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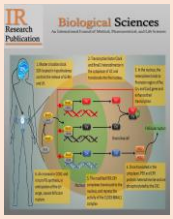

A review on salient pharmacological features and chemical constituents of Bitter Melon

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ABSTRACT

Since prehistoric times, plants have been used as medicine and foodstuff across the world. The Cucurbitaceae family includes the Bitter Melon *Momordica charantia*. The bitter melon plant is a vine with green leaves and yellow blooms, and the cucumber-like fruit is rectangular and green. It has been used as food and medicine for millennia in the Amazon, Asia, South America, India, East Africa, and the Caribbean. The name "Momordica" derives from the Latin word Mordica, which means "to bite," and refers to the notched margins of the leaf that appear to have been bitten. The plant, also known as "bitter melon" or "bitter gourd," lives truly the case to its common name by being exceedingly bitter throughout, including the fruit. This review seeks to offer information on the distribution and cultivation of bitter gourd and also explain the chemical constituents and their biological or pharmacological activity of herbal drugs of *Momordica charantia* Linn. (Cucurbitaceae). Our first goal was to understand more about the different pharmacological activities of the plant and the mode of action through which the activity is responsible. This review gives a thorough knowledge of traditional use of *Momordica charantia* with its detailed botanical description. *Momordica charantia* includes a large number of chemically distinct compounds, needing intensive screening processes to determine the pharmacological effects of its phytoconstituents at the molecular level. Furthermore, the paper highlights the medicinal potential of its bioactive components as well as their use in value-added food items. It has the power to fight against numerous lifestyle-related ailments, such as cancer recurrence, diabetes mellitus, abdominal pain, kidney (stone), fever, and scabies, due to the presence of bioactive chemicals.

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Introduction

Plants and plant derived products are vital in human nutrition, not only for giving important nutrients but also for preventing a number of diseases [1]. They do actually improve people's lives all around the world. Plant-based traditional remedies have been

used since the dawn of time, [2-3] but standardization is required to assess their potential [4]. Bitter Melon, or *Momordica charantia*, is a popular vegetable in India that is also used in traditional medicine [5]. *Momordica charantia* is one such sample that contains a diversity of phytochemistry and can be used in dietary regimens to alleviate a different ailment. Ayurveda prescribes the fruit as a tonic, stomachic, emetic, antibilious, and laxative. Bitter melon has been used in Asian conventional medicine for centuries. Triterpenes, enzymes, steroids, alkaloids, saponins, glycosides, and acids, among others, offer *Momordica charantia* its antifungal, antibacterial, antiviral, anti-fertility, anti-tumorous, hypoglycaemic, and anti-carcinogenic qualities.

Septic arthritis, rheumatism, parasites, colic, and diseases of the liver and spleen are all treated with fruits in traditional medicine. It's also been discovered to help with cancer and diabetes treatment [6-15].

Because of its anti-helminthic, diuretic, and laxative effects., the juice is used to cure a variety of ailments, including joint pain, chronic fever, jaundice, and liver and digestive system problems. It is used to cure burns, boils, and rashes and also to treat chronic skin problems. For the treatment of T2DM, the whole plant should be consumed as food. The oil extracted from ripe bitter melon fruits macerated in sun-warmed olive oil was mixed with honey and used to prevent and heal stomach ulcers in Turkish folk medicine.

In India, two types of *Momordica charantia* are grown. *Momordica charantia* var., charantia has huge fusiform fruits, whereas *Momordica charantia* var., muricate has small, spherical fruits [16The fruits of *Momordica charantia* are frequently consumed as a vegetable and have long been a staple of the west Indian cuisine. India has historically used its fruits, seeds, and leaves to cure diabetes [17].

It is claimed to purify the blood as well as expel melancholy and ill spirits. [18]. Leaf juice is used as an emetic and purgative in bilious diseases. Leprosy, hemorrhoids, and jaundice are all treated using fruit and leaves.

Leaf juice is applied to the soles of the feet during foot burning. Leaf juice and a pinch of turmeric powder, which works as an emetic and cleanses the stomach, are used to relieve nausea in children. It is administered externally to pustular eruptions on the scalp, burns, and boils [19].

Momordica charantia plants are rich in minerals like copper, iron, magnesium, zinc, and calcium. Among the fatty acids discovered are lauric, mydriatic, palmitic, stearic, and linoleic acids [20].

This paper examines a number of features of recent *Momordica charantia* research findings. Its purpose is to provide a comprehensive analysis of *Momordica charantia* phytochemistry and commercial application features in order to raise awareness of the plant's biological activities and educate people on how to use *Momordica charantia* more effectively.

Distribution and origin

The Karela is supposed to have originated in the tropics of the ancient world. In India and other countries of the Indian subcontinent, Southeast Asia, China, Africa, the Caribbean, and South America, it is widely produced as a food and medicinal [21].

Cultivation of *Momordica charantia*

Karela is an herbaceous perennial vine native to India that may be grown at elevations up to 1500 meters. It is grown by sowing seeds in a pit throughout the warm season, from April to July. Manure is used to fertilize the seeds, which are sown half a meter apart. Only one plant is retained, and seedlings are watered once or twice a week. Fruits are ready to harvest 15-20 days after flowering, and plants flower 30-35 days after seeding [22-23].

General description

Momordica charantia Linn is also known as *M. chinensis, M. elegans, M. indica, M. operculata, M. sinensis,* and *Sicyos fauriei* (Karela). It has a variety of common names in numerous languages, including [24].

- Karela in Hindi;
- Bitter gourd in English;
- Karavelli in Sanskrit;
- Karli in Marathi;
- Karelo in Gujarati;
- Baramasiya in Bengali;
- Karali in Kannada;
- Kaypa in Malayalam;
- Pakar in Tamil;
- Kakara in Telugu.

Botanical description

The flowering climber *Momordica charantia* Linn. (Karela) belongs to the Cucurbitaceae family. The herbaceous plant with tendrils can reach a height of six meters or more. Leaves are 4-12 cm wide and contain 3-7 deeply split lobes (**Figure 1**).

Despite the fact that the lobes are mostly wide, they do have little marginal tips. Stipules are not present. Flowers are always unisexual and actinomorphic. The epigynous zone on the perianth is short to long, and the peduncles are short (female) or long (male). The fruit has an ovoid, ellipsoid, or spindle-shaped exterior with a pronounced warty appearance and an oblong shape (**Figure 2**).

Figure 1. *Momordica charantia* plant (bearing fruits).

Figure 2. *Momordica charantia* fruit.

In cross-section, it is hollow, with a thin layer of flesh surrounding a central seed chamber filled with huge flat seed and pith [25]. 8-13mm seeds, long compressed, corrugated on the margins, and sculptured on both sides [26]. It has simple, alternating leaves with 3-7 deeply separated lobes that are 4-12 cm across. Although the lobes are primarily broad, they do have few marginal tips. There are no stipules. Flowers are always unisexual and actinomorphic. In India, it has a different morphology, with a smaller shape, sharp ends, and a surface covered in ragged, triangular "teeth" and green ridges. It possesses the most intense bitterness of any vegetable [27] (**Figure 3**).

Figure 3. Leaves of *Momordica charantia*.

Classification of *Momordica charantia*

Kingdom: Plantae

Common name: Karela, Bitter gourd

Order: Cucurbitales

Species: M. charantia

Genus: Momordica

Family: Cucurbitaceous

Class: Magnoliopsida

Division: Magnoliophyta

It is grown for the fruits, which are used as a vegetable. Karela is utilized as a traditional remedy in all sections, especially the fruits. Its usage in diabetes treatment has made it a well-known medicinal herb.

Chemical constituents & nutritional value of *Momordica charantia*

Bitter Melon is a nutrient-dense plant that has a diverse range of therapeutic chemicals. The phytochemicals present in the *Momordica charantia* and their pharmacological actions are explained in table 1. Triterpene, protein, steroid, alkaloid, inorganic, lipid, and phenolic chemicals are the primary elements of bitter melon (Karela) [28]. *Momordica charantia* has a nutritional composition of 91.8 percent water and 0.20 percent fat.

Momordica charantia (Karela) consists of the several chemical constituents, including alkaloids, gentilic acid, guanylate cyclase inhibitors, gypsogenin, hydroxytryptamines, karounidiols, lanosterol, lauric acid, linoleic acid, linolenic acid, momorcharasides, momorcharins, momordenol, momordicillin, momordicinin, momordicosides, momordin, momordolo, multiflorenol, myristic acid, nerolidol, oleanolic acid, oleic acid, oxalic acid, pentadecans, peptides, petroselinic acid, polypeptides, proteins, ribosome-inactivating proteins, rosmarinic acid, rubixanthin, spinasterol, steroidal glycosides, stigmastadiols, stigmasterol, taraxerol, trehalose, trypsin inhibitors, uracil, vacine, v-insuline, verbascoside, vicine, zeatin, zeatinriboside, zeaxanthin, zeaxanthin, amino acids, aspartic acid, serine, glutamic acid, thscinne, alanine, g-amino butyric acid and pipecolic acid, ascorbigen, bsistosterol-d-glucicide, citruline, elasterol, flavochrome, lutein, lycopene, pipecolic acid [29-31].

Fruits: Fruits contain glycosides, saponins, alkaloids, reducing sugars, resins, phenolic components, fixed

oil, and free acids. Karela is a miracle treatment for illnesses due to its unique blend of properties [32].

Leaves: Fruits and leaves are high in B vitamins: thiamine (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3) 2 percent, vitamin B6 3 percent, folate (vitamin B9) 13 percent [33-35].

Momordica charantia seeds are also high in lipids, such as polyunsaturated fatty acids (nearly 45 percent by weight) and conjugated linolenic acid (63–68 percent as eleostearic acid) and are one of the few foods that contain conjugated linolenic acid. The essential oil produced from drought seeds contains sesquiterpenes, phenylpropanoids, and monoterpenes. Other beneficial components found in *Momordica charantia* seed oil include tocopherols and polyphenols. The plant's pericarp, aril, stem, and leaves are also rich in phenolic chemicals, which can protect against oxidative damage by acting directly on reactive oxygen species and inducing endogenous defense systems. Cucurbitane-type triterpenoids are a group of glycosides identified from *Momordica charantia* fruit and stem, with cucurbitacins being the most common. They have a wide spectrum of biological properties, the majority of which are anti-inflammatory and anti-diabetic.

Traditional uses of *Momordica charantia*

For a long time, the Bitter gourd has been utilized in several Asian traditional medicine systems to prevent and treat various disorders. Bitter melon fruits are used in the treatment of asthma, burns, constipation, cough, diabetes, fever, gout, helminthiasis, inflammation, leprosy, skin illnesses, ulcers, and wounds. It has been shown to have hypoglycaemic effects in both animal and human investigations. The leaf juice is used to heal piles, purify the blood, and even treat liver damage, dyspepsia, jaundice, and cholera [44-46].

Fruits: Asthma, colic, constipation, cough, diabetes, fever (malaria), gout, helminthiases, inflammation, leprosy, skin ailments, ulcers, and wounds are all treated using *Momordica charantia* (karela) fruits. It has also been proven in animal and human research to have hypoglycaemic (antidiabetic) effects. Karela leaf juice was utilized to treat piles. Due to its bitter tonic effects, karela is utilized as a blood purifier. It has the ability to treat boils and other skin-related blood issues. Karela juice is also useful for treating and preventing liver disease [47-48].

Leaves: Leaves are used to treat menstrual issues, burning feelings, constipation, fever (malaria), colic, infections, worms, and parasites, as well as measles, hepatitis, and helminthiases [49]. In Guyana's traditional medicine, a leaf tea is used for diabetes, to relieve intestinal gas, to promote menstruation, and as an antiviral for measles, hepatitis, and fewer illnesses. Internally and externally, it heals sores, wounds, infections, worms, and parasites [50].

Seeds: Seeds can be used to treat ulcers, liver and spleen problems, diabetes, intestinal parasites, high cholesterol, and intestinal gas, as well as wounds and stomach aches [51].

Roots: Syphilis, rheumatism, boils, ulcers, septic swellings, ophthalmia, and prolapsus vagenae are all treated with roots of the Bitter gourd. Pyorrhoea can be alleviated by drinking karela juice (bleeding from the gums) [52-53].

Pharmacological activity

Antidiabetic activity

It is one of the world's fastest-growing diseases [54]. In Asia and other developing countries, many traditional herbal medicines have been adopted to treat diabetes. *Momordica charantia* (Karela) is a kind of plant have been thoroughly explored for the treatment of diabetes [55]. Several investigations have suggested that a variant of *Momordica charantia* extract can be utilized to treat diabetes [56-61]. According to research into the traditional uses of *Momordica charantia* (bitter gourd) in India, it is one of the most important plants for lowering blood glucose levels in diabetic patients. Karela includes bitter compounds such as charantin, vicine, glycosides, and karavilosides, as well as polypeptide-p, and plant insulin, which have hypoglycaemic properties and help to lower blood sugar levels by enhancing glucose uptake and glycogen synthesis in the liver, muscles, and fat cells [62-64]. *Momordica charantia* protein extract significantly boosted insulin secretion and glucose absorption in adipocytes, according to Yibchok-Anun et al. [65]. The hypoglycaemic effects of *Momordica charantia* extracts and their components are thought to be mediated by a variety of physiological, pharmacological, and biochemical mechanisms. It stimulates the peripheral nervous system, glucose utilizations in skeletal muscles and suppression of glucose absorption in the intestine, isle-cell prevention and treatment functions.

Antioxidant activity

Besides from diabetes, different portions of this plant have been employed in Indian medicine for a variety of diseases. The production of ammonium free radicals might lead to lipid peroxidation and liver injury. Excessive ammonia consumption enhances NMDA receptor activation as well as

Table 1. Phytochemical constituents and their pharmacological activities.

Phytochemical constituents	Pharmacological properties	References
Polysaccharides	Anti-tumour, Radioprotective, Hepatoprotective, Immunomodulation, Antioxidant, Anti-diabetes	[36]
Peptides & Proteins	Anti-cancer, Immunosuppressant, Anti-lipolytic, Lipogenic	[37-38]
Lipids	Antihyperlipidemic, Antitumor	[39]
Terpenoids	Anti-diabetic, anti-cancer, Anti-HIV, Anti-feedant, Anti-obesity, Anti-inflammatory	[40]
Saponins	Anti-diabetic, Cardioprotective, Regulate blood cholesterol levels.	[41]
Phenolics	Antioxidant, Antimicrobial, Cytotoxic	[42]
Sterols	Antimicrobial	[43]

neuronal degeneration, resulting in oxidative damage from lipid peroxidation and suppresses antioxidant action. Induction of ammonium salts, either chloride or acetate, caused ammonia toxicity and oxidative stress, resulting in lipid peroxide and free radical formation [66]. Bitter melon supplementation reduced the levels of Thiobarbituric acid reactive substances, hydroperoxides, Alanain Transminase, Aspartate Transaminase, and Glutathione peroxidase, all of which are linked to liver injury and lipid peroxidation. Leaf extract of *Momordica charantia* had the most antioxidant activity based on DPPH radical scavenging activity and ferric reducing power, whereas green fruit of this plant extract had the highest antioxidant activity based on hydroxyl radical scavenging activity, carotene-linoleate bleaching assay, and total antioxidant capacity as shown in **Figure 4** [67]. Several investigations have shown that Under the right conditions, charantia is a good natural source of antioxidants [68-70]. Antioxidant activity of extracted phenolic compound from bitter melon has been reported by [71]. It has anti-oxidant activity in vitro and in vivo under experimental conditions; the bioactive phytochemicals mainly include polysaccharides, saponins, and phenolics [72-73]. Seed powder and its ethanol/water extracts were shown to be more effective than gourd pulp and extracts. The anti-oxygenic activity was higher than that of other solvent extracts, as shown by multiple in vitro test models [74].

Antifertility activity

Bitter melon fruit and leaves have been shown to have antifertility effects in female rats in vivo [75].

Antimicrobial activity

The extract of the Bitter Melon leaf has shown clinical symptoms of broad-spectrum antibacterial action. Essential oils from *Momordica charantia* seeds exhibit a strong antibacterial effect on S. aureus, but not on E. coli or Candida albicans [76]. *P. multocida, S. typhi, S. epidermidis*, and *L. bulgaricus* were among the bacteria that the aqueous extract from *Momordica charantia* seed showed strong antibacterial action against *S. aureus, M. luteus, E. coli, S. epidermidis,* and *L. bulgaricus* were all killed by the ethanolic extract, while n-hexane and petroleum ether extracts were efficient against S. aureus [77]. Methanol, water, and ethanol extracts of BM leaves have been shown to have antibacterial efficacy against Salmonella, *Pseudomonas aeruginosa, E. coli*, Bacillus, and Streptococcus chain. *Momordica charantia* pulp extract, like the hydrophilic leaf extracts, has been shown to have broad-spectrum antimicrobial action [78], including antibacterial activity against E. coli, Staphylococcus, Pseudomonas, Salmonella, and Streptobacillus. In plasmodium-infected mice, oral administration of leaves exhibited significant antimalarial action, lowering parasitaemia levels. *Momordica charantia* leaf extract was tested for antimalarial activity against Plasmodium falciparum cultured parasites. P. falciparum growth was observed to be reduced by this extract.

Antiviral activity

Karela and its extracted phytochemicals have also been shown to have in vitro antiviral activity against a variety of viruses, including Epstein-Barr, herpes, and human immunodeficiency virus [79-80]. Three

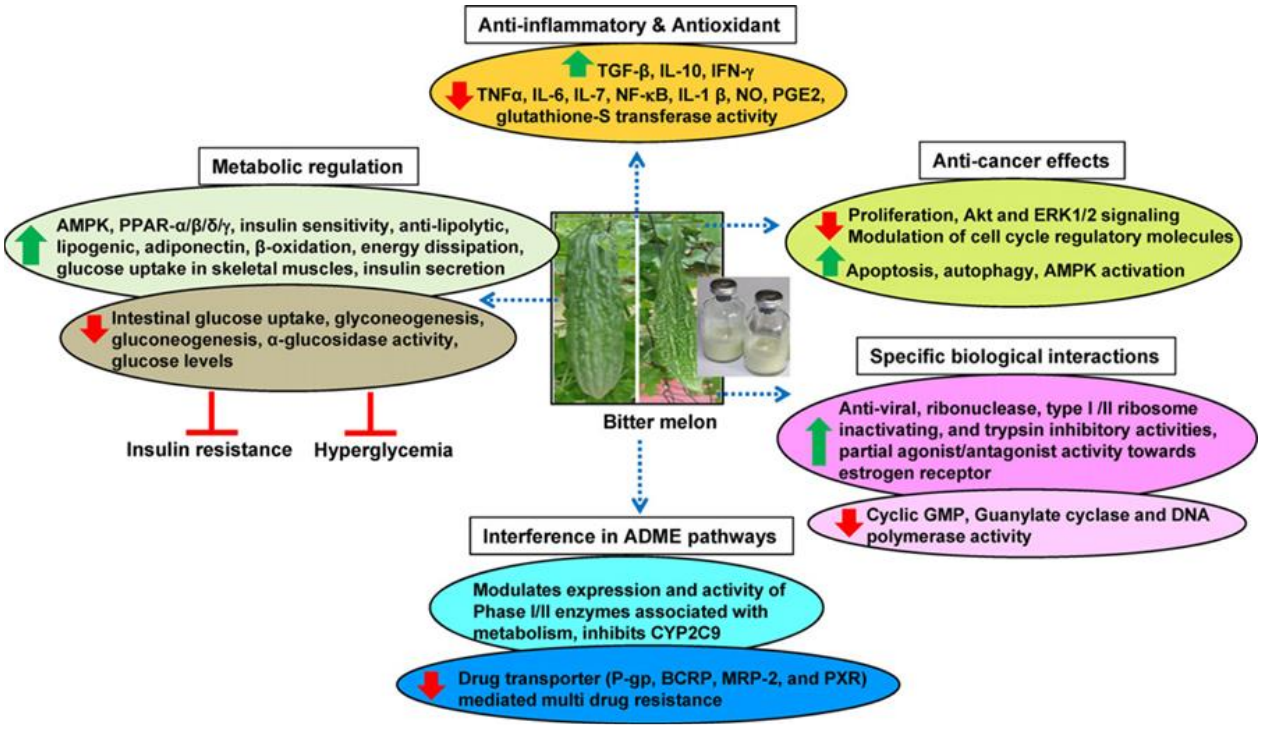

Figure 4. Mechanism of action of the pharmacological activity of the *Momordica charantia* Linn. (Cucurbitaceae)

HIV-positive individuals who were given periodic dosages of *Momordica charantia* fruit juice reported an increase in T-cell count and a stabilization of the CD4/CD8 ratio. A leaf extract revealed the ability to boost viral infection resistance as well as offer an immunostimulant impact in humans and animals in an in vivo investigation (raising interferon production and natural killer cell activity). The HIV virus has been demonstrated to be suppressed in vitro by two proteins called alpha- and beta-momorcharin (found in the seeds, fruit, and leaves) [81]. HIV-infected cells treated with alpha- and beta-momocharin lost practically all viral antigens in one investigation, whereas healthy cells were essentially unaffected. Another clinical investigation found that MAP-30's had antiviral activity in vitro against the herpes virus [82].

Anticancer activity

Because of the rising prevalence of cancer around the world, there has been significant progress in the development of anticancer therapies [83]. Bitter melon extract inhibits cancer cell proliferation and has no negative side effects in both people and animals [84]. Anticipations of approaches are becoming more important in order to reduce cancer risk and control the cancer revolution. Cancer and tumor formation are inhibited by bitter melon and its extract. A new phytochemical found in karela has been shown in clinical trials to block the enzyme guanylate cyclase. This enzyme is hypothesized to play a role in the pathogenesis and replication of psoriasis, as well as leukemia and cancer [85]. A water extract prevented the growth of rat prostate carcinoma, while a hot water extract of the entire plant inhibited the formation of breast tumors in mice, according to other studies. Bitter Melon is ineffective in the treatment of breast cancer, which is a major public health concern among women. BME (bitter melon extract) has been shown to have antiproliferative properties in breast cancer. Anti-cancer effect of *Momordica charantia* is well explained in **Figure 4**.

Antihyperlipidemic activity

Hyperlipidemia is a social problem these days, and it's often linked to diabetes, which increases morbidity and death. *Momordica charantia* was found to have a substantial antihyperlipidemic effect. In diabetic rats, metformin, a fraction of *Momordica charantia*, and other fractions such as flavonoids, saponins, tannins, triterpenes, and alkaloids all have an influence on total cholesterol levels. High blood lipid concentration is linked to ischemic heart disease, atherosclerosis, and cerebrovascular disease as major risk factors. Significantly, *Momordica charantia* antihyperlipidemic impact was observed. A new mechanism for bitter melon has just been discovered, which implies that it repairs damaged β-cells, improving insulin levels and sensitivity [86]. It also promotes the release and synthesis of adiponectin and thyroid hormones, as well as reducing glucose absorption by lowering the action

of glucosidase. The hyperlipidaemic effect of HIV-1-protease inhibitors that contain lipoprotein instead of lipoprotein clearance is also influenced by hepatic triglyceride synthesis. BM increases the activity of AMPK (adenosine-5-monophosphate kinase), a protein involved in a fat release from fatty tissues and glucose intake, leading to weight loss [87]. Another study found that giving diabetic rats *Momordica charantia* extract reduced their blood lipid levels significantly.

Conclusion

Momordica charantia has a large number of chemically unique chemicals that will need to be screened against new targets in the future. To sum up, the functional and health-promoting potential of *Momordica charantia* should be investigated for the treatment of various ailments. Several scientific pieces of evidence have come in front of us in support of these acclaimed benefits. *Momordica charantia* bioactivity research has progressed quickly up to this point. *Momordica charantia* Linn. (Karela) is a good source of various medicinally important biochemicals such as triterpene, protein, steroid, alkaloid, and phenolic, which are responsible for its biological and pharmacological activities such as anti-diabetic, antioxidant, anti-cancerous and anti-tumorous, antimicrobial, anti-fertility, anti-viral, antimalarial. In order to best exploit this valuable natural resource, further trials are required to establish *Momordica charantia* efficacy and safety. The biological or pharmacological activity of the *Momordica charantia* plant is the main focus of this review. *Momordica charantia* is effective and as safe for patients as other hypoglycaemic agents. *Momordica charantia* has a large number of chemically unique chemicals that will need to be screened against new targets in the future.

Contribution of authors

We proclaim that this work was completed by the authors mentioned in this article and that the author will bear all liability for aspects relevant to the content of this article. Ms sonia tanwar compiled the article's content from various research papers published. Yet Ms Garima Dhingra, Kartik Tanwar and Dr. Prashant Dhakad authenticated the entire manuscript and recommended changes, as well as assisted in the layout of the manuscript.

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Conflict of interest

There is no conflict of interest

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