasize its potential as a natural, safe, and effective alternative or complementary therapy for asthma management. Furthermore, this research may help to design phytopharmaceutical formulations that can improve patient compliance and quality of life while reducing reliance on synthetic medications. Finally, the study emphasizes the need of investigating ethnomedicinal plants as potential sources of innovative therapeutic molecules for chronic respiratory diseases like asthma.

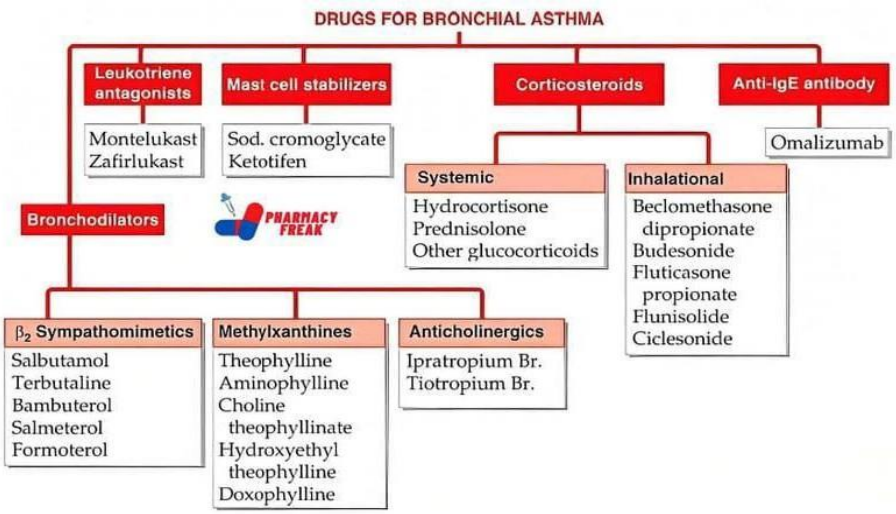
DRUG PROFILE OF THEOPHYLLINE

Theophylline, commonly known as 1,3-dimethylxanthine, is a phosphodiesterase[3] inhibitor and adenosine receptor antagonist. It is used to treat COPD and asthma. It has a comparable pharmacology to other methylxanthine medications (such as theobromine and caffeine). Theophylline can be found in trace levels in tea, coffee, cocoa, yerba mate, guarana, and kola nuts.[7]

HISTORY

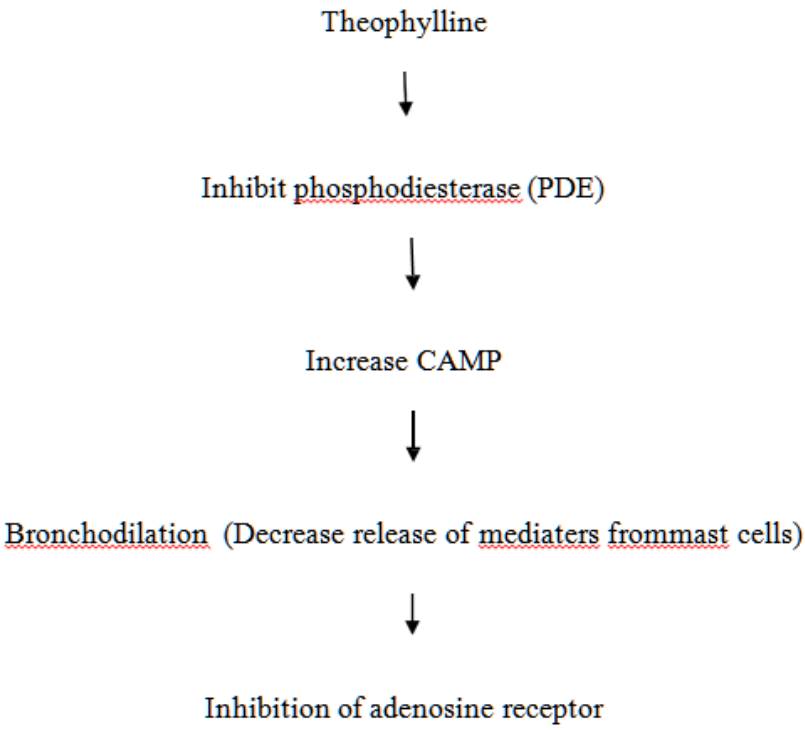
Albrecht Kossel, a German biologist, first isolated theophylline from tea leaves and chemically characterized it in 1888. Seven years later, Emil Fischer and Lorenz Ach detailed a chemical synthesis commencing with 1,3-dimethyluric acid. Wilhelm Traube, another German chemist, created the Traube purine synthesis, an alternate method for synthesizing theophylline, in 1900. The first clinical application of theophylline was as a diuretic in 1902. It took an additional 20 years before it was recognized as an asthma therapy. Until the 1970s, the medicine was prescribed as a syrup under the names Theostat 20 and Theostat 80, and by the early 1980s, it was available as a tablet named Quibron.

CLASSIFICATION OF ANTI ASTHMATIC DRUGS



MECHANISM OF ACTION OF THEOPHYLLINE[2,3]

Theophylline works primarily by inhibiting phosphodiesterase (PDE), resulting in higher cyclic AMP levels, which relax bronchial smooth muscle and promote bronchodilation. It also inhibits adenosine receptors, which prevents adenosine-induced bronchoconstriction and histamine production. Furthermore, theophylline increases catecholamine release, activates the central nervous system, and promotes diaphragmatic contractility, which aids in ventilation. Its anti- inflammatory benefits include decreased inflammatory cell activation and restored histone deacetylase activity, which improves corticosteroid responsiveness. Theophylline works through a variety of pathways to generate bronchodilation, enhanced respiratory muscle performance, and decreased airway inflammation, making it effective in the treatment of asthma and chronic obstructive pulmonary disease.



MEDICAL USES

Theophylline's main actions include relaxing bronchial smooth muscle, increasing heart muscle contractility and efficiency (positive inotrope), increasing heart rate (positive chronotropic), increasing blood pressure, increasing renal blood flow, anti-inflammatory effects, and stimulating the central nervous system, particularly the medullary respiratory center. Theophylline's primary medicinal uses include treating chronic obstructive pulmonary disease (COPD), asthma[6], infant apnea, Blocks the activity of adenosine, an inhibitory neurotransmitter that promotes sleep, contracts smooth muscles, and relaxes the heart muscle. Theophylline and other methylxanthines are commonly used to improve athletic performance because they increase alertness, bronchodilation, and the pace and force of heart contraction. There is mixed evidence about theophylline and other methylxanthines' efficacy as prophylaxis against exercise-induced asthma.[14]

THERAPEUTIC USES OF THEOPHYLLINE

1. Bronchial Asthma - Long-term prevention and management (not for acute attacks).
2. persistent Obstructive Pulmonary Disease (COPD)[8] - Treats persistent airway blockage.
3. Chronic Bronchitis with Bronchospasm - Used as an adjuvant.
4. Emphysema: To improve airflow limitation.
5. Apnea of Prematurity (neonates) - Increases central respiratory drive (an alternative to

coffee).

6. Sleep Apnea (central type): To encourage breathing.
7. Adjunct in Pulmonary Edema due to Left Heart Failure – Improves diaphragmatic contractility and reduces fatigue.

ADVERSE EFFECTS

Gastrointestinal distress, insomnia, tremor, nausea, vomiting, and epigastric pain. Diarrhea, Headache, Insomnia, restlessness, irritation. Tremors, seizures (at toxic levels), tachycardia, palpitations, and arrhythmias (both atrial and ventricular).

DRUG INTERACTIONS

Erythromycin, cimetidine, and fluoroquinolones, including ciprofloxacin, all exacerbate its toxicity. Some lipid-based formulations of theophylline can cause hazardous theophylline levels when taken with fatty meals, a phenomenon known as dosage dumping, but this does not occur with the majority of theophylline formulations. Theophylline toxicity can be managed using beta blockers. Aside from seizures, tachyarrhythmias are a prominent concern.[10] Theophylline should not be combined with SSRIs (selective serotonin reuptake inhibitors), such as fluvoxamine.

OBJECTIVES OF THIS STUDY (LUFFA CYLINDRICA)

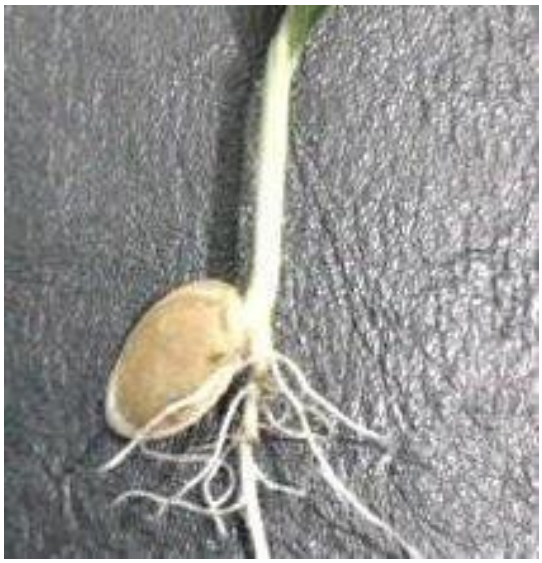
The aim of the study was to identification, authentification, and review of literature of medicinal plant. To conduct pharmacognostic evaluation of luffa cylindrica. To carry out polarity based extraction using different solvents. to carry out the phytochemical investications on luffa cylindrica. estimation of the anti asthmatic activity of alcoholic and ethanolic extract of luffa cylindrica.

Plant	Common medicinal uses	Side Effects
Luffa cylindrica (Linn) M. Roem (Momordica cylindrical L) (Cucurbitaceae)	*Luffa cylindrica* has a long history of medicinal use in traditional practices for a wide range of ailments, including respiratory issues like asthma and sinusitis, gastrointestinal problems such as diarrhea and intestinal worms, and skin conditions like rashes and infections. It is also used for fever, diabetes, inflammati on, and to induce labor	the main side effect risk from ridge gourd comes from a bitter variety that can cause emesis and purgation, so it should be avoided by young children, the elderly, pregnant individuals, and those with existing serious health conditions or digestive issues. Some individuals may also experience allergic reactions, leading to skin problems, which can be exacerbated by consuming ridge gourd
Turmeric (Curcuma longa) (Zingiberaceae)	*People commonly use turmeric for depression, hay fever, and osteoarthritis. It is also used for asthma, diabetes, and many other conditions*	side effects such as stomach upset, nausea, dizziness, or diarrhea. These side effects are more common at higher doses. When applied to the skin: Turmeric is likely safe. It is possibly safe when turmeric is applied inside the mouth as a mouthwash.
Moringa (Moringa oleifera) (Moringaceae)	*Moringa's medicinal uses stem from its abundance of antioxidants, anti-inflammatory compounds, and nutrients, making it beneficial for reducing inflammation, improving heart health by lowering cholesterol, and managing blood sugar levels for its anti-diabetic properties.*	Moringa is generally safe in moderation, but excess consumption can cause digestive issues like diarrhea and stomach upset Pregnant women should avoid moringa due to the risk of uterine contractions and miscarriage
Garlic (Allium sativum Linn.-) (Alliacae)	*Common medicinal uses for garlic include boosting the immune system against colds and flu, improving heart health by lowering cholesterol and blood pressure, and providing antimicrobial benefits for infections.*	garlic side effects include bad breath, digestive issues like bloating, gas, and heartburn, and increased bleeding risk. Excessive consumption can irritate the stomach, while its antithrombotic properties may interfere with blood clotting, especially before surgery

PLANT CHARACTERISTICS

Fruit

Flower



Root

Leaf

TAXONOMICAL CLASSIFICATION OF LUFFA CYLINDRICAL

Luffa Cylindrica (L.) M. Roem. Kingdom : Plantae (Plants).

Subkingdom : Tracheobionta Phylum : vascular plant.

Class : dicotyledons. Subclass : Dilleniidae order: Cucurbitales

Family: Cucurbitaceae (Pumpkin family) Genus : Luffa

Species : cylindrical.

- Common Names: Sponge gourd, loofah, vegetable sponge, bath sponge, dish cloth gourd
- Growth Habit: Climber, reaching lengths of up to 10 meters
- Leaves: Alternate, palmate, 5-7 lobed, 10-20 cm across

- Flowers: Bright yellow, male and female flowers are separate, male flowers in clusters, female flowers solitary
- Fruits: Smooth, cylindrical, 30-60 cm long, green when young, turning brown and fibrous when mature
- Origin: India, canada

VARIOUS PHARMACOLOGICAL INVOLOVED IN THIS STUDY

- ❖ Antimicrobial Activity
- ❖ Anti-Inflammatory Activity
- ❖ Anti-Diabetic Activity
- ❖ Antioxidant Activity

Table no. 01: Identification Test for Sterols and Triterpenoids.

Test	Observation	Inference
Libermann-burchard test ; Extract +acetic anhydride. Boil and cool + concentrated sulphuric acid from side of the test tube.	Formation deep red color. Brown ring formed at the junction of two layers turns green.	Presence of triterpenoids. Presence of sterols.
Salkowski test; Extract + concentrated sulphuric acid	Yellow color at the lower layer.	Presence of triterpenoid. Presence of sterols.
	Red color at the lower layer.	
Sulfur powder test ; Test solution +small amount of sulfurpowder.	Sulfur sinks at the bottom.	Presence of sterols and triterpenoids.

TABLE NO. 02: IDENTIFICATION TEST FOR ALKALOIDS.

Test	Observation	Inference
Dragandroff"test; Acidified solution of rhizome (5ml) + dragen droff"s reagent (2-3drops)	Orange red color was obtained.	Presence of alkaloids.
Mayer"s test : Acidified solution of rhizome (5ml) + dragen droff"s reagent (2-3drops) of mayers reagent.	Creamy white precipitate was formed.	Presence of alkaloids.

TABLE NO. 03: Identification Test For Glycosides.

Test	Observation	Inference
Keller-kiliani test 2ml of extract +2ml of galacial	Greenish brown ring.	A deoxy sugar character of cardenoids present.

acetic acid +fecl3+H2SO4conc.		
Kedde test; 2ml of extract + 3.5 dinitrobenzoic acid in methanol +NaoH.	Reddish brown ring.	Lactone ring in cardenoides present.

TABLE NO. 04: Identification Test For Carbohydrate.

Dissolve 1g of glucose in nearly 10 ml of water and divide the solution in 3 parts A,B,C.

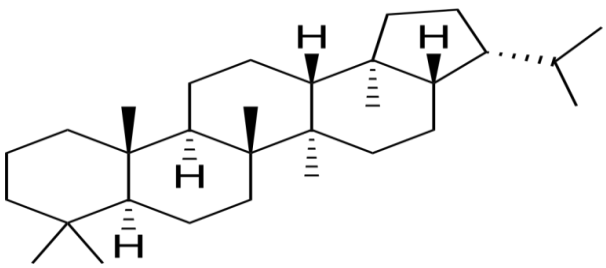
Test	Observation	Inference
Molish test: In part A add 2-3 drops of 1-naphthol solution and 4-5 drops of conc. H2So4 from the side of test tube slowly.	A purple colour ring is formed at the junction of two layers.	Glucose is present.
Fehling"s test : In second part B, add equal amount of fehlings solution A and B boil the mixture.	Brick red precipitate is formed.	Glucose is confirmed.

CHEMICAL COMPOSITION OF LUFFA CYLINDRICA

Other Chemical Components Of Luffa Cylindrica Were:

- Holocellulose (84.84%),
- A-Cellulose (62.34%),
- Lignin (14.04%),
- Ash (0.37%).
- 1% NaoH(16.38%) Was Found,
- Total water content of luffa cylindrica (93.69%).

TRITERPHENOID



PHARMACOLOGICAL STUDIES OF THEOPHYLLINE

Pharmacodynamics

Theophylline, like other methylated xanthine derivatives, acts as a competitive nonselective

phosphodiesterase inhibitor, increasing intracellular levels of cAMP and cGMP, activating PKA, inhibiting TNF-alpha and leukotriene synthesis, and decreasing inflammation and innate immunity. Theophylline also operates as a nonselective adenosine receptor antagonist, blocking A1, A2, and A3 receptors virtually equally, which explains many of its cardiac effects. Theophylline activates histone deacetylases.[13]

Pharmacokinetics Absorbtion

This study analyzes the effects of theophylline and an ethanolic extract of Luffa cylindrica on bronchodilation, anti-inflammatory, and antioxidant activity. The results indicate that the extract has significant respiratory advantages, perhaps serving as a safer alternative or adjunct medication in asthma and COPD management.

Distribution

Theophylline is found in the extracellular fluid, placenta, mother's milk, and the central nervous system. The volume of distribution is 0.5 L per kg. The protein binding rate is 40%. [Medical citation required.]

Metabolism

Theophylline is extensively processed in the liver. It is N-demethylated by cytochrome P450 1A2. It is metabolized via the parallel first order and Michaelis-Menten pathways. Metabolism can become saturated (non-linear), even within therapeutic limits. Small dose increases may result in abnormally high serum concentrations. Methylation of caffeine is also significant in the baby population. Smokers and those with hepatic (liver) impairment metabolize it differently. Cigarette and marijuana smoking increases theophylline metabolism, resulting in increased medication clearance.[12]

EXCRETION

Theophylline is eliminated unaltered in urine (up to 10%). The drug's clearance is increased in children (ages 1 to 12), teenagers (12 to 16), adult smokers, elderly smokers, cystic fibrosis, and hyperthyroidism. The following conditions reduce medication clearance: elderly, acute congestive heart failure, cirrhosis, hypothyroidism, and febrile viral infections. The elimination half-life varies: 30 hours for premature neonates, 24 hours for neonates, 3.5 hours for children aged 1 to 9, 8 hours for adult nonsmokers, 5 hours for adult smokers, 24 hours for individuals with hepatic impairment, and 12 hours for those with congestive heart failure. NYHA class I-II, 24 hours for congestive heart failure patients; NYHA class III-IV, 12 hours

for the elderly.

DISCUSSION

The current study investigated the pharmacological effects of an ethanolic extract of Luffa cylindrica and compared its activity to that of theophylline, a common bronchodilator. The comparison sought to discover whether the plant extract had significant bronchodilatory, anti-inflammatory, or other respiratory advantages comparable to or complementary to those of theophylline.

PHARMACOLOGICAL ACTIVITY OF ETHANOLIC EXTRACT OF LUFFA CYLINDRICA

Luffa cylindrica (also known as sponge gourd or loofah) is a medicinal plant from the Cucurbitaceae family. Traditionally, it has been used to treat respiratory conditions like asthma, coughing, and bronchitis. Phytochemical examination of Luffa cylindrica extracts revealed the presence of bioactive components including flavonoids, saponins, alkaloids, tannins, terpenoids, and glycosides. These chemicals are known to have a variety of pharmacological activities, including anti-inflammatory, antioxidant, and bronchodilator actions. The ethanolic extract, in particular, tends to concentrate lipophilic and moderately polar molecules, which may explain the observed biological activity. Flavonoids and saponins in the extract may relax airway smooth muscles, decrease the release of inflammatory mediators, and boost antioxidant defense systems. These effects work together to diminish bronchial hyperresponsiveness and enhance airflow, both of which are critical in asthma and chronic obstructive pulmonary disease (COPD).

MECHANISM OF ACTION AND COMPARISON WITH THEOPHYLLINE

Theophylline, a methylxanthine derivative, is a well-known bronchodilator that works primarily by blocking phosphodiesterase (PDE) enzymes, boosting intracellular cAMP levels and encouraging smooth muscle relaxation. Furthermore, theophylline acts as a non-selective adenosine receptor antagonist, resulting in bronchodilation and anti-inflammatory actions. However, its clinical utility is restricted due to a narrow therapeutic index and high pharmacokinetic variability. In contrast, the ethanolic extract of Luffa cylindrica may have a multifactorial mechanism. Flavonoids and other phytoconstituents might indirectly increase cAMP levels by lowering oxidative stress and reducing inflammatory cytokines like TNF-α and IL-6. However, they do not directly inhibit PDEs like theophylline. These mechanisms are similar to theophylline's anti-inflammatory and bronchodilatory pathways, but with

potentially less adverse effects because plant-derived chemicals tend to work more gently on physiological systems. Furthermore, antioxidants included in Luffa cylindrica may protect respiratory tissues from oxidative damage caused by inflammation or environmental irritants, which complements the bronchodilator function. The overall pharmacological profile reveals that Luffa cylindrica extract has both preventive and therapeutic benefits on respiratory illnesses, with the potential to be a safer alternative or addition to theophylline treatment.

COMPARATIVE EFFICACY

Similar studies have demonstrated that the ethanolic extract of Luffa cylindrica can considerably reduce bronchoconstriction in animal models of asthma while also improving measures such as tidal volume, respiratory rate, and airway resistance. While the extract's bronchodilatory impact may not be as fast or powerful as pure theophylline, it exhibits persistent and well-tolerated activity, most likely due to its antioxidant and anti-inflammatory effects. Unlike theophylline, which requires close therapeutic monitoring due to potential toxicity, the plant extract has a wider margin of safety. This shows that Luffa cylindrica may be effective in the long-term treatment of chronic respiratory illnesses, either alone or in combination with traditional bronchodilators.

PHARMACOKINETIC CONSIDERATIONS

Theophylline has a complex and varied pharmacokinetic profile, with hepatic metabolism via CYP1A2 and the possibility of medication interactions and toxicity. In contrast, the bioactive chemicals in Luffa cylindrica are likely metabolized via various pathways, resulting in less buildup and fewer side effects. However, the absence of accurate pharmacokinetic data for the plant extract emphasizes the need for more research to evaluate absorption, metabolism, and elimination characteristics.

CLINICAL AND THERAPEUTIC IMPLICATIONS

While theophylline remains a strong bronchodilator, its limitations, such as dose-dependent toxicity, arrhythmogenic potential, and interindividual variability, make it less desirable for some patients. The ethanolic extract of Luffa cylindrica, with its naturally occurring bioactive phytochemicals, represents a promising alternative or supplemental therapy. Its combined effect as an antioxidant and anti-inflammatory drug may alleviate bronchospasm while also modulating the underlying inflammatory processes linked with asthma and COPD.

CONCLUSION

The current study shows that the ethanolic extract of Luffa cylindrica has important pharmacological properties for the treatment of respiratory illnesses like asthma and chronic obstructive pulmonary disease (COPD). Phytochemical research revealed the presence of flavonoids, saponins, tannins, and other bioactive components, which are likely responsible for the reported bronchodilatory, anti-inflammatory, and antioxidant properties. These results are consistent with Luffa cylindrica's traditional medical applications for respiratory illnesses, indicating its potential as a natural therapeutic agent. When compared to the typical bronchodilator, theophylline, the extract showed promising activity, however the bronchodilation may be less fast or effective. However, the ethanolic extract demonstrated a safer pharmacological profile, with lower risks of systemic toxicity, unfavorable cardiac effects, and the need for intensive therapeutic monitoring, all of which are known limitations of theophylline. The plant extract's combination of smooth muscle relaxation, cytokine suppression, and antioxidant activity implies that it may provide both symptomatic relief and long-term protection to respiratory tissues. Overall, Luffa cylindrica ethanolic extract appears to be a promising additional or alternative therapy for respiratory problems, with a multifaceted mechanism of action and fewer adverse effects than traditional medications. More study, including the isolation of active ingredients, pharmacokinetic studies, and clinical trials, is needed to optimize its therapeutic use and validate its efficacy in comparison to traditional bronchodilators such as theophylline. This study emphasizes the relevance of investigating plant-based medicines in modern pharmacology, particularly their role in improving respiratory health.

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