JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A Review of Catharanthus and Wheatgrass Juice Used for the Treatment of Cancer

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Abstract :
Wheatgrass (Triticum aestivum) and Catharanthus roseus (L.) G. Don is two medicinal plants widely recognized for their significant roles in cancer prevention and therapy. Wheatgrass juice is rich in bioactive compounds such as chlorophyll, flavonoids, vitamins, minerals, and enzymes that exhibit strong antioxidant, detoxifying, and immunomodulatory properties. Clinical and experimental studies have shown that wheatgrass juice can enhance immune function, increase levels of anti-inflammatory cytokines such as IL-10, and reduce chemotherapy-induced toxicities by maintaining white blood cell (WBC) counts. These effects suggest that wheatgrass acts as a potent supportive supplement during chemotherapy, improving the patient's overall tolerance and recovery.
On the other hand, Catharanthus roseus, commonly known as Madagascar periwinkle, is an important source of more than 130 alkaloids, among which vincristine and vinblastine are widely used in the treatment of various cancers, including leukemia, Hodgkin's lymphoma, and breast cancer. These alkaloids interfere with cell division by binding to tubulin, thereby inhibiting mitosis in rapidly dividing cancer cells. Beyond its anticancer potential, C. roseus also exhibits antidiabetic, antimicrobial, and antioxidant activities. Modern biotechnological techniques such as tissue culture and metabolic engineering are being employed to enhance the yield of its valuable alkaloids for pharmaceutical applications.

Together, wheatgrass juice and Catharanthus roseus demonstrate the powerful therapeutic potential of medicinal plants in cancer treatment—wheatgrass serving as an immune-supportive and detoxifying adjunct during chemotherapy, and C. roseus as a primary source of potent anticancer compounds. Their combined significance highlights the importance of integrating natural plant-based therapies with conventional medicine for improving cancer care and patient outcomes.

Keywords: vincristine, vinblastine, anticancer activity, antioxidant, chemotherapy, alkaloids, immunomodulatory effects

INTRODUCTION

I. Catharanthus roseus, commonly known as Vinca rosea or Madagascar periwinkle, is an important species of the Apocynaceae family, valued for its wide range of medicinal properties and ornamental appeal, and has long been utilized in traditional Chinese medicine. Methodology**:** Electronic databases such as Scopus, PubMed, and Google Scholar were searched for publications from 2011 onwards, and the collected studies were compiled to provide a comprehensive overview of the pharmacological significance of C. roseus in cancer management. This paper presents a comprehensive overview of the traditional uses and pharmacological significance of various alkaloids derived from C. roseus in the treatment of cancer and diabetes mellitus. The alkaloids extracted from C. roseus possess diverse medicinal properties, including antihypertensive, antimicrobial, anti-inflammatory, and anticancer activities. Specifically, vinblastine and vincristine derived from C. roseus have demonstrated significant efficacy in treating various cancers, including Hodgkin's lymphoma and leukemia. Along with vindesine and vinorelbine, these compounds are recognized as potent antitumor agents originating from traditional Chinese medicine. This paper discusses strategies to enhance alkaloid production from C. roseus and highlights their associated drug delivery systems [1,2].

II. It is classified under the Kingdom Plantae, Class Magnoliopsida, and Order Gentianales ,belongs to the family Apocynaceae. Catharanthus roseus is often called as "Nayantara" or "Sadabahar," and its name stems from the combination of two Greek words, Katharos meaning pure and anthos meaning flower. It grows to the height of 1 meter and produces white to dark pink, dark red, and petal-like lobes. Catharanthus roseus is the evergreen plant with oval to oblong leaves, with glossy green hairless flowers, and a pair of follicles. Catharanthus roseus is commonly known as the periwinkle. The plant contains around 400 alkaloids, which are utilized as medications, agrochemicals, taste ingredients, fragrance components, food additives, and insecticides. It is highly valued for its medicinal properties and has been extensively studied for its potential in treating various diseases, such as cancer and diabetes. Additionally, this versatile plant is also cultivated as an ornamental species due to its vibrant flowers and ability to thrive in diverse climates. Related species of C. roseus have been utilized for the commercial reduction of milk flow in Europe.Actinoplastidemeric, vinblastine, vincristine, vindesine, vindeline, and tabersonine are commonly occurring alkaloids found in the aerial parts of Catharanthus roseus. C. roseus and Ajmalicine, Vincente, Vineamine, Raubasin, Reserpine, Vinflunine Catharanthine are commonly found in its roots. It is reportedly an efficient oral hypoglycemic medication in the Philippines and has been used to treat diabetic ulcers in the British West Indies [3,4].

III. Catharanthus roseus Linn a perennial plant is commonly seen in tropical counties and are native to Madagascar and Southern Asia. In Malaysia it is locally called as Kemunting Cina.The flower of these plants, which are often cultivated for decorative purposes, appear in shades of pink, purple, and white. Stem produces the milky sap which is a source of more than the 70 indole alkaloids. Vincristine and vinblastine, isolated from this plant, are well known anticancer drugs used in the treatment of childhood leukemia and Hodgkin's lymphoma, respectively. The Hair loss, peripheral neuropathy, constipation and hyponatremia are the major side effects of this drugs. Traditionally, Madagascar periwinkle has been used to treat various ailments, including high blood pressure, infections, and diabetes mellitus. The plant has spread all over tropical and subtropical parts of India and grows wild all over the plains and lower foothills in Northern and Southern hills of India The mechanism of action being binding to tubulin thus inhibits the metaphase of cellular mitosis. [5,6].

IV. It is also known as "living food" and is a superior source of chlorophyll – appropriately referred to as the "green blood".Wheatgrass refers to the young grass of the common wheat plant, Triticum aestivum Linn., family Poeaceae (Graminae), which is freshly juiced or

dried into powder for animal and human consumption both the forms provide chlorophyll, amino acids, minerals, vitamins, and enzymes. Thus, wheatgrass, containing about 70% chlorophyll, has been proclaimed to improve blood flow, aid in digestion and in general detoxification of the body.Various chlorophyll-rich greens are being used from since prehistoric times, various sources have been used as blood builders[7,8].

V. Photodynamic therapy (PDT) is an emerging and highly effective treatment modality that relies on the photoactivation of photosensitizers to generate reactive oxygen species (ROS), such as singlet oxygen (^1O_2) and superoxide anion (O_2^-). These ROS induce oxidative stress within tumor tissues, ultimately leading to cellular apoptosis, necrosis, or autophagy, depending on the type and localization of the photosensitizer. The photodynamic reaction is initiated when the photosensitizer absorbs light of a specific wavelength in the presence of molecular oxygen, triggering a cascade of photochemical reactions that destroy malignant cells while sparing healthy tissues. In recent years, PDT has gained substantial attention as a precisely controllable, minimally invasive, and site-specific therapeutic approach for treating cancers that are resistant to conventional chemotherapy or radiotherapy. According to previous studies, PDT has demonstrated therapeutic efficacy in various malignancies, including skin, thyroid, lung, breast, and cervical cancers, as well as in precancerous lesions. Its dual selectivity—through both light-targeting and preferential photosensitizer accumulation in tumor tissues—makes PDT particularly advantageous compared to traditional cancer treatments.

VI. Beyond oncology, PDT has also been explored as a novel antimicrobial strategy, exhibiting potent antiviral, antibacterial, and antifungal effects, especially against drug-resistant pathogens. This broad therapeutic applicability arises from the ability of ROS to non-specifically damage microbial membranes, proteins, and nucleic acids. Consequently, PDT is now regarded as a promising adjunct or alternative approach for treating infections where antibiotic resistance poses a major clinical challenge. However, despite its numerous advantages, current generations of photosensitizers face significant limitations, including poor water solubility, aggregation tendencies in aqueous environments, photobleaching, prolonged retention in the body, and dose-dependent toxicity. These drawbacks hinder light penetration, reduce ROS yield, and increase the risk of side effects such as skin photosensitivity. Therefore, recent research has focused on developing next-generation photosensitizers, particularly those derived from natural sources, that offer improved photophysical properties, higher selectivity, faster clearance, and reduced systemic toxicity.

VII. Given these considerations, ongoing studies aim to identify biocompatible and cost-effective natural photosensitizers, such as chlorophyllin, that could enhance the efficacy and safety profile of PDT and broaden its clinical applications. [9,10].

VIII. Although numerous natural compounds possess promising photoactive properties, many of them remain largely unexplored for photodynamic therapy (PDT) applications. Natural products have long been used in traditional and modern medicine due to their potent therapeutic properties and minimal side effects compared with synthetic drugs. One such compound is chlorophyllin, a semi-synthetic derivative of the natural green pigment chlorophyll. It has been safely used as a medicinal and dietary agent for more than 50 years, with no significant reports of adverse effects.Chlorophyllin is an FDA-approved natural food additive and colorant commonly utilized in dietary supplements and cosmetics. It exhibits several advantageous physicochemical properties that make it an attractive candidate for PDT, including high photostability, water solubility, biocompatibility, and low toxicity. Moreover, chlorophyllin demonstrates a unique ability to localize within mitochondria, enhancing its potential to induce apoptosis in cancer cells upon light activation. It also offers a short biological half-life, allowing for rapid clearance from the body and reducing systemic toxicity risks.

IX. Biologically, chlorophyllin exerts multiple beneficial effects—it acts as a detoxifying and antioxidant agent, neutralizing reactive oxygen species (ROS), reducing inflammation, and suppressing the activation of carcinogenic compounds. Studies have shown that chlorophyllin can inhibit mutagenesis, protect DNA from oxidative damage, and modulate cellular signaling pathways associated with tumor suppression.Therefore, the present study aims to explore the potential of chlorophyllin as an natural photosensitizer in photodynamic therapy and the evaluate its anticancer efficacy against the human cervical cancer cells. By validating its photoactive and cytotoxic effects, this research could provide valuable insights into the development of safe, cost-effective, and naturally derived photosensitizers for cancer treatment. [11,12].

Scientific classification: Catharanthus

Kingdom: Plantae

Division: Magnoliophyta (Flowering plants)

Class: Magnoliopsida (Dicotyledons)

Order: Gentianales

Family: Apocynaceae

Genus: Catharanthus

Species: roseus

Scientific classification: Wheatgrass

Kingdom:Plantae

Division:Tracheophytes [vascular plants]

Class:Lilliopsida [Monocotyledons]

Order:Cyperales

Family:Poaceae[Grass family]

Genus:Triticum

Species:Triticum asestivum

Methods for collection of wheatgrass:

Preparation of Wheat Grass Juice and Powder:

The early-stage wheatgrass leaves were cleaned with water prior to drying in dehydrator. The temperature used for drying leaves was about 30-35ºC for time of 24 hours. The juice was prepared from early-stage leaves of wheatgrass. For juice preparation 100g of leaves

was crushed in about 40ml of water and it was filtered through muslin cloth and final volume of filtrate was makeup to 100ml by increasing water content. The leaves which were dried were blended in powder form and stored in plastic bags [13,14].

Nutritional analysis of wheatgrass:

It is mostly consume as fresh juice which boosts the level of chlorophyll ,minerals [zinc, magnesium, selenium, and chromium] ,antioxidants [beta-carotene [provitamin A] ,vitamine C, vitamine E,anti-anemic factors like vitamine B12,iron ,folic acid ,pyridoxine, phytonutrients,bioactive compounds, many other minerals,amino acids,and enzymes [15].Wheatgrass is nutritional rich called power house of the nutrients. The nutrient contents, especially minerals, bioactive components and antioxidants in wheatgrass, depend upon wheatgrass plant height [16].The values of wheatgrass summarized in table 1:

Table No.1: Nutritional analysis of wheatgrass by pines international, Inc.2004

Nutrient	**Amount**	**Nutrient**	**Amount**
Calories	13	Protein	800
Cholesterol	0	Dietary Fiber	1
Carbohydrate	1.6	Chlorophyll	18.5

Vitamine			
Nutrient	**Amount**	**Nutrient**	**Amount**
Biotin	4ug	Vitamine B8	21ug
Choline	5mg	Vitamine B12	0.05ug
Vitamine A	1668IU	Vitamine C	7.5mg
Lycopene	29ug	Vitamine B2	260ug
Vitamine B1	11ug	Vitamine B3	252ug
Vitamine B5	36ug	Vitamine E	320ug
Vitamine B6	39ug	Vitamine K	35ug

Amino acid profile			
Alanine	69mg	Lysine	38mg
Arginine	66mg	Methionine	18mg
Aspartic Acid	50mg	Phenylaline	36mg
Cysteine	11mg	Proline	46mg
Glutamin Acid	76mg	Serine	31mg
Glycine	49mg	Threonine	42mg
Histidine	18mg	Tryptophan	6mg
Isoleucine	35mg	Tyrosine	33mg
Leucine	72mg	Valine	48mg

Nutritional analysis of wheatgrass juice powder

Nutrient	**Amount**	**Nutrient**	**Amount**
Cabohydrate	23.5	Protein	46.7
Moisture	0.9	Fat	3.7
Ash	26.1		

Mineral and trace minerals mg/g			
Boron	0055	Calcium	4.9

Chloride	4.9	Chromium	0.012
Cobalt	<0.0005	Iron	0.51
Fluoride	0.065	Germanium	<.011
Iodine	<0.0005	Iron	0.51
Magnesium	4.4	Manganese	0.26
Molybdenum	<0.0005	Nickel	<0.0005
Phosphorous	29	Potassium	2.8
Selenium	<0.0005	Sodium	1.1
Silicon	1.6	Titanium	<0.0005
Tin	<0.0005	Zinc	0.66
Vanadium	<0.0005		

The collection of *Catharanthus roseus* (Madagascar periwinkle) involves several systematic steps to ensure the preservation of its medicinally important alkaloids such as vincristine, vinblastine, ajmalicine, and serpentine. Healthy and disease-free plants are selected from cultivated or naturally growing areas with well-drained, slightly acidic soil. The plants are first properly identified using morphological characteristics like glossy opposite leaves, pink or white flowers with five petals, and milky latex from the stem. Authentication is carried out by a botanist, and a voucher specimen is usually deposited in a recognized herbarium for reference. The collection of plant material should be done at the stage when the alkaloid content is maximum [17]. Leaves are generally collected during the full vegetative phase, roots after 6–8 months of growth, and flowers and seeds during the blooming and maturation stages. The best time for collection is early morning or late evening to prevent degradation of active constituents by sunlight. Clean and sterilized tools such as scissors or pruning shears are used, and the collected material is placed in clean, labeled paper or muslin bags to avoid fungal growth. The plant parts are then dried in the shade or in a hot air oven at 40–45°C until a constant weight is achieved. Shade drying is preferred as it helps preserve the delicate alkaloids and pigments [18]. The dried material is stored in airtight glass containers or polyethylene-lined bags, clearly labeled with the name, date, and place of collection, and kept in a cool, dry, and dark place to maintain alkaloid stability. Proper documentation, including details like the site, date, collector's name, and environmental conditions, is essential for scientific recordkeeping and traceability of the collected samples [19].

Role of alkaloids extracted from Catharanthus roseus and strategies to enhance their production of alkaloids:

Vinblastine and Vincristine are crucial in cancer treat ment, while Ajmalicine has antihypertensive, antimicrobial, and antiarrhythmic effects. Medical significance of different alkaloids extracted from Catharanthus roseus Catharanthus roseus contains various alkaloids with diverse medicinal properties [20]. Serpentine and Reserpine manage hypertension. Table 2 highlights different therapeutic applications of various alkaloids extracted from Catharanthus roseus [21].

Table 2 : Therapeutic role of various alkaloids found in catharanthus roseus.

Sr no.	**Alkaloid name**	**Medicinal Importance**	**Biological Mode action**
1.	Ajmaline	1.Antiarrhythmic Properties. 2.Cardiovasular Health. 3.Anti-cancer Potential. 4.Antioxidant Properties.	1. Used for treating different cardiac arrhythmias, especially atrial and ventricular tachycardia ,by extending heart muscle's rhythums. 2.Aids in clot Prevention and lower heart disease. 3.Hinders cancer cell growth ,showing promise for anti cancer drug Develpoment . 4.Plays a vital role in neutralizing free Radicals, protecting cell, and lowering chronic disease risk.
2.	Alpha- Tabersonine	1.Anticancer 2. Antidiabetic potential 3.Anti-hypertensive effects	1. Inhibits various cancer cell, especially leukemia. 2. Demonstrates hypoglycemic effects, thought more research is necessary for understanding its Role in diabetes. 3.lower blood pressure, facilitating hypertension control.

3.	Cryptole pine	1.Anti cancer potential 2.Antimalarial properties	1.Research suggests that it may exhibit cytotoxic effects against cancer cell lines .
4.	Dihydro-corynantheine	Anticancer properties	Displays cytotoxicity towards various cancer cell lines .
5.	Dihydro-Tabersonine	1.Anticancer properties 2.Antihypertensive effect	1.It shows cytotoxicity, especially against specific cancer cell. 2.Mangement of hypertension and related cardiovascular.
6.	Vindoline	Anticancer properties	Involved in the biosynthesis of vinblastine ,a potent Anti-tubline agent.
7.	Vinblastine and vincristine	Anticancer properties	Dirupts the formation of microtubules during cell division ,effectively inhibiting the growth of cancer cell.

Role of alkaloids in Wheatgrass juice : Wheatgrass juice contains various plant-derived alkaloids, Tryptamine derivatives , Indole alkaloids , Quinoline alkaloids , Piperidine alkaloids , Phenolic alkaloids . Alkaloids in wheatgrass act as natural antioxidants**,** neutralizing reactive oxygen species (ROS) that damage DNA and promote cancer cell proliferation. By reducing oxidative stress, alkaloids help protect normal cells and prevent cancer initiation.Wheatgrass alkaloids inhibit cancer cell growth by interfering with DNA replication and mitosis [22]. Some indole type alkaloids interact with microtubule proteins, similar to the mechanism of vinca alkaloids ,disrupting cell division in tumor cell. Certain alkaloids trigger apoptosis by activating the caspase pathway and mitochondrial depolarization in cancer cells. This mechanism helps eliminate malignant cells without harming normal tissues . Wheatgrass alkaloids enhance immune system function by stimulating macrophages and lymphocytes , improving the body's ability to recognize and destroy tumor cells [23]. They may also increase interferon and cytokine levels , strengthening natural anticancer defense mechanisms. Alkaloids aid hepatic detoxification and help eliminate carcinogenic substances from the body . In patients undergoing chemotherapy , wheatgrass alkaloids may reduce bone marrow suppression and hematological toxicity ,promoting faster recovery [23].

Biological Role	**Effect on cancer**	**Alkaloid Action**
Antioxidant	Prevents DNA damage	Scavenges ROS
Anti proliferative	Stops cancer cell growth	Inhibits mitosis
Apoptotic	Induces cancer cell death	Activates caspases
Immunomodulatory	Boosts immune defense	Stimulates macrophages, cytokines
Detoxifying	Protects from chemotherapy toxicity	Supports liver detox

Chemical Constituents:

Researchers investigating the medicinal potential of Catharanthus roseus (commonly known as the Madagascar periwinkle) discovered that the plant contains a diverse group of indole alkaloids, many of which, although highly toxic in their pure form, possess significant therapeutic potential in cancer treatment. Like many medicinal plants, C. roseus synthesizes a wide array of secondary metabolites, which play crucial roles in physiological regulation, defense against pathogens and herbivores, and adaptation to environmental stresses. Phytochemical studies have revealed that C. roseus is rich in carbohydrates, flavonoids, saponins, phenolic compounds, tannins, and alkaloids, among which the alkaloids represent the most pharmacologically active group of constituents. To date, over 400 alkaloids have been identified from various parts of the plant, making it one of the most chemically diverse medicinal species known. These alkaloids have found extensive applications in the pharmaceutical, agricultural, and food industries, serving as anticancer agents, antihypertensives, antimicrobial compounds, insecticides, and natural flavor or fragrance additives. The distribution of alkaloids in C. roseus varies with the plant part. The aerial portions (leaves and stems) are particularly rich in actineoplastidemeric, vinblastine, vincristine, vindesine, vindeline, and tabersonine, all of which exhibit potent cytotoxic and antimitotic properties through interference with microtubule dynamics. These compounds have been developed into clinically approved chemotherapeutic drugs, widely used in the treatment of various cancers such as Hodgkin's lymphoma, leukemia, breast cancer, and lung cancer. Conversely, the roots and basal stems predominantly contain ajmalicine, vinceine (raubasine), reserpine, catharanthine, and serpentine, which possess antihypertensive, antiarrhythmic, and sedative effects due to their ability to modulate neurotransmitter levels and vascular tone. These compounds are also utilized in the production of drugs for managing hypertension and mental disorders. In addition to alkaloids, C. roseus flowers contain the anthocyanin pigment rosindin, which contributes to the pink and purple coloration of the petals. Anthocyanins such as rosindin exhibit antioxidant and anti-inflammatory properties, further adding to the plant's medicinal significance.

Overall, Catharanthus roseus serves as a remarkable source of bioactive metabolites, combining traditional ethnopharmacological importance with modern biomedical applications. Its diverse chemical composition continues to inspire research into biotechnological enhancement, metabolic engineering, and sustainable production of high-value alkaloids for pharmaceutical use. [26].

The name "green blood" of wheatgrass is attributable to its high chlorophyll content which accounts for 70% of its total chemical constituents. Wheatgrass juice is a rich source of Vitamins A, C, E and B complex group. It contains a plethora of minerals like calcium, phosphorus, magnesium, alkaline earth metals, potassium, zinc, boron, and olybdenum. The enzymes contributing to its pharmacological effects include protease, amylase, lipase, cytochrome oxidase, transhydrogenase and superoxide dismutase (SOD). The other notable feature of wheatgrass is its high proportion of ami no acids such as aspartic acid, glutamic acid, arginine, ala nine and serine. The major clinical utility of wheatgrass juice is due to present, which make this grass therapeutically effective, are the indole compounds, choline and laetrile (amygdalin) [27,28]. The different constituents of wheatgrass occuring in different proportions are repre sented in. In a study conducted to determine the elemental concentration profile of wheatgrass using instrumental neutron acti vation analysis, it was found that the concentration of elements such as the levels of K, Na, Ca and Mg in shoots increased linearly with the growth period, whereas the concentrations of Zn, Mn and Fe remained constant in the shoots after 8th day of growth under all three growth conditions.

However, it was observed that the shoot to root concentration ratio in all the conditions increased linearly for K, Na, Ca, Mg and Cl and decreased for Zn, Fe, Mn, and Al with growth period [29,30].

Role of vinblastine and vincristine obtained from C. roseus in cancer management :

Two important alkaloids, vinblastine and vincristine, isolated from Catharanthus roseus, have demonstrated remarkable antineoplastic activity against a wide range of cancers, including Hodgkin's lymphoma, acute lymphoblastic leukemia, breast cancer, lung cancer, and testicular cancer. These compounds belong to the class of vinca alkaloids, which are among the most successful plant-derived chemotherapeutic agents used in clinical oncology. Both vinblastine and vincristine exert their cytotoxic effects by targeting microtubules, which are essential components of the cytoskeleton and play a critical role in mitotic spindle formation during cell division. Vinblastine binds specifically to tubulin dimers, inhibiting their polymerization into microtubules. This disruption leads to metaphase arrest, preventing proper chromosomal segregation, and ultimately triggering cell cycle arrest and apoptosis in rapidly dividing cancer cells [31,32].

Vinblastine and vincristine, two clinically important vinca alkaloids derived from Catharanthus roseus, are widely recognized for their potent antineoplastic properties. Vinblastine is extensively used in the treatment of Hodgkin's disease, non-Hodgkin's lymphoma, testicular carcinoma, and choriocarcinoma, while also being evaluated experimentally for its efficacy against other solid tumors. Vincristine, another major alkaloid from the same plant, has shown remarkable therapeutic success in managing childhood leukemias, particularly acute lymphoblastic leukemia (ALL), as well as in Wilms' tumor, neuroblastoma, and other pediatric malignancies. Beyond the purified alkaloids, crude methanolic extracts of Catharanthus roseus have also demonstrated significant in vitro anticancer activity against a wide spectrum of cancer cell lines. Studies have reported that varying concentrations of these extracts can effectively inhibit cell proliferation, induce apoptosis, and suppress colony formation in tumor cells. Notably, the highest cytotoxic activity has been observed against multidrug-resistant (MDR) cancer cell lines, suggesting that certain bioactive compounds in the extract may overcome chemoresistance mechanisms commonly encountered in cancer therapy [33] .

Vinca alkaloids, such as vinblastine and vincristine, derived from Catharanthus roseus (Madagascar periwinkle), are among the most successful plant-based chemotherapeutic agents used in modern oncology. These compounds function as potent anti-microtubule agents, disrupting the polymerization of α- and β-tubulin proteins that are essential for spindle fiber formation during mitosis. By binding to tubulin, they inhibit the assembly of microtubules, thereby arresting the cell cycle at the metaphase stage and preventing proper chromosome segregation. This disruption ultimately triggers mitotic catastrophe and apoptosis in rapidly dividing cancer cells. Vinblastine and vincristine have demonstrated broad-spectrum activity against various cancers, including Hodgkin's lymphoma, acute lymphoblastic leukemia, breast cancer, and lung carcinoma, and remain key components of combination chemotherapy regimens [34]. Phyllanthosides, including bioactive lignans such as hypophyllanthin and phyllanthin, derived from Phyllanthus niruri, exhibit strong anticancer and antineoplastic activities. These compounds exert their effects primarily by inducing apoptosis and suppressing autophagy-mediated survival pathways, thereby overcoming multidrug resistance (MDR) in breast cancer cell lines. Furthermore, dried ethanolic extracts of Phyllanthus niruri, when used in combination with cisplatin, have demonstrated synergistic cytotoxic effects against HT29 (colon carcinoma) and HepG2 (hepatocellular carcinoma) cell lines. This synergism is attributed to enhanced reactive oxygen species (ROS) generation, cell cycle arrest at the G2/M phase, and downregulation of anti-apoptotic proteins such as Bcl-2 and survivin. Additionally, P. niruri extract has been reported to modulate signaling pathways like PI3K/Akt/mTOR and NF-κB, which play crucial roles in cancer cell proliferation and resistance, suggesting its potential as an adjuvant therapy in conventional chemotherapy [35,36].

Vindesine, a semi-synthetic Vinca alkaloid derived from vinblastine, is widely employed in the treatment of various malignancies, most notably acute lymphoblastic leukemia (ALL). It functions as a potent antimitotic and cytotoxic agent by binding to tubulin dimers, thereby inhibiting microtubule assembly and disrupting spindle formation during metaphase. This interference with mitotic spindle dynamics results in cell cycle arrest at the metaphase stage and subsequent apoptotic cell death [37] .

Vindesine acts by inhibiting microtubule polymerization, thereby preventing cells from progressing into metaphase during mitosis. In in vitro studies, vindesine has been shown to be approximately three times more potent than vincristine and nearly ten times more effective than vinblastine at concentrations that inhibit 10–15% of cells from entering mitosis. Unlike vinblastine, vindesine results in the formation of a smaller proportion of post-metaphase cells, reflecting a more pronounced arrest in the early mitotic phase. Clinically, vindesine has demonstrated significant therapeutic potential in patients who have relapsed following vincristine-containing combination chemotherapy regimens, particularly in acute lymphoblastic leukemia (ALL) and non-small cell lung carcinoma (NSCLC). Its enhanced antimitotic activity and lower neurotoxicity profile make it a valuable alternative for patients with vincristine-induced peripheral neuropathy. [38,39].

Vindesine is a second-generation semi-synthetic Vinca alkaloid that possesses broad-spectrum antitumor activity in-vitro with lesser neurotoxicity [38].

Vinorelbine is a semi-synthetic Vinca alkaloid that exerts its antiproliferative effects by selectively binding to tubulin, a key structural protein involved in microtubule formation. This interaction disrupts the polymerization of microtubules, thereby impairing the formation of the mitotic spindle apparatus essential for proper chromosome segregation during metaphase. Unlike other vinca alkaloids, vinorelbine shows a higher affinity for mitotic rather than axonal microtubules, which contributes to its reduced neurotoxicity and favorable safety profile [39,40].

Vinorelbine has demonstrated significant efficacy in the treatment of glial tumors, particularly those with low proliferative indices, where conventional chemotherapeutic agents often show limited activity. Clinical studies have suggested that vinorelbine can be safely administered as a single-agent therapy in juvenile patients with progressive optic pathway gliomas, leading to measurable tumor stabilization and improved clinical outcomes. Mechanistically, vinorelbine exerts its effects by disrupting microtubule dynamics, inducing mitotic arrest, and promoting apoptosis in tumor cells. Beyond its cytotoxic activity, vinorelbine has been reported to modulate the tumor microenvironment, triggering innate immune responses and enhancing inflammatory signaling pathways. This immunomodulatory effect suggests that vinorelbine could synergize with immunotherapies, potentially improving outcomes in aggressive or treatment-resistant malignancies, including pontine gliomas, which may exhibit enhanced sensitivity to combined chemo-immunotherapeutic strategies. [41,42,43].

The alkaloid accounts for approximately 25–65% of the indole alkaloids in Vinca minor and is widely utilized for the prevention and treatment of cerebrovascular disorders, including cerebral ischemia, memory impairment, and cognitive decline. Pharmacologically, it exerts effects on both the central nervous system (CNS) and the cardiovascular system, although its primary therapeutic action targets cerebral blood vessels, enhancing cerebral perfusion and microcirculatory function. At the cellular level, its mechanism of action involves inhibition of tubulin polymerization and disruption of microtubule dynamics, leading to mitotic arrest and the induction of apoptosis in rapidly proliferating or aberrant cells [44 ,45].

Vinflunine is a novel semi-synthetic Vinca alkaloid that demonstrates potent antitumor activity by disrupting microtubule dynamics, leading to mitotic arrest, inhibition of cell proliferation, and induction of apoptosis in rapidly dividing cancer cells. Mechanistically, vinflunine binds to tubulin at the vinca domain, destabilizing microtubules, suppressing dynamic instability, and interfering with the spindle assembly checkpoint, which results in cell cycle arrest at the G2/M phase.Clinically, vinflunine has shown significant efficacy in patients with advanced or metastatic urothelial carcinoma, particularly in cases refractory to platinum-based chemotherapy, providing an important therapeutic option for this difficult-to-treat population. In addition to bladder cancer, preclinical studies indicate potential activity against non-small cell lung cancer (NSCLC), breast cancer, and hematological malignancies [46 ,47].

Pharmacokinetic limitations :

First-pass metabolism, which means that when taken orally, a significant portion of the drug is metabolized by the liver However, these compounds have pharmacokinetic limitations that impact their efficacy and use. One major limitation is their poor oral bioavailability due to extensive before reaching systemic circulation. As a result, these drugs are typically administered intravenously to ensure adequate bioavailability. Additionally, vinblastine and vincristine are rapidly distributed to tissues, which can lead to variable pharmacokinetics and impact their therapeutic effects [101]. Their metabolic degradation by cytochrome P450 enzymes also contributes to variability in pharmacokinetics, making it challenging to predict their effects [48]. Furthermore, the limited solubility of these compounds can affect their formulation and delivery, which may impact their efficacy and safety. Overall, understanding these pharmacokinetic limitations is crucial for optimizing the use of vinblastine and vincristine in cancer treatment and for developing strategies to improve their delivery and efficacy [49,50].

Bioavailability: The bioavailability of wheatgrass juice's active compounds may be limited due to degradation in the gut, poor absorption, or rapid metabolism. Instability: Wheatgrass juice is a perishable product, and its active compounds may degrade quickly, affecting its potency and efficacy [51]. Variable composition: The composition of wheatgrass juice can vary depending on factors like growing conditions, harvesting time, and processing methods, which may impact its pharmacokinetics. Limited solubility: Some compounds in wheatgrass juice may have limited solubility, which can affect their absorption and bioavailability. Metabolic degradation: The active compounds in wheatgrass juice may be rapidly metabolized by enzymes in the gut or liver, reducing their bioavailability and efficacy [52].

EXTRACTION METHODS OF ANTI-CANCER MOLECULES FROM C. Roseus AND WHEATGRASS JUICE :

The extraction conducted by using water as the solvents is an alternative method to extract the bioactive compound. However, in water extraction method, high temperature of water is required to extract the compound. The increase in temperature during extraction might deteriorate the quality of extract and degrade the desired bioactive compound. Moreover, water extraction method required a long time in order to complete the extraction process C. roseus produces low levels of two dimeric terpenoid indole alkaloids, vinblastine and vincristine, which are widely used in cancer chemotherapy [53 ,54]. The extraction and purification of several alkaloids found in C. roseus was first developed by Eli Lilly in the 1970s using organic solvent based methods. These extraction methods using water with sulphuric acid includes four steps such as fractionation by partition with benzene, two chromatographic columns, crystallization in ethanol and sulphuric acid. Extraction of vindoline, catharanthin, and vinblastine from C. roseus leaves has been extensively carried out using ultrasound extraction with dilute or methanol as solvent, heating, boiling and refluxing with methanol [55].

Vinblastine and vincristine are the key dimeric indole alkaloids that are frequently employed in cancer treatment, are produced in low quantities by C. roseus [56]. There are four processes in these sulphuric acid and water extraction techniques, including

fractionation by partition with benzene, two chromatographic columns, and crystallization in ethanol [57]. Significant advancements have been achieved in the extraction of key alkaloids such as vindoline, catharanthine, and vinblastine from Catharanthus roseus leaves. Various techniques have been explored to enhance yield and efficiency, including ultrasonic-assisted extraction, which uses high-frequency sound waves to disrupt plant cell walls and facilitate the release of bioactive compounds. Solvent-based methods, particularly using methanol, ethanol, or their mixtures, are commonly employed due to their effectiveness in dissolving indole alkaloids. Additionally, conventional approaches such as heat treatment, boiling, and refluxing continue to be used, often in combination with modern techniques, to optimize extraction efficiency. Recent studies also highlight the potential of integrating microwave-assisted extraction, supercritical fluid extraction, and enzyme-assisted methods to further increase the recovery of these pharmacologically important compounds while minimizing degradation. Optimizing parameters such as temperature, solvent concentration, extraction time, and particle size of the leaves is crucial to maximize alkaloid yield and preserve their bioactivity [56]. The use of supercritical fluid extraction (SFE) to extract phytochemicals from C. roseus has also been used [57].

The experiment used fresh organic wheatgrass powder and followed a standardised extraction protocol in which 50g of dried wheatgrass powder was dissolved in 500ml of a 1:1 DCM:methanol mixture. The sample was gently and continuously mixed in the solvent system using a magnetic stirrer for 4 hours to ensure uniform dispersion and enhanced solvent penetration. Following this thorough agitation, the mixture was allowed to stand and soak overnight at room temperature, facilitating maximum diffusion of the target compounds from the plant matrix into the solvent. This extended soaking period helps improve extraction efficiency by allowing the bioactive constituents, including alkaloids and other phytochemicals, to fully dissolve into the solvent, while minimizing potential thermal degradation that could occur with prolonged heating. The extraction was performed in 4 steps: 1-soaking , 2-stirring ,3-filtering ,and 4- freeze-drying[58].

This four –step procedure was performed three times for maximal extraction wash of the wheatgrass powder was performed using 500m of CaCl3 –dried methanol, and the sample was soaked for 24 hrs and filtered the following day. Merck whatman paper no.1 was used for all filtration steps. A total of 500ml of the eluate was collected from the four filtraction processes and was subsequently freeze-dried in a lyophiliser at -75 ^{o}c for 24 hrs. A total of 25 g of crude green colored powder was recovered after freeze-drying the eluate for 6 hrs. After conducting solubility test, researchers conducted TLC profiling on the crude green powder, to understand its composition [59].

Column chromatography fractionaction technique: This crude green colored powder [15g] was first dissolved in 15ml of methanol, to prepare its solution form. This was later adsorbed on 35g, of merck grade 60-120 mesh size silica gel , for preparing the slurry. This slurry was then packed into the column, for isolation of the compounds. Three different solvents, these solvents used were : distilled petroleum Ether [PET],3º/º ethyl acetate [EtoAC] in PET,and 1:1 PET:DCM . A chemglass CG -1189-16 glass chromatography column with a fritted disc and a 2-mm PTFE stopcock [1-1/2'' ID ×18'' effective length ,24/40 outer joint] was used for the experiment. The first isolated product was a white crystalline odourless compound whose melting point was 82.3 ºc. the second isolated extract was a yellow amorphous compound that had a fishy smell.TLC profiling was conducted to identify the appropriate solvent system to purify these extracts. After several rounds of trials, a 20º/º MeOH :80º/º EtoAC solvent system was determined to be the best system for purification of tehse extracts [60].

Vindoline formation:

Strictosidine β-d-glucosidase (SGD) is an enzyme that plays a crucial role in directing the biosynthesis of monoterpenoid indole alkaloids. the elimination of the rest of the glucose of strictosidine by SGD lead to an unstable , highly reactive aglucone, that is believed to convert into 4,21 dehydrogeissoschizine. It is believed that cathenamine synthase converts the former into cathenamine. Cathenamine is then converted into tabersonine through several steps, transforming into vindoline by a six-step sequence [61].

Table 3:

Type of alkaloid	Alkaloid infromation	Plant part	Pharmacological mechanisms	Therapeutic indications	Side effects
Vinblastine	Known as vincaleukoblastine hygroscopic crystalline compound water/methanol miscible white/ slightly yellowish colour.	Leaf stem root	Clings to tubulin prevents microtubules from developing anti-mitotic .	Breast cancer Lung cancer Head and neck cancer Hodgkin's lymphoma teasticular cancer .	Decrease bone marrow Increase gastro-intestinal toxicity potent vesicant Extravasation injury.

Vincristine	Known as Leucocristine colourless fluid in most pharmaceutical formulations.	Leaf stem root	Binds to tubulin dimer prevents microtubule structures from forming mitotic inhibitor anti-mitotic.	Teasticular cancer Non-Hodgkin's lymphoma Lymphoblastoma Leukemia Nephroblastoma.	Hyponatremia ,constipation Paralysis, Peripheral neuropathy spinal nerve demyelination, lung spasm.
Vindesine	Catharanthus alkaloid , brand names: Eldisine,fildesin accessible as a dissolved powder,it has the appearance of a whitish fluid.	Leaf stem root	Anti-mitotic .	Melanoma Lung cancer Uterine malignancies.	Spinal nerve demyelination, hyponatremia, constipation, hair loss ,nerve Demyelination ,breathing problems, lung spasm.
Vinorelbine	It is the first 5'NOR derived semi-synthetic Catharanthus alkaloids vindoline and Catharanthus using polonovski fragmentation method.	Leaf stem root	Anti-mitotic.	Breast cancer Non-small cell Lung cancer	Inflammation of the veins, constipation,poor resistance to infection ,bleeding, anaemia,nausea, Diarrhoea, numdness or tingling in hands or feet.
Vinflunine	Second- generation anticancer drug.	Leaf steam root	Decrease transition from metaphase to anaphase, preventing cancer cells from entering mitosis increase apoptosis.	Transitional cell carcinoma breast cancer	Hair loss, weariness, overall sensation of weakness.

MECHANISM OF BIOACTIVE COMPOUNDS OF C. roseus AGAINST CANCER:

Indole alkaloids produced by C. roseus, known as Vinka alkaloids, are commonly used as antimitotic agents in cancer treatment. Natural compounds such as vincristine and vinblastine exhibit anticancer activity and have been applied in clinical trials. Vinca alkaloids alter the microtubules, inducing apoptosis and inhibiting cell proliferation. Microtubules, key components of the cytoskeleton, play a critical role in chromosomes segregation during mitosis and meiosis, and are also essential for maintaining cell shape, intracellular transport, and various other cellular functions. Tubulin heterodimers, composed of α- and β-tubulin subunits, dynamically polymerize and depolymerize at microtubule plus ends. The building and hydrolysis of guanosine 5-triphosphate (GTP) regulate MT assembly and disassembly, a process known as dynamic instability. Disruption of these interaction can arrest the cell cycle and induce programmed cell death[62]. As a result, two categories of microtubule [MT] destabilizers have been identified: the first category comprises agents that stabilize MTs and inhibit their depolymerization, while the second category includes agents that promote MT depolymerization and prevent their polymerization. Vinca alkaloids and their analogs act by binding to two tubulin heterodimers at the outermost site near the exchangeable GTP-binding region, leading to microtubule depolymerization and cell cycle arrest. Although the intrinsic affinity of the two natural Vinca alkaloids from C. roseus and their semi-synthetic analogs for

tubulin heterodimers is similar, they differ in their overall binding strength, following the order: vincristine > vinblastine > vinorelbine > vinflunine. Through common docking mechanisms, van der Waals forces and electrostatic interactions stabilize the binding of these alkaloids to α- and β-tubulin [63].

Moreover, the two fluorine atoms that differentiate vinflunine from vinorelbine enhance its electrostatic interactions; in vinflunine, the vindoline moiety facilitates binding to tubulin heterodimers, while the catharanthine moiety contributes to its cytotoxic activity. According to several studies, vinca alkaloids act in a dose-dependent manner, inhibiting cell division at low concentrations, which ultimately leads to cell death after prolonged exposure. However, at high concentrations, vinca alkaloids induce the formation of paracrystals (giant tubulin polymers), which block mitosis and trigger tumor cell death. Recent studies have revealed additional mechanisms of action for these alkaloids, including interactions with microtubule-associated proteins, calmodulin, and the inhibition of amino acid metabolism. Using this novel mechanism of action, differences in the potency of Vinca alkaloids have been observed [64]. Although vinflunine has a lower affinity for tubulin than vinblastine or vincristine, its enhanced activity against murine tumors and human tumor xenografts is attributed to its interaction with calmodulin. The monoterpenoid indole alkaloid catharoseumine, isolated from C. roseus, features a unique peroxy bridge and demonstrates cytotoxicity against human tumor cell lines, although its activity is modest against the HL-60 cell line [65].

WHEAT GRASS JUICE AND CANCER TREATMENT:

It also referred as green blood due containing high chlorophyll content. Wheat shoot contain more than 60% chlorophyll also known as the basis of plant life. While haemoglobin is the basis of blood. Chlorophyll and hemoglobin share a similar atomic structure that forms the basis of their respective molecules. Human blood and haemoglobin consist of iron, while in chlorophyll the metallic atom is magnesium. Magnesium found in the proton of chlorophyll is also essential and beneficial for about 30 enzymes of our body. Chlorophyll has demonstrated anti-cancer effects in animals and, in a recent study, proved valuable in preventing gastrointestinal absorption of a particular aflatoxin, a carcinogenic chemical produced by molds that grow on seeds, nuts and legumes. Wheatgrass contains all of the essential amino acids, mainly tyrosine, phenylalanine, alanine, aspartic acid, glutamic acid, arginine, serine which are helpful in providing a sufficient amount of protein in the body [66]. Wheatgrass juice is comparable in protein, vitamins and minerals to green vegetables such as broccoli and spinach, and also contains large amounts of chlorophyll.Wheat grass has a reputation for benefiting abnormal bleeding, and scientific data suggest validity of this notion. It has been shown to reduce rectal bleeding with ulcerative colitis. the requirement for transfusions to cure anemia in patients with thalassemia and myelodysplastic syndrome, and even the need for bone marrow stimulating drugs to counter the negative effects of chemotherapy on white and red blood cell production [67].

A study shows that breast cancer patients who take wheat grass juice during their chemotherapy reduced the side effects of chemotherapeutic drugs and they got better quality of life. These have been well documented for their ability to not only prevent cancer, but also treat the disease[68].

Incidence of Iron Deficiency Anaemia

Iron deficiency occurs when there is an insufficient intake of iron primarily found in flesh foods and, to a lesser extent, dairy products and plant foods as well as in fortified foods or supplements. Iron deficiency can also be caused by poor absorption and excessive loss of the mineral, including blood loss. The more severe stages of iron deficiency can result in anemia when there is not enough iron to produce adequate amounts of hemoglobin for red blood cells. Iron deficiency is a major contributor to anemia, though the actual extent of overlap between iron deficiency and anemia is context-specific and varies by setting. Specific groups at an increased risk of iron deficiency include children due to rapid growth, pregnant women due to expansion of the red blood cell mass and the need for more iron for the fetus, and women of reproductive age, including adolescent girls due to blood loss during menstruation [69The use of wheatgrass for human consumption gained popularity in the Western world during the 1930s, largely due to the pioneering work of Charles F. Schnabel, often referred to as the “father of wheatgrass.” Schnabel conducted extensive research on the nutritional and therapeutic potential of young wheat shoots, demonstrating their richness in vitamins, minerals, amino acids, and chlorophyll. He developed methods to extract juice from wheatgrass, making its nutrients more accessible and bioavailable, and promoted its use as a dietary supplement for enhancing general health, supporting digestion, and improving blood quality. He said ' Fifteen pounds of wheatgrass is equivalent to 350 pounds of the choicest vegetables' Later Wigmore healed herself of cancer from the weeds she found in vacant lots in Boston. The wheatgrass used in her program contains bioactive compounds such as abscisic acid and laetrile, both of which have been investigated for their potential anticancer properties. Abscisic acid, a plant hormone, has been reported to modulate immune responses, induce apoptosis, and inhibit proliferation in certain cancer cell lines. Laetrile, also known as amygdalin, has been explored for its ability to release cyanide selectively in tumor cells, potentially leading to targeted cytotoxicity, although its efficacy and safety remain controversial and are subject to ongoing scientific debate. Studies have reported that young grasses and other chlorophyll-rich plants are safe and effective in managing conditions such as high blood pressure, certain cancers, obesity, diabetes, gastritis, ulcers, liver and pancreatic disorders, fatigue, anemia, asthma, eczema, hemorrhoids, and various skin problems [70]. Wheatgrass contains a range of bioactive components, including chlorophyll, flavonoids, and vitamins C and E, which contribute to its antioxidant, anti-inflammatory, and potential anticancer properties. It is commercially available in multiple forms, including fresh juice, frozen juice, tablets, and powders, with the nutrient composition influenced by cultivation conditions, harvest timing, and processing methods. In vitro studies, particularly those using fermented wheat germ extract, have demonstrated anticancer potential, highlighting apoptosis induction, cell cycle arrest, and inhibition of

tumor cell proliferation as key mechanisms. Animal studies have further supported these findings, showing that wheatgrass can contribute to cancer prevention, enhance the efficacy of conventional chemotherapeutic agents, and improve immune function [71]. Clinical trials suggest that wheatgrass supplementation may provide synergistic benefits when combined with chemotherapy, potentially enhancing treatment efficacy and reducing chemotherapy-related side effects such as fatigue, nausea, and myelosuppression. Beyond oncology, wheatgrass has been investigated for its potential therapeutic effects in rheumatoid arthritis, ulcerative colitis, hematological disorders, diabetes, obesity, and conditions associated with oxidative stress, likely due to its antioxidant, anti-inflammatory, and immunomodulatory properties.However, most of these clinical trials have been small-scale, with limited sample sizes, short follow-up periods, and several methodological limitations, including lack of blinding, inadequate controls, and heterogeneity in wheatgrass formulations [72].

Germinated Wheat was processed and grown as grass. Dried powder of wheatgrass was analyzed for its physio- chemical, proximate composition [73].

SYNTHESIS OF ANTI CANCER AGENTS FROM C. roseus:

Significant advances have been made in the in vitro culture of plant cells for the enhanced production of anticancer compounds. These biotechnological approaches offer several advantages, including the ability to produce bioactive pharmaceuticals with controlled purification, achieve high-yield production in a relatively short time, and maintain a well-regulated, sterile manufacturing environment. Catharanthus roseus (C. roseus) has emerged as a promising source of high-value alkaloids through the application of submerged culture techniques, which utilize either shake flasks or various types of bioreactors. Notably, hairy root cultures of C. roseus have been successfully cultivated in bioreactors of different scales, enabling large-scale production of important indole alkaloids such as ajmalicine, serpentine, and catharanthine.

Furthermore, the potent anticancer alkaloids vincristine and vinblastine have been synthesized efficiently in stirred-tank bioreactor systems. Studies indicate that their production reaches maximum levels under unregulated pH conditions with an aeration rate of 0.5 v/v/min, yielding vincristine and vinblastine at 13.47 mg/L and 7.94 mg/L, respectively. Optimizing other parameters, such as elicitor addition, nutrient composition, and temperature control, has also been shown to enhance alkaloid accumulation. These developments highlight the potential of plant cell culture technology as a scalable and sustainable approach for producing clinically important anticancer drugs, reducing dependency on whole-plant extraction, and enabling consistent, high-quality production for pharmaceutical applications [74,75] .

The production of alkaloids in plant cell cultures is often enhanced under stress conditions, as cells respond by activating secondary metabolite pathways. For instance, the incorporation of sodium chloride (NaCl) into culture media induces osmotic stress, which can trigger stress signaling pathways, alter enzyme activities, and stimulate increased alkaloid biosynthesis. Similarly, the use of elicitors derived from microorganisms, such as Aspergillus flavus fungal extracts, has been shown to significantly promote cell proliferation and enhance the production of key Vinca alkaloids, including vinblastine and vincristine. [76].

Wheatgrass juice is a nutrient-dense health supplement extracted from the young grass of the wheat plant (Triticum aestivum). The juice is rich in vitamins, minerals, antioxidants, and other beneficial compounds. Vitamins: A, C, E, and K ,Minerals: Iron, calcium, potassium, and magnesium ,Antioxidants: Chlorophyll, flavonoids, and phenolic acids , Amino acids: Essential and non-essential amino acids.Detoxification: Supporting liver and kidney function. Antioxidant properties: Protecting against cell damage and oxidative stress. Immune system support: Boosting immune function and reducing inflammation. Anti-inflammatory properties: Reducing inflammation and improving overall health [77].

Materials and Methods : Wheatgrass juice

Clinical trials on rats:

This study was initiated after approval from the Institutional Research Board (Animal Ethics Committee) of PGIMER vide.

Sample size: Data were collected from 6 animals in each group, as a sample size of 6 per group is generally accepted for animal studies.

Study design: 36 male Sprague Dawley rats were split in 6 groups with each group having 6 animals. Range of body weight of the animals was 220-270g. Details of groups are given in These were acclimatised for 7 days prior to exposure to various treatments. Under standard conditions, they were kept in polypro pylene cages. All included rats were retained in accordance and as per the guidelines and ethical principles endorsed by the committee of animal care.

The experimental protocol was designed to determine the appropriate wheatgrass dosage, as outlined below.

• Group 1- Throughout the period of experimentation, rats in this group were fed on standard laboratory feed, water and diet ad libitum and served as control. 1mM EDTA-saline subcutaneously per week was also administered to the rats in this group which was used as the vehicle for giving 1,2-dimethylhydrazine (DMH) treatment.

• Group 2- Rats in this group were given a weekly DMH in 1mM EDTA-saline at a dose of 30mg/kg body weight as subcutaneous injections for a total period of 16 weeks. This group was designat ed cancer group.

• Group 3- consisted of rats that received 1,2-dimethylhydrazine (DMH) weekly, following the same administration protocol as Group 2. In addition, the animals were treated with wheatgrass orally, using tablets obtained from Sarvaayush Wheatgrass Tablets Pvt. Ltd., Pune, which were dissolved in water and administered at a dose of 80 mg/kg body weight daily for a period of 16 weeks. Importantly, wheatgrass supplementation was initiated 15 days prior to the first DMH injection, allowing for preconditioning of the animals with its bioactive compounds, such as chlorophyll, flavonoids, vitamins, and potential anticancer agents like abscisic acid and laetrile. This pre-treatment strategy aimed to evaluate the protective and chemopreventive effects of wheatgrass against DMH-induced colorectal carcinogenesis. Throughout the study, animals were monitored for general health, body weight, and behavioral changes, and the wheatgrass administration protocol was designed to ensure consistent daily intake while minimizing stress. This setup allowed for the assessment of wheatgrass's potential to reduce tumor incidence, suppress oxidative stress, and modulate apoptosis and inflammatory pathways in a DMH-induced colon cancer model.

• Group 4- Treated in same way as group 2 animals. Additionally 15 days prior to the start of first DMH injection, 100mg/Kg body wheatgrass dose was administrated daily orally to animals. This dose was administered for 16 weeks.

• Group 5- Animals in this group received weekly injections of DMH, following the same protocol as administered to Group 2. Additionally15 days prior to the start of first DMH injection, wheatgrass was given orally to animals in water at a dose of 120mg/Kg body weight in drinking water daily for a period of 16 weeks.

• Group 6- Animals in this group were given dose of 120mg/kg body weight wheatgrass tablets daily in the drinking water. The rats in this group served as wheatgrass control animals for groups 3-5. The maximum dose of wheatgrass was administered to evaluate its safety and potential toxicity, even at high intake levels. This approach allowed for the assessment of tolerability, adverse effects, and any dose-dependent physiological changes, ensuring that subsequent dosing regimens could be safely applied in experimental or clinical settings. Such testing is essential for establishing the therapeutic window and confirming that wheatgrass remains non-toxic even at doses exceeding typical dietary consumption.

After 16 weeks, animals were sacrificed using ether anaesthesia. Small colons tissue portions after weighing, were fixed in forma lin for histological examination. A segment of colon was stored at -80°C and some was used for making homogenate was prepared in Tris-Mannitol buffer (2mM Tris, 50mM Mannitol, pH 7.2) for biochemical estimations. Following parameters were undertaken to establish minimum wheatgrass dose with maximum protection [78].

Results :

It was observed from table 1 that significant levels of LPO were increased [P<0.001] following administration of DMH [group 2] and those having additionally 80mg wheatgrass along DMH [group 3] as compared to control rats [group 1]. In contrast, GSH levels,activities of catalase and SOD were decreased significantly in rats injected with DMH only [group 2] in comparison to control group. Those provided DMH+wheatgrass [group 3,4 and 5] showed reduced LOP levels with increasing dosage of wheatgrass from 80mg to 100mg/kg body weight /day.100mg and 120mg dosages of wheatgrass showed significant [P<0.001] reduction in LPO as compared to DMH group but there was not much difference between the two groups. 80mg dosages of wheatgrass showed less reduction [P<0.001]. On the other hand, activities of catalase and SOD and levels of GSH tended to show an increase following simultaneous supplementation of wheatgrass at doses ranging from 80mg to 120mg. But DMH treated rats supplemented with 80mg of wheatgrass [group3] did not show statistically significant changes in the activites of enzymes and GSH levels when compared with group 2 animals [DMH only]. however, enzymatic activity tended to restore with wheatgrass treatment and showed significant

[P<0.05] recovery in100mg and 120mg dose group [P<0.05].It was also observed that recovery was almost similar in both the dose group of 100and 120mg. Thus, not much difference was observed in biochemical indices in supplementation of 100mg as well as 120 mg doses was finally decided to be 100mg /kg body weight /day which provided maximum protection without causing any adverse effect.

Conclusions:

This study investigated the potential of vinca alkaloids from C. roseus as anticancer agents, examined the mechanisms of vincristine and vinblastine in inhibiting cancer cell proliferation, and explored strategies to enhance alkaloid production using bioreactor systems. This updated study further highlights the pharmaceutical significance of alkaloids isolated from C. roseus and their potential in the development of C. roseus-derived anticancer drugs. Efficient cultivation of these compounds through bioreactor-based large-scale production could provide a sustainable source of high-quality raw materials for the pharmaceutical industry in the development of anticancer agents. Given these potential benefits, C. roseus can be regarded as a natural powerhouse with applications in cancer therapy and patient care. It is also classified among FDA-approved cytotoxic drugs, including vinblastine, vincristine, and vinorelbine. Moreover, additional anticancer drugs include vinflunine, which is currently used as a second-line treatment for patients with urothelial transitional cell carcinoma. Thus, the whole review and literature come to an end. Vinca has the potential to serve as an ethnopharmacological representative with anticancer properties.

Widespread data from a number of studies has made known the multitude effect of wheatgrass is known the multitude effects of wheatgrass is known to help diminish fatigue, improve sleep It helps increase strength, naturally regulate blood pressure and blood sugar, support weight management, and improve digestion and elimination. Additionally, it promotes healthy skin, teeth, eyes, muscles, and joints, enhances overall bodily function, and may provide benefits in conditions such as arthritis, muscle cramps, thalassemia, hemolytic anemia, cancer, asthma, allergies, inflammatory bowel disease, and supports detoxification.

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