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A Comprehensive Review on: Nutraceuticals Approaches of *Momordicacharantia* L. Fruits for Neurodegenerative Disease

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Abstract

The *Momordicacharantia* is a tropical plant, also known as bitter gourd or bitter melon, is a crucial herbal remedy with a wide range of medicinal properties. People in Indian subcontinent and China consider, *M.charantia*as key components to treats variety of elements such as cancer, diabetes and neurodegenerative diseases like Alzheimer's disease, Parkinson's disease, multiple sclerosis etc. These diseases are described by degeneration or loss of selective neuron populations in a progressive manner. The two main characteristic of neurodegenerative illness are oxidative stress and inflammation, which have been studying using the variety of medicinal herbs and their derivatives. However, very few authors have reported the protective effects of *M. charantia* against neurodegenerative diseases. This short review focus on the neuroprotective effects of *M. charantia*. Based on their anti-oxidant and anti-inflammatory properties, the present study emphasizes to further explore the protective effects of *M. charantia* against neurodegenerative and neuroinflammatory diseases.

Key Words: *M.charantia*, Invivo Studies, Invitro Studies, Neurodegenerative Diseases.

1. Introduction

*Momordicacharantia*belonging the family of Cucurbitaceae is a herbaceous vine plant with ridged fruits called bitter gourd [Zhang et al.,2016]. These fruits (*M. charantia)* are emerald green in colour while ripened fruits are yellow-orange in colour**[Nagarani et al.,2014].***M. charantia* is a tropical and subtropical plant that has long been utilized in Chinese, Indian, Sri Lankan, and Pakistan for traditional medicines **[Polito et al.,2016].** Different varieties of *M. charantia* are available in different habitats **[Thakur et al.,2018].** Proteins, polysaccharides, flavonoids, alkaloids, glycosides, phenolics, tannins, triterpenoids, and steroids are the common phytochemicals present in *M. charantia***[wang et al.,2017]**. Moreover, this plant is a rich source for a range of saponins such as momordicin, karavilagenin, and karaviloside**[Keller et al.,2011]**. *M. charantia* plant has been used against a wide range of diseases including diabetes, cancer, obesity, microbial infections, hypertension, and AIDS **[Gorver et al.,2004]**, and these medicinal properties are described to the fruits, unripe fruits in the plant **[Scartezzini et al.,2000]**. Earlier reviews had discussed the medicinal role of M. charantia against obesity and inflammatory diseases **[Bortolotti et al.,2019]**. Other pleiotropic effects such as antitumor effects and anthelmintic effects **[Jiraung et al., 2017]** have also been discussed in recent reviews; however, no review article had specifically pointed out its neuroprotective effects. In this review we discuss the

preclinical studies focused on studying the neuroprotective effects of M. *charantia*. Collects from PubMed and google scholar search was done to collect information about Neuroprotective effect of *M.charantia* using the keywords *'Momordicacharantia'* and 'Neuroprotective effects', '*Momordica*charantia' and 'Neurodegenerative diseases', and 'Momordicacharantia' and 'Neuroinflammatory diseases'.And also this review paper characterised the efficacy of *M. charantia* as a therapeutic agent against the yet unexplored neurodegenerative and neuro-inflammatory diseases.

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2. Biographical & Botanical Description:

As per the historical literature [**Swarn et al.,2012**] and recent analysis of random affiliated polymorphic DNA [**Poolperm et al.,2017**],Inter Simple sequence repeat [**Behera et al.,2008**] and molecular analysis [**Asna et al., 2020**], this Plant is widely found in different states of Eastern India with different local names(Table:1) and taxonomic classification described in Table 2.

Some of its wild species are also found in North-eastern region of India and Andaman. Fruits are medium to big size (10-gms), fleshy, green in colour oblong in shape having adding soft spines, warps. Seeds are enclosed in a orange,red sacra taste **[sorifa et al.,2018].**

Names of Regions	Used local Names
English	Bitter gourd, Balsam pear, Balsam Apple
Nepali	Teeta, Karela
Arab	Quisaul-Barri
Assam	Kakiral, Kakral
Bengali	Karela, Uchchhe, kerule
Bombay	Kurela,jangro
Gujrati	Karela
Hindi	Karela,Kardi
Kannada	Hagal
Odia	Kalara
Sanskrit	Sushavi, Karavella
Tamil	Pakal, Pavaka, Chedi, Paharkai
Telegu	Koekara, kaaya
Urdu	Karela

Table1. Commonly used names of *Momordicacharantia L.* based on culture of people in a particular locality[Behera et al.,2008]

Taxonomical classification

Kingdom	**Plantae**
Sub-Kingdom	**Viridiplantae**
Division	**Tarcheophyta**
Sub-Division	**Spermatophytina**
Class	**Mangoliopsida**
Order	**Cucurbitales**
Family	**Cucurbitaceae**
Genus	***Momordica***
Species	***Charantia***

Table 2. Taxonomical Classification of *Momordicacharantia L.**[Gupta et al.,2011]***

3. Traditional Uses of*Momordicacharantia L.*

Bitter melon is often eaten cooked while it is green or in early fading. Shoots and leaves of Bitter melon can be consumed as greens. The fruit is bitter when raw, but it may be soaked in cold water and drained to reduce part of the bitterness. Bitter melon or *Momordicacharantia*is appreciated in Chinese cuisine for its bitter flavour, and it is commonly used in stir-fries (usually with pork and douchi), soups, and herbal teas like gohyah tea. It has also been used as a bittering additive instead of hops in some beers in China and Okinawa[**Kumar et al., 2010**].

The plant has been used in traditional and folk medicines for various medical applications, including treating T2DM, hypertension, obesity, cancer, bacterial and viral infections, and AIDS[**Anilkumar et al., 2015**]. In Ayurveda medicine, bitter melon, known as karela, are used for thousands of years. The juice is used for joint pain relief, chronic fever, jaundice, liver and digestive system illnesses, and treating burns, boils, and rashes. In Turkish folk medicine, the oil from ripe fruits is used for gastric ulcers[**Prasd et al., 2006**].

4. Nutritional Value of*M. Charantia*

Due to its bitter taste, bitter gourd is often considered as medicinal vegetable but ithas higher nutritional value than any other fruits belonging to cucurbitaceae family.The fruit comprises of six elements that includes sugars, fats (lipids), proteins, nutrients, minerals, and water (Table 3)which basically serves as building materials of body, produce energy and regulate several physiological processes [**RI et al.,2010**]. It also contains good amount of dietary fibres. The dried fruits of *Momordicacharantia L.* are found to contain higherconcentration of Vitamin A, E, C and B12. The plant material comprises of verylow ash content, indicating a low total mineral element content [**Saeed et al., 2018**].

Name	Amount	Name	Amount	Name	Amount
Calcium	19 mg	**Vitamin C**	84 mg	**Water**	94.03 g
Magnesium	17 mg	**Vitamin B1 (Thiamin)**	0.04 mg	**Energy**	17 kcal
Iron	0.43 mg	**Vitamin B1 (Riboflavin)**	0.04 mg	**Protein**	1 g
Phosphorous	31 mg	**Vitamin B1 (Niacin)**	0.4 mg	**Total Lipid**	0.17 g
Potassium	296 mg	**Vitamin B5 (Pantothenic Acid)**	0.212 mg	**Ash**	1.1 g
Sodium	5 mg	**Vitamin B6**	0.043 mg	**Carbohydrate**	3.7 g
Zinc	0.8 mg	**Vitamin B9 (Folate)**	72 mg	**Fiber**	2.8 g
Copper	0.034 mg	**Vitamin A**	24 µg	**Fatty Acid**	0 g
Manganese	0.089 mg	**Beta Carotene**	190 µg	**Cholesterol**	0 mg
Selenium	0.2 µg	**Alpha Carotene**	185 µg		

Table: 3 Nutritive substances in *M.charantia* L.[**Saeed et al.,2018**]

5. Bioactive components Present in Bitter gourd

Proteins and chlorophyll are the primary metabolites of *Momordicacharantia*, while the secondary metabolites are phenolic ,alkaloids, Saponinsetc[**Nagarani et al., 2014**]. In addition to these aqueous extract of *Momordicacharantia* also containscarbohydrates, proteins, amino acid, sterols, falvonoids, terponoids .[**Barua et al.,2020**]

The most prominent bioactive components are the triterpenoids, specifically cucurbitane-type, which include momordicines, charantins, and karavilosides. Momordicines, particularly momordicine I and II, are known for their bitter taste and potent medicinal properties[**Barca et al.,2008**]. The ethno medical uses of *Momordicacharantia* essential phytocomponents described in Table 4. These compounds exhibit antidiabetic, anticancer, and anti-inflammatory properties. Charantins,area group of steroidal saponins, are well known for their hypoglycemic effects. Phenolic acids and flavonoids are another significant group of bioactive compounds found in *M. charantia*[**Kumari et al.,2017**] , which includes gallic acid, caffeic acid, catechin, epicatechin, and quercetin,[**Gupta et al., 2011**]**.** These compounds are powerful antioxidants, capable of scavenging free radicals and reducing oxidative stress, which is implicated in the pathogenesis of many chronic diseases such as cardiovascular diseases and cancer[**Ullah et al., 2011**].. Proteins and peptides also contribute to the bioactivity of *M. charantia*.,The plant also contains a significant insulin-like peptide known as polypeptide-p or p-insulin[**Jayasooriya et al., 2000**].

Sl no	Broad category	Types of Compounds	Ethno medical Uses	Parts Present
1	Triterppeniods Phenolic compounds Phytosterols	Momordicine	Protective effect against Coxsackie virus.	Fruit
		Carotene	Dietary fiber supplement for diabetic and pre-diabetic patient.	
		Map 30b	Treatment against Breast Tumor	
		Polypeptide	Treatment against p-Diabetes	
		Diosgenin	Treatment against hepatic ABCG5 and ABCG8	
		Tocopherol	Act against oxidative stress	
		Catechin	Act on Anti-Inflammatory Properties	

Table 4 Shows the Bioactive chemical compounds reported in *M.charantia*fruits, their ethno medical uses.

6. **Medicinal Value of *M. Charantia*Fruits**

The fruits of *M.charantia* contains large amount of Minerals and vitamins A, C, thiamine, and riboflavin. The bitter melon has the greatest antioxidant capacity of its family members due to its extensive phytochemistry[**Abas et al., 2014**].Phenolic acid, is a significant phytocomponent of *M. charantia* fruits, because of its aromaticity and strong conjugation with many hydroxyl groups, it allows to combat oxidative stress and other harmful substances **[Bhattacharjee et al.,2022].**

In general, eating *M. charantia* as a dietary practical food will give huge cell reinforcement benefits against Asthma, consuming sensations, clogging, colic, diabetes, hack, fever (intestinal sickness), gout, helminthiases, skin ailments, ulcers, and wounds. Experimental data in both human and animal suggests that the fruit of *M.charantia* has polyglycemic (antidiabetic) effects **[Horax et al., 2005**].The fruit of *M.charantia* has the ability to treat boils and other blood-related skin diseases **[Beloin et al.,2005**]. *Momordicacharantia L.* juice is likewise helpful for treating and forestalling liver illness. Cardiac edema and hypertrophy which is a fatal disease has been studied by taking methanolic fruit extract **[yan et al., 2021].**Fruits of *Momordicacharantia L.* are utilized to treat feminine cycle anomalies, consuming sensations, clogging, intestinal sickness, colic, diseases, worms, and parasites, as well as measles, hepatitis, and helminthiases**[Verissimo et al.,2011].** Ittreatssores,wounds,infections, andwormsandparasites.. Further, fresh bitter gourd leaf juice is also an effective medicine in the early stages of cholera and other types of diarrhoea **[choi et al., 2014].**And also the fruit of *Momordicacharantia L.* are used to treat ulcers, problems with the liver and spleen, diabetes, high cholesterol, parasites in the digestive tract, gas in the stomach, and wound healing. **[Fang et al., 2011**]. Due to possibility of foetal malformation, the fruit extract or any supplement

prepared from the seed of *M. charantia* is generally used for pregnant women to avoid such foetal malformation[**Dugger et al., 2017**].

Syphilis, stiffness, ulcers, bubbles, septic swellings, Opthalmia, and Prolapsus are typically treated by*Momordicacharantia L.*fruits.It has been found that *M. charantia* roots also contains anti HIV properties. [**Hussain et al., 2018**].

7. Nutraceutical Approaches of *Momordicacharantia L.*

For its hypoglycemic effect, *M.charantia*is beneficial in the management of diabetes mellitus. The fruit contains charantin, vicine, and polypeptide-p, all of which contribute to its glucose-lowering capabilities. Charantin, a steroidal saponin, and polypeptide-p, an insulin-like compound, enhance glucose uptake and glycogen synthesis in the liver, muscle, and adipose tissues, mimicking the action of insulin[**Joseph et al., 2013**]. Additionally, *M. charantia* exhibits strong antioxidant properties, primarily due to its high content of phenolic compounds and flavonoids[**Nagaraniwt al., 2014**]. These antioxidants combat oxidative stress, which is implicated in the pathogenesis of various chronic diseases , including cardiovascular diseases and cancer[**Kumari et al.,2017**]. By neutralizing free radicals and reducing oxidative damage, *M. charantia* helps in mitigating inflammation and protecting cellular integrity.

The anti-cancer potential of *M. charantia* has also been a focal point of recent studies. The bioactive compounds in bitter melon, such as cucurbitane-type triterpenoids, have demonstrated the ability to inhibit cancer cell proliferation and induce apoptosis in various cancer cell lines, including breast, prostate, &colon cancers[**Gorver et al.,2004**]. These compounds interfere with multiple cellular pathways, including those involved in cell cycle regulation, apoptosis, and metastasis, highlighting their potential as chemopreventive and therapeutic agents[**Kubola et al., 2008**]. Moreover, *M. charantia* extracts have shown to inhibit angiogenesis, which is crucial for tumour growth and metastasis[**Ray et al.,2010**] .

In terms of cardiovascular health, *M. charantia* has been noted for its lipid-lowering effects. The fruit and its extracts can reduce levels of low density lipoprotein (LDL) cholesterol and triglycerides while increasing high density lipoprotein (HDL) cholesterol. These lipid-modulating effects are beneficial in preventing atherosclerosis and other cardiovascular diseases[**Akhtar et al., 1981**]. Furthermore, *M. charantia* has shown promising anti-inflammatory and immune modulatory properties and are primarily known to inhibit the key inflammatory mediators such as cyclooxygenase (COX) and nitric oxide synthase (NOS)[**Roman et al., 1996**]. By downregulating the production of pro-inflammatory cytokines and enzymes, bitter melon helps in managing inflammatory conditions like rheumatoid arthritis and inflammatory bowel disease. Another significant aspect of *M. charantia'*snutraceutical is its potential role in weight management. The fruit's high fiber content aids in promoting satiety and reducing overall calorie intake, while its compounds enhance lipid metabolism and inhibit adipogenesis, the process of fat cell formation[**Basch et al., 2003**].

Moreover, *M. charantia* has antimicrobial properties that can protect against various pathogenic bacteria, viruses, and fungi. The fruit's extracts have demonstrated efficacy in inhibiting the growth of harmful microorganisms, which is attributed to the presence of bioactive compounds such as momordicin, a protein that exhibits antifungal and antibacterial activity [**Srivastava et al., 1993**].

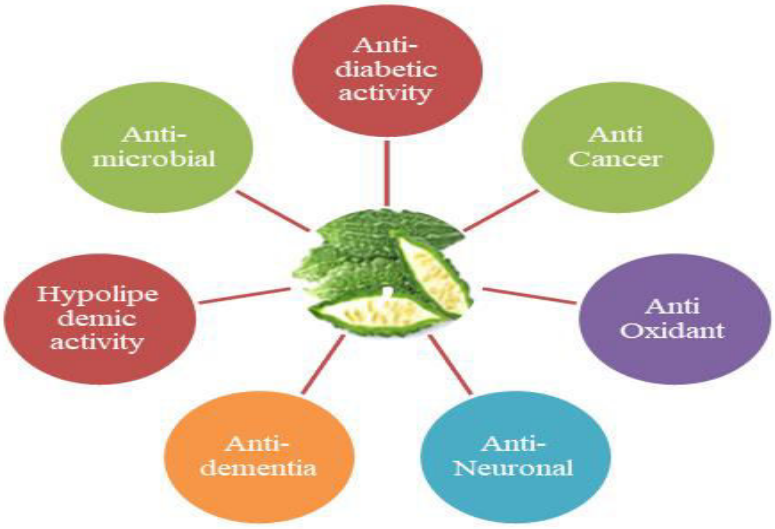

Figure 1. Shows nutraceutical properties of *Momodica charantia L.*

8. Neuroprotective Properties

Neurodegenerative diseases (NDs) are incurable, fatal disorders characterized by degeneration and loss of selective neuron populations in a progressive manner, which differs from the cell death, occurs due to any metabolic or toxic stress [**Chi et al., 2018**]. There are different types of Neurodegenerative diseases (ND) including Alzheimer's disease (AD), Parkinson's disease (PD), and Multiple Sclerosis (MS), Motor neuron diseases (MND), Huntington's disease (HD), and Prion disease. Among these, AD, PD, MS and HD are the most commonly occurring Neuro-Degenerative Diseases (NDs)[**Kim et al., 2018**]. Neuronal cell death is considered as a major hallmark of NDs. Neurotoxic molecules such as reactive oxygen species (ROS) and protein aggregates induce neuroinflammation or neuronal cell death, which eventually leads to neurodegeneration[**Tamilanban et al.,2018**]. Number of several studies demonstrated that the neuroprotective effects of crude extract or purified compounds *of M. charantia* helps in attenuating oxidative stress, neuro-inflammation and cell death.

i. Invitro Studies:

Choi et al. report that *M. charantia*-derived phenolic protocatechuic acid significantly reversed C6 glial cell damage induced by hydrogen peroxide (H_2O_2) and AD-associated amyloid beta 25-35 (Aβ25–35). In this study, ROS production was controlled by protocatechuic acid [**Gong et al.,2015].** Similar antioxidant and anti-apoptotic effects were exerted by ethanol extract of *M. charantia* fruits against oxidative stress-induced SK-N-MC human neuroblastoma cell death. Results from this study showed that the extract blocked mitochondria dependent apoptotic pathways, which is also inhibited mitogen-activated protein kinase (MAPK) signaling by suppressing MAPK phosphorylation [Pathakota et al.,2017]. In another study, **Tamilanban et al.** proved that charantin derived from the fruits of *M. charantia* efficiently protected human SH-SY5Y neuroblastoma cells against neurotoxins 1-methyl-4-phenylpyridinium (MPP) and tunicamycin[**Tamilanban et al., 2018**]. Gong et al. found that *M. charantia* polysaccharides exerted neuroprotection against primary rat hippocampal neuronal cells

subjected to oxygen glucose deprivation [**Miri et al., 2019**]Altogether, these in vitro studies found substantial anti-oxidant and neuroprotective effects of *M. charantia*.

ii. Invivo studies

Neuroprotective effects of *M. charantia* have been considerably investigated in limited number of In vivo Neurodegenerative diseases (ND) models. Neuronal cell loss followed by memory impairment is a characteristic feature in Alzheimer's Disease. In (Figure 2), it is mentioned that the medicinal properties and underlying molecular mechanisms of *M. charantia,* and Its possible protective effects against the yet unexplored neurodegenerative diseases.Pathakotla et al. demonstrated the neuroprotective effect *of M. charantia* fruits in scopolamineinduced mouse AD model. The data of this research showed that ethanolic extract of *M. charantia* fruits attenuated the memory loss and improved learning and memory in Alzheimer's disease (AD) mice by blocking lipid peroxidation and acetyl cholinesterase activity [**Huang et al., 2018**]. Similar anti-amnesic activity was reported in by scopolamine-induced rat AD model [**Nerukar et al.,2011**]. In a recent investigation, Deng et al.,2019 reporthydro alcoholic extract of *M. charantia* fruits showed to restore the memory in scopolamine-induced mouse model [**Deng et al.,2019**]**.** In another important study,*M. charantia* fruit powder was found to reduce the side effects of Lithium Chloride-mediated treatment in TgAD mice and in streptozotocin-induced AD mice. The results of this study provided more details on the underlying neuroprotective mechanisms of *M. charantia* in Alzheimer's Disease.

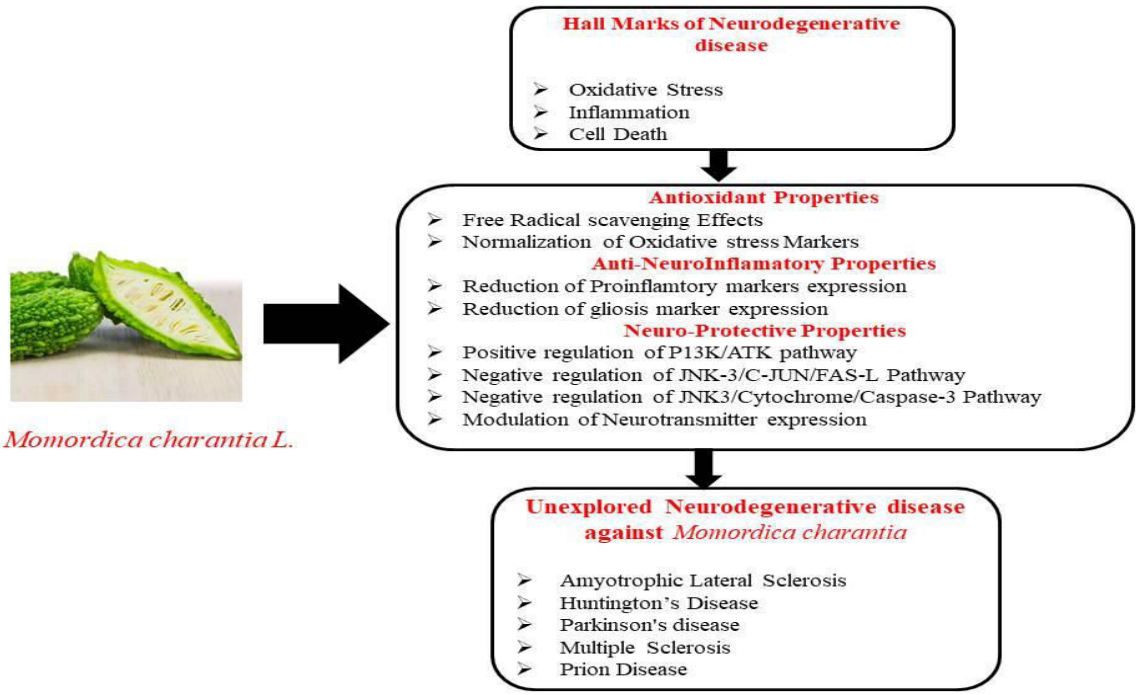

Figure 2: The medicinal properties and underlying molecular mechanisms of *M. charantia,*and Its possible protective effects against the yet unexplored neurodegenerative diseases.

Typical AD pathological features including extensive neuronal loss, gliosis, oligomeric Amyloid βeta protein formation, and hyperphosphorylated tau protein level were substantially reduced by *M.*

charantia[**Ishola et al., 2013**]. Thus, these studies showed that *M. charantia* shall be a promising Phyto-therapeutic drug candidate plant to treat AD. Nerurkar et al. demonstrated anti-oxidant and anti-neuroinflammatory properties of *M. charantia* in high-fat diet associated oxidative stress and neuro-inflammation in mice. Anti-oxidant markers glutathione, glutathione peroxidase, catalase, and superoxide dismutase were significantly normalized while pro-inflammatory markers interleukin-16 (IL-16), IL-17R, IL-22, and NFκB1 were markedly reduced in mouse brain by *M. charantia*. In addition, gliosis markers Iba1, CD11b, GFAP and S100β were decreased in *M. charantia*-fed mice [**Duan et al., 2015**]. A recent study by Deng et al. report that *M. charantia* down-regulated the hippocampal expression of pro-inflammatory cytokine markers tumour necrosis factor-alpha (TNF-α), IL-6, and IL-1β in mouse model associated with chronic social defeat stress. Moreover, hippocampal expression of positive inflammation mediators c-jun N-terminal kinase (JNK3), c-Jun, P-110β was reduced and activity of negative inflammation mediators phosphatidylinositol 3-kinase (PI3K) and protein kinase B (AKT) was increased in *M. charantia*-treated mice [**Gong et al., 2015**]. Thus, these studies demostrates effective anti-neuroinflammatory properties of *M. charantia* fruits. Findings of Ishola et al. showed anti-depressant and anxiolytic effects of methanolic extract of *M. charantia* in mice subjected to depression and anxiety.

They found that anti-depressant mechanism was attributed to the activation of receptors for serotonergic, noradrenergic, dopaminergic, and muscarinic cholinergic neurons and anxiolytic mechanism was attributed to the activation of receptors for GABAAergic neurons [**joshi et al., 2017**]. Neuroprotective effects of *M. charantia* have been examined in in vivo neuronal injury models. In rat intracerebralhemorrhage-induced brain injury model, polysaccharide obtained from *M. charantia* exerted neuroprotection via negatively regulating the expression of pro-apoptotic factors JNK3, cjun, and caspase-3 [**Malik et al., 2011**]. In another study, *M. charantia* polysaccharides were proved to execute protective effects in rat model of cerebral ischemia-reperfusion injury. Data from this study were in line with Duan et al. as the polysaccharides of *M. charantia* blocked the stimulation of JNK3/cJun/Fas-L and JNK3/cytochrome C/caspases-3 signaling pathways in brain regions damaged with ischemic injury. In addition, scavenging effects was also noticed against free radicals including NO,O2 – and ONOO– [**Malik et al.,2013**]. **Malik et al.** demonstrates the neuroprotective effect of M. charantia against neuronal cell death induced by cerebral ischemia-reperfusion model in diabetic mice. In this study, it was observed that *M. charantia* reduced the cerebral infarct size and free ROS generation [**Malik et al.,2011**]. In 2013, the same group report neuroprotective effect of *M. charantia* in Streptozotocin-driven mice diabetic neuropathy model. Serum markers associated with oxidonitrosativestress were reduced in *M. charantia*treated diabetic mice, which eventually protected against diabetes-induced neuropathy [**63**]. Altogether, these studies revealed the neuroprotective effects of *M. charantia*against different in vivo neuronal injury models. The medicinal properties and underlying molecular mechanisms of *M. charantia*, and its possible protective effects against the yet unexplored NDs have been presented in Figure 2.

9. Future Prospective

Medicinal properties of *M. charantia* have been largely explored in preclinical studies linked to diabetes and cancer. Very few experiments have been attempted to investigate its efficacy in Neurodegenerative diseases (ND), for ex., AD and neuronal injury. As mentioned earlier, oxidative stress and inflammation are the key pathological hallmarks ofNeurodegenerative diseases (ND). Research in recent years has been focusing on finding traditional herbs or their novel phytochemicals that may target multiple pathological conditions via antioxidant and anti-inflammatory properties. Moreover, they modulate free radical scavenging activity, mitochondrial stress, apoptotic factors, and neurotrophins expression. Preclinical studies revealed that the extract of *M. charantia* provide neuroprotection via its exemplary

antioxidant and anti-inflammatory properties. At molecular level, *M. charantia* was found to modify PI3K/ATK, JNK3/c-Jun/Fas-L and JNK3/cytochrome C/caspases-3 signaling pathways which are key pathways associated with inflammation. By considering these data we propose that therapeutic efficacy of *M. charantia* plant must be explored against NDs like ALS, PD, HD and MS using appropriate in vitro and in vivo models. Pathwaystargeted phytocompounds identification and isolation from *M. charantia* shall be initiated and studied in large scale using suitable model systems. Based on the results, clinical trials shall be promoted to treat patients withNeurodegenerative diseases (ND).

10. Conclusions

M. charantia is used in traditional medicine to treat diabetes, cancer, inflammatory diseases, viral diseases, hypercholesterolemia and other diseases. NDs are incurable, life-threatening diseases with severe oxidative stress and inflammation. The presence of effective natural anti-oxidant and antiinflammatory compounds and supportive preclinical studies suggested the usage of *M. charantia* as a promising therapeutic plant candidate against NDs. Additional and new in vitro and in vivo models are guaranteed to decipher the role of *M. charantia* in ND treatment.

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References:-

1. Zhang, F., Lin, L., Xie, J. 2016. A mini-review of chemical and biological properties of polysaccharides from Momordicacharantia. International Journal of Biological Macromolecules, 92:246–253.
2. Nagarani, G., Abirami, A., Siddhuraju, P. 2014. Food prospects and nutraceutical attributes of Momordica species: A potential tropical bioresources – A review. Food Science and Human Wellness, 3(3-4):117–126.
3. Polito, L., Bortolotti, M., Maiello, S., Battelli, M., Bolognesi, A. 2016. Plants Producing RibosomeInactivating Proteins in Traditional Medicine. Molecules, 21(11):1560–1560.
4. Thakur, V. 2018. Yield and yield contributing traits of bitter gourd (Momordicacharantia L.) genotypes. J. Pharmacogn. Phytochem, 7(3):844–846.
5. Wang, S., Li, Z., Yang, G., Ho, C. T., Li, S. 2017. Momordicacharantia: a popular healthpromoting vegetable with multifunctionality. Food & Function, 8(5):1749–1762.
6. Keller, A. C., Ma, J., Kavalier, A., He, K., Brillantes, A.-M. B., Kennelly, E. J. 2011. Saponins from the traditional medicinal plant Momordicacharantia stimulate insulin secretion in vitro. Phytomedicine, 19(1):32–37.
7. Grover, J. K., Yadav, S. P. 2004. Pharmacological actions and potential uses of Momordicacharantia: a review. Journal of Ethnopharmacology, 93(1):123–132.

8. Scartezzini, P., Speroni, E. 2000. Review on some plants of Indian traditional medicine with antioxidant activity. Journal of Ethnopharmacology, 71(1- 2):23–43.
9. Bortolotti, M., Mercatelli, D., & Polito, L. (2019). Momordicacharantia, a nutraceutical approach for inflammatory related diseases. *Frontiers in pharmacology*, *10*, 451026.
10. Jiraungkoorskul, W., Poolperm, S. 2017. An update review on the anthelmintic activity of bitter gourd, Momordicacharantia. Pharmacognosy Reviews, 11(21):31–31.
11. Swarna, J., and R. Ravindhran. "Agrobacterium rhizogenes–mediated hairy root induction of Momordicacharantia Linn. and the detection of charantin, a potent hypoglycaemic agent in hairy roots." *Res J Biotechnol* 7, no. 4 (2012): 227-231.
12. Gupta, M., Sharma, S., Gautam, A. K., &Bhadauria, R. (2011). Momordicacharantia Linn.(Karela): Nature's silent healer. *International Journal of Pharmaceutical Sciences Review and Research*, *11*(1), 32-37.
13. Sorifa, A. M. (2018). Nutritional compositions, health promoting phytochemicals and value added products of bitter gourd: a review. *International Food Research Journal*, *25*(5).
14. Grover, J. K., & Yadav, S. P. (2004). Pharmacological actions and potential uses of Momordicacharantia: a review. *Journal of ethnopharmacology*, *93*(1), 123-132.
15. Behera, T. K., Staub, J. E., Behera, S., & Simon, P. W. (2008). Bitter gourd and human health. *Medicinal and Aromatic plant science and Biotechnology*, *1*(2), 224-226.
16. Poolperm, S., &Jiraungkoorskul, W. (2017). An update review on the anthelmintic activity of bitter gourd, Momordicacharantia. *Pharmacognosy reviews*, *11*(21), 31.
17. Poolperm, S., &Jiraungkoorskul, W. (2017). An update review on the anthelmintic activity of bitter gourd, Momordicacharantia. *Pharmacognosy reviews*, *11*(21), 31.
18. Asna, A. C., Joseph, J., & Joseph John, K. (2020). Botanical description of bitter gourd. *The bitter gourd genome*, 7-31.
19. Behera, T. K., Behera, S., Bharathi, L. K., John, K. J., Simon, P. W., & Staub, J. E. (2010). Bitter gourd: botany, horticulture, breeding. *Horticultural Reviews, Volume 37*, *37*, 101-141.
20. Kumar, K. S., & Bhowmik, D. (2010). Traditional medicinal uses and therapeutic benefits of Momordicacharantia Linn. *International Journal of Pharmaceutical Sciences Review and Research*, *4*(3), 23-28.
21. Anilakumar, K. R., Kumar, G. P., & Ilaiyaraja, N. (2015). Nutritional, pharmacological and medicinal properties of Momordicacharantia. *International Journal of Nutrition and Food Sciences*, *4*(1), 75-83.
22. Prasad V, Jain V, Girish D, Dorle AK. Wound-healing property of Momordicacharantia L. fruit powder. Journal of Herbal Pharmacotherapy. 2006 Jan 1;6(3-4):105-15.
23. RI B, Magbagbeola OA, Akinwande AI, Okunowo OW. Nutritional and chemical evaluation of Momordicacharantia. Journal of Medicinal Plants Research. 2010 Nov 4;4(21):2189-93.
24. Saeed F, Afzaal M, Niaz B, Arshad MU, Tufail T, Hussain MB, Javed A. Bitter melon (Momordicacharantia): a natural healthy vegetable. International Journal of Food Properties. 2018 Jan 1;21(1):1270-90.
25. Nagarani, G., Abirami, A., &Siddhuraju, P. (2014). Food prospects and nutraceutical attributes of Momordica species: a potential tropical bioresources–a review. *Food Science and Human Wellness*, *3*(3-4), 117-126.
26. Barua, R., Talukder, M. E. U., Islam, M. S., Yesmin, F., Chakma, K., Kabir, M. G., & Bhuiyan, R. H. (2020). Nutritional analysis and phytochemical evaluation of Bitter Gourd

(MomordicaCharantia) from Bangladesh. *Asian Journal of Agriculture and Food Sciences (ISSN: 2321–1571)*, *8*(02).

27. Braca, A., Siciliano, T., D'Arrigo, M., &Germanò, M. P. (2008). Chemical composition and antimicrobial activity of Momordicacharantia seed essential oil. *Fitoterapia*, *79*(2), 123-125.
28. Kumari, P., Kumari, R., Rani, N., Verma, R., & Verma, R. (2017). Genetic divergence of bitter gourd (Momordicacharantia L.) for sixteen important yield attributing traits. *Current Journal of Applied Science and Technology*, *23*(2), 1-11.
29. Gupta M, Sharma S, Gautam AK, Bhadauria R. Momordicacharantia Linn.(Karela): Nature's silent healer. International Journal of Pharmaceutical Sciences Review and Research. 2011;11(1):32-7.
30. M. Ullah, M. U., Chy, F. K., Sarkar, S. K., Islam, M. K., & Nurul Absar, N. A. (2011). Nutrient and phytochemical analysis of four varieties of bitter gourd (Momordicacharantia) grown in Chittagong hill tracts, Bangladesh.
31. Jayasooriya AP, Sakono M, Yukizaki C, Kawano M, Yamamoto K, Fukuda N. Effects of Momordicacharantia powder on serum glucose levels and various lipid parameters in rats fed with cholesterol-free and cholesterol-enriched diets. Journal of ethnopharmacology. 2000 Sep 1;72(1-2):331-6.
32. Abas R, Othman F, Thent ZC. Protective effect of Momordicacharantia fruit extract on hyperglycaemia-induced cardiac fibrosis. Oxidative Medicine and Cellular Longevity. 2014 Oct 13;2014.
33. Bhattacharjee D, Prathibha GS, Mallikarjun DP, Megharaj KV, Manoj AN, Dhanush CR, KUMAR M, CHANNAMMANAVAR P. A Systematic Review on Momordicacharantia. World Journal of Pharmaceutical Research. 2022 Oct 19;11(16):1907.
34. Horax R, Hettiarachchy N, Islam S. Total phenolic contents and phenolic acid constituents in 4 varieties of bitter melons (Momordicacharantia) and antioxidant activities of their extracts. Journal of food Science. 2005 May;70(4):C275-80.
35. Beloin N, Gbeassor M, Akpagana K, Hudson J, de Soussa K, Koumaglo K, Arnason JT. Ethnomedicinal uses of Momordicacharantia (Cucurbitaceae) in Togo and relation to its phytochemistry and biological activity. Journal of Ethnopharmacology. 2005 Jan 4;96(1-2):49-55.
36. Yan JK, Yu YB, Wang C, Cai WD, Wu LX, Yang Y, Zhang HN. Production, physicochemical characteristics, and in vitro biological activities of polysaccharides obtained from fresh bitter gourd (Momordicacharantia L.) via room temperature extraction techniques. Food Chemistry. 2021 Feb 1;337:127798.
37. Verissimo LF, Bacchi AD, Zaminelli T, Paula GH, Moreira EG. Herbs of interest to the Brazilian Federal Government: female reproductive and developmental toxicity studies. RevistaBrasileira de Farmacognosia. 2011;21:1163-71.
38. Choi, J. R., Choi, J. M., Lee, S., Cho, K. M., Cho, E. J., & Kim, H. Y. (2014). The protective effects of protocatechuic acid from Momordicacharantia against oxidative stress in neuronal cells. *Korean Journal of Pharmacognosy*, *45*(1), 11-16.
39. F Fang E, B Ng T. Bitter gourd (Momordicacharantia) is a cornucopia of health: a review of its credited antidiabetic, anti-HIV, and antitumor properties. Current molecular medicine. 2011 Jul 1;11(5):417-36.
40. Dugger, B. N., Dickson, D. W. 2017. Pathology of Neurodegenerative Diseases. Cold Spring Harbor Perspectives in Biology, 9(7):a028035–a028035.

41. Hussain, R., Zubair, H., Pursell, S., Shahab, M. 2018. Neurodegenerative Diseases: Regenerative Mechanisms and Novel Therapeutic Approaches. Brain Sciences, 8(9):177–177.
42. Joseph, B., & Jini, D. (2013). Antidiabetic effects of Momordicacharantia (bitter melon) and its medicinal potency. *Asian pacific journal of tropical disease*, *3*(2), 93-102.
43. Kubola, J., &Siriamornpun, S. (2008). Phenolic contents and antioxidant activities of bitter gourd (Momordicacharantia L.) leaf, stem and fruit fraction extracts in vitro. *Food chemistry*, *110*(4), 881-890.
44. Ray, R. B., Raychoudhuri, A., Steele, R., & Nerurkar, P. (2010). Bitter melon (Momordicacharantia) extract inhibits breast cancer cell proliferation by modulating cell cycle regulatory genes and promotes apoptosis. *Cancer Research*, *70*(5), 1925-1931.
45. Akhtar, M. S., Athar, M. A., & Yaqub, M. (1981). Effect of Momordicacharantia on blood glucose level of normal and alloxan-diabetic rabbits. *Planta Medica*, *42*(07), 205-212.
46. Raman, A., & Lau, C. (1996). Anti-diabetic properties and phytochemistry of Momordicacharantia L.(Cucurbitaceae). *Phytomedicine*, *2*(4), 349-362.
47. Basch, E., Gabardi, S., & Ulbricht, C. (2003). Bitter melon (Momordicacharantia): a review of efficacy and safety. American Journal of Health-System Pharmacy, 60(4), 356-359.
48. Srivastava, Y., Venkatakrishna-Bhatt, H., Verma, Y., Venkaiah, K., & Raval, B. H. (1993). Antidiabetic and adaptogenic properties of Momordicacharantia extract: an experimental and clinical evaluation. *Phytotherapy Research*, *7*(4), 285-289.
49. Chi, H., Chang, H. Y., Sang, T. K. 2018. Neuronal Cell Death Mechanisms in Major Neurodegenerative Diseases. International Journal of Molecular Sciences, 19(10):3082–3082.
50. Kim, K., Lee, S., Kang, I., Kim, J. H. 2018. *Momordicacharantia* Ethanol Extract Attenuates H2O2- Induced Cell Death by Its Antioxidant and AntiApoptotic Properties in Human Neuroblastoma SK-N-MC Cells. Nutrients, 10(10):1368–1368.
51. Tamilanban, T. 2018. In vitro neuroprotective effect of charantin from Momordicacharantia against neurotoxin and endoplasmic reticulum stressinduced cell death in SH-SY5Y cells. International Journal of Green Pharmacy (IJGP), 12(03).
52. Gong, J., Sun, F., Li, Y., Zhou, X., Duan, Z., Duan, F., Shen, J. 2015. Momordicacharantia polysaccharides could protect against cerebral ischemia/reperfusion injury through inhibiting oxidative stress mediated c-Jun N-terminal kinase 3 signaling pathway. Neuropharmacology, 91:123–134.
53. Pathakota, R. 2017. Neuroprotective Effects Of MomordicaCharantia On Scopolamine Induced Alzheimer's Disease. World Journal of Pharmacy and Pharmaceutical Sciences, 6(4):2141–2155.
54. Joshi, A., Soni, P., Malviya, S., Kharia, A. 2017. Memory enhancing activity of Momordicacharantia by scopolamine induced amnesia in rats. Indian J ClinAnatPhysiol , 2:11–18.
55. Miri, A., Askari, S. F., Shahraki, E. 2019. Examining The Effects Of Hydro-Alcoholic Extract Of MomordicaCharantia Fruit On Avoidance Memory Alterations In Mice Using Step- Through Model. J FundamApplSci, 11(1):101–116.
56. Huang, H. J., Chen, S. L., Chang, Y. T., Chyuan, J. H., Hsieh-Li, H. 2018. Administration of Momordicacharantia Enhances the Neuroprotection and Reduces the Side Effects of LiCl in the Treatment of Alzheimer's Disease. Nutrients, 10(12):1888–1888.
57. Nerurkar, P. V., Johns, L. M., Buesa, L. M., Kipyakwai, G., Volper, E., Sato, R., Shah, P., Feher, D., Williams, P. G., Nerurkar, V. R. 2011.

58. Deng, Z., Yuan, C., Yang, J., Peng, Y., Wang, W., Wang, Y., Gao, W. 2019. Behavioral defects induced by chronic social defeat stress are protected by Momordicacharantia polysaccharides via attenuation of JNK3/PI3K/AKT neuroinflammatory pathway. Annals of Translational Medicine, 7(1):6–6
59. Ishola, I., Akinyede, A., Sholarin, A. 2013. Antidepressant and Anxiolytic Properties of the Methanolic Extract of Momordicacharantia Linn (Cucurbitaceae) and its Mechanism of Action. Drug Research, 64(07):368–376.
60. Duan, Z. Z., Zhou, X. L., Li, Y. H., Zhang, F., Li, F. Y., SuHua, Q. 2015. Protection of Momordicacharantia polysaccharide against intracerebralhemorrhageinduced brain injury through JNK3 signaling pathway. Journal of Receptors and Signal Transduction, 35(6):523–529
61. Gong, J., Sun, F., Li, Y., Zhou, X., Duan, Z., Duan, F., Shen, J. 2015. Momordicacharantia polysaccharides could protect against cerebral ischemia/reperfusion injury through inhibiting oxidative stress mediated c-Jun N-terminal kinase 3 signaling pathway. Neuropharmacology, 91:123–134
62. Malik, Z. A., Singh, M., Sharma, P. L. 2011. Neuroprotective effect of Momordicacharantia in global cerebral ischemia and reperfusion induced neuronal damage in diabetic mice. Journal of Ethnopharmacology, 133(2):729–734.
63. Malik, Z. A., Tabassum, N., Sharma, P. L. 2013. Attenuation of experimentally induced diabetic neuropathy in association with reduced oxidativenitrosative stress by chronic administration of Momordicacharantia. Advances in Bioscience and Biotechnology, 04(03):356–363.