



CODEN (USA): IAJPBB

ISSN: 2349-7750

**INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES**<http://doi.org/10.5281/zenodo.228170>Available online at: <http://www.iajps.com>**Review Article****NUTRITIVE AND ANTIDIABETIC BENEFITS OF *MOMORDICA CHARANTIA* L. (BITTER GOURD)****Narendra Kumar and S. M. Paul Khurana**

Amity Institute of Biotechnology, Amity University Haryana, Manesar-122413, Gurgaon, Haryana (India).

Abstract

M. charantia L. (Bitter gourd) is a delicate flowering vine in the family of Cucurbitaceae. The plant has climbing nature with elongated fruit. The unripe fruit is white or green in color and has a bitter taste that becomes more pronounced as the fruit ripens. It is used in cooking for its bitter flavor, typically in stir-fries, soups, for tea, culinary purposes and that can purify our blood. The leaf and fruit contain considerable amount of carbohydrate, significantly ($P < 0.05$) higher than the amount present in the seed. Percent of moisture, total ash, crude fat and crude fibre are low in the seed. The most abundant mineral present in the leaf of *M. charantia* is calcium significantly greater than the amount of sodium, potassium, manganese, zinc, magnesium, iron and copper present and vitamins A, E, C, B₁₂ and folic acid. While trace amount of vitamins B₃, B₆, A, D and K were also found present. The review records nutritive value, antidiabetic potential work done in present scenario as it is said to regulate blood sugar.

Keywords: *M. charantia* L., nutrient profile, carbohydrate, vitamins, antidiabetic.**Corresponding author:****Narendra Kumar,**Amity Institute of Biotechnology,
Amity University Haryana, Manesar-122413,
Gurgaon, Haryana (India).Email-narendra.microbiology@rediffmail.com,
smpkhurana@ggn.amity.edu

QR code



Please cite this article in press as Narendra Kumar and S. M. Paul Khurana, *Nutritive and Antidiabetic Benefits of Momordica Charantia* L. (Bitter Gourd), *Indo Am. J. P. Sci.*, 2016; 3(12).

INTRODUCTION:

Bitter gourd (*Momordica charantia* L) of family Cucurbitaceae also commonly known as , bitter melon, balsam pear, karela and pare is important market vegetable in Southern and Eastern Asia. This is a perennial climbing vine with long leaves, yellow flowers, elongated fruit and widely spread throughout tropical Africa and has long been traditionally been used as a medicinal food in many developing countries[1].The fruits may be used fresh as pulp or juice or dry in powders or in fluid extracts .Bitter tea, known as gohyah tea is an herbal tea made from an infusion of dried slices of the bitter gourd sold for medicinal tea and culinary purposes [2].

Since antiquity, the fruits of this plant have been used as vegetable in India. It is a rich source of nutrients such as essential amino acids, vitamin A, carotenoids, folic acid and vitamin C and the whole plant contains many bioactive compounds[3].It has been known to exhibit blood sugar lowering potential. Diabetic patient use it in various forms e.g., Juice of *M.charantia* as home remedy against diabetes mellitus.Indigenous people all over the world employ the fruit juice or leaf tea for diabetes[4][5].

Bitter gourd is one of the nature's most bountiful gifts yet it is one of the discarded vegetables by people, just because of its bitter taste. The Latin name *Momordica* means "to bite," referring to the jagged edges of the leaves, which appear as if they have been bitten. All parts of the plant, including the fruit, taste very bitter. In the Amazon, local people and indigenous tribes grow bitter gourd in their gardens for food and medicine purposes. They add the fruit and/or leaves to beans and soup for a bitter or sour flavor; parboiling it first with a dash of salt that may remove some of the bitter taste.

It has been used as an old traditional antidiabetic remedy in eastern countries[6]. It is now commercially available as tea (from fruits or leaves), juice, extracts, and tablets. Although these products promise health benefits, most of the manufacturers do not provide scientific evidence on the effectiveness of bitter gourd or their products. However, in recent years researchers have focused on the antidiabetic effects.

This article provides information about nutritional profile and food value of bitter gourd and also scientific acceptance about its anti-diabetic properties.

Plant Description

A flowering vine in the family Cucurbitaceae, slender, climbing annual vine with long-stalked

leaves and yellow, solitary male and female flowers borne in the leaf axils. Leaves: simple, usually palmately 5-7 lobed, tendrils unbranched or 2 branched. It bears simple, alternate leaves 4-12 cm across, with 3-7 deeply separated lobes(Fig 1). Flowers: Staminate flowers usually solitary on a bracteate scape, hypanthium shallow, calyx 5 lobed, petals 5, usually yellow, distinct, 1-3 with incurved scales at base, stamens usually 3, inserted toward base of hypanthium, filaments distinct, broad, anthers distinct or coherent, 2 of them dithecal, the other monotheical, cells curved or flexuous; pistillate flowers usually solitary on a bracteate scape, hypanthium ovoid to spindle shaped, perianth usually smaller than in staminate flowers, staminodes absent or 3, ovules numerous, horizontal, stigmas 3, 2 lobed. Each plant bears separate yellow male and female flowers.

Fruits: ovoid, ellipsoid, or spindle shaped, usually ridged or warty, dehiscent irregularly as a 3 valved fleshy capsule or indehiscent. The young fruit is emerald green(Fig 2,3) turning to orange-yellow when ripened. On maturity the fruits split into irregular halves that curl backwards and release numerous reddish-brown or white seeds(Fig, 4) encased in scarlet arils. Seeds: few to numerous, ovate, usually sculptured which are white in unripe fruits and red in ripe ones.



Fig 1. Flowering vine of *M. charantia*

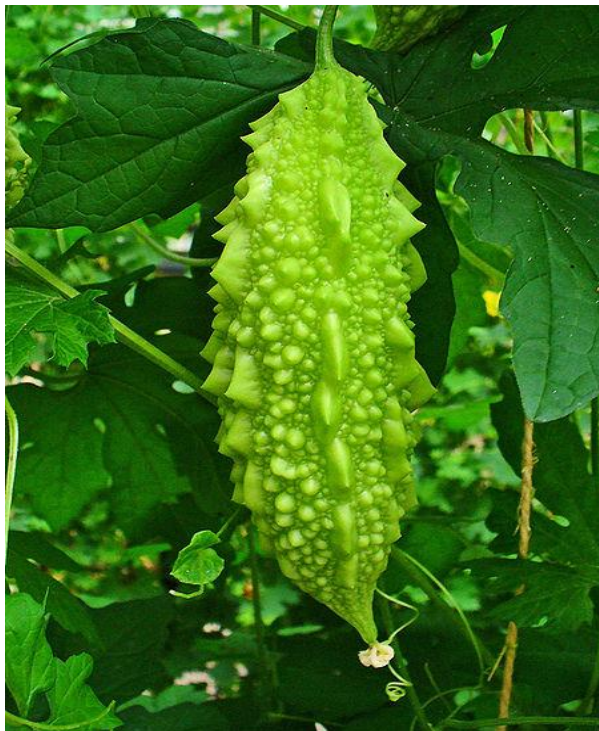


Fig 2.Climbing habit of *M. charantia*



Fig 3.Harvested fruits of *M. charantia*



Fig 4.Seeds of *M. charantia*

Nutrient profile

Bitter gourd contains a complex array of many beneficial compounds hence a powerful nutrient-dense plant. These have bioactive chemicals, vitamins, minerals and antioxidants which all together contribute to its remarkable versatility in treating a wide range of illnesses. The fruits contain high amounts of vitamins C, A, E, B1, B2 and B3, as well as vitamin B9 (folate). The reported caloric values for leaf, fruit and seed are 213.26, 241.66 and 176.61 Kcal/100 g respectively[7].

The fruit is also rich in minerals like potassium, calcium, zinc, magnesium, phosphorus and iron. It is also a good source of dietary fiber. Medicinal value of bitter gourd has been attributed to its high antioxidant properties due in part to phenols, flavonoids, isoflavones, terpenes, anthroquinones, and glucosinolates, all of which confer a bitter taste[8]. Bitter gourd being rich in all the essential vitamins and minerals, its regular use can help/prevent

hypertension, eye complications, neuritis and

The leaf and fruit contain considerable amount of carbohydrate. This was significantly ($P < 0.05$) higher than the amount present in the seed. Per cent moisture, total ash, crude fat and crude fibre are low in the seeds. The most abundant mineral present in the leaf of *M. charantia* is calcium, significantly ($P < 0.05$) greater than the amount of sodium,

defective metabolism for carbohydrates [9].

potassium, manganese, zinc, magnesium, iron and copper present (Table 1). The dried leaves of *M. charantia* contain small amount of vitamin A, E, C, B12 and folic acid. While trace amounts of vitamin B3, B6, A, D and K were also found in the methanolic and pet-ether leaf extract of the plant (Table 2)[7].

Table 1: Proximate composition of *M. charantia* leaf, fruit and seed[7] *

Parameter (%)	Leaf	Fruit	Seed	Element in leaf	ppm
Moisture (wet wt)	17.97 ± 1.00	10.74 ± 2.29	20.69 ± 5.85	Calcium	20510.00 ± 5.77
Total ash (dry wt)	15.42 ± 2.08	7.36 ± 0.52	9.73 ± 2.34	Sodium	2200.00 ± 1.15
Crude fat (DW)	3.68 ± 0.68	6.11 ± 0.42	11.50 ± 1.77	Potassium	413.00 ± 1.45
Crude fibre (DW)	3.31 ± 1.25	13.60 ± 1.13	29.60 ± 1.25	Magnesium	255.00 ± 0.69
Crude protein (DW)	27.46 ± 1.60	27.88 ± 3.75	19.50 ± 0.73	Manganese	156.00 ± 0.33
Carbohydrate (DW)	32.34 ± 0.24	34.31 ± 0.30	9.18 ± 0.86	Zinc	120.00 ± 1.15
Caloric value kcal/100 g	213.26	241.66	176.61	Iron	98.00 ± 0.23
				Copper	32.00 ± 1.85

*Results are mean of 3 determinations ± SEM. Means with same superscript down the row are not significant ($P > 0.05$), DW = Dry weight.

Table 2: Vitamin content of dried and different leaf extract of *M. charantia*[7]

content of dried leaf		content (ppm) in different leaf extracts			
Vitamin	ppm	Vitamin	Aqueous extract	Methanolic extract	Pet-ether extract
A	0.03 ± 0.003	B3	ND	0.08	ND
B12	5355.00 ± 7.10	B6	ND	98.38	ND
C	66000.00 ± 141.42	C	115	ND	0.08
E	800.00 ± 14.14	A	ND	ND	11.25
Folic acid	20600.00 ± 42.43	D	ND	ND	14.25
		E	ND	ND	ND
		K	0.06	ND	5.00

*Results are mean of 3 determinations ± SD; *ND – Not detected

Table 3: Culinary practice involved at different places for Bitter gourd

S.N	Name of place	Involved culinary practice
1.	North India	served with yogurt on the side to offset the bitterness, used in curry such as <i>sabzi</i> or stuffed with spices and then cooked in oil
2.	South India	used in the dishes <i>thoran/thuvaran</i> (mixed with grated coconut), <i>mezukkupuratti</i> (stir fried with spices), <i>theeyal</i> (cooked with roasted coconut) and <i>pachadi</i> (which is considered a medicinal food for diabetics)
3.	Tamilnadu	preparation of <i>pagarkai pitla</i> , a kind of sour <i>koottu</i>
4.	Konkan region of Maharashtra	In finely chopped bitter gourd salt is added, known as <i>karle</i> in Marathi and then removing its bitter juice to some extent and squeezed and after frying this with different spices, the less bitter and crispy preparation is served with grated coconut
5.	Kannada	preparation of <i>haagalakaayi</i> . It is stuffed with spices and then fried in oil
6.	Indonesia	known as <i>pare</i> prepared in various dishes such as <i>gado-gado</i> and also stir fried, cooked in coconut milk, or steamed
7.	Philippines	known as <i>ampalaya</i> (<i>En-Pah-Lay-Ah</i>) in Filipino and <i>parya</i> in Ilokano, may be stir-fried with ground beef and oyster sauce, or with eggs and diced tomato
8.	Ilocos region of Luzon	dish <i>pinakbet</i>
9.	Trinidad and Tobago	known as <i>caraille</i> or <i>carilley</i> , are usually sautéed with onion, garlic and scotch bonnet pepper until almost crisp
10.	Pakistan	cooked with lots of onions, served with hot tandoori bread, naan, chapati, or with khichri (a mixture of lentils and rice)
11.	Japan	primary component of Okinawan
12.	Vietnam	consumed with dried meat floss and stuffed to make bitter gourd soup with shrimp are popular dishes
13.	Philippines	Prepare dishes known as <i>Ampalaya</i> may also be stir-fried with ground beef and oyster sauce or with eggs and diced tomato
14.	Nepali	prepare fresh <i>achar</i> (a type of pickle)
15.	In Panama	known as <i>Balsamino</i> leaves of the plant are brewed in hot water to create a tea to treat malaria and diabetes
16.	China and Okinawa	The young shoots and leaves of the bitter gourd may also be eaten as greens, also used in place of hops as the bittering ingredient in some beers in China
17.	Sri Lanka	known as <i>karavila</i> an ingredient in many different curry dishes (e.g., Karawila Curry and Karawila Sambol) which are served mainly with rice in a main meal

Food value and uses/recipes

The plant has a long history of use by the indigenous people and is used in native medicines for enhancing the digestion[10]. The bitter gourd has been in use in various Asian traditional medicine systems for a very long time and traditionally believed that bitter gourd stimulates digestion[11] and culinary practices are compiled in Table 3.

Antidiabetic activity

There are many traditional herbal remedies that have been used to treat diabetes in Asia and other developing countries. Khanna and Mohan[12] reported that besides the fruits, p- insulin was also found in seeds and tissue cultures of bitter gourd. According to Dutta *et al.* [13] and Barron *et al.* [14] the seeds of bitter gourd contain pyrimidine nucleoside, vicine which has been found to induce

hypoglycemia in rats when administered intraperitoneally.

Dosage recommendations depend on the way bitter melon is being consumed. The dose of fresh juice is 50-100 mL but it is extremely bitter and difficult to drink. Although encapsulated dry powder is easier to ingest, the standard dose is 3-15 g daily – a large dose in capsule form. A standardized, encapsulated extract dose ranges from 100-200 mg three times daily [15]. Raman and Lau[16] described a number of adverse effects have been for *M. charantia*. After drinking bitter gourd tea, hypoglycemic coma and convulsions have been observed in children and headache has been reported after ingestion of bitter gourd seeds. Even cases of detachment of retina has been experienced. It is therefore, recommended not to use crude juice.

To date, more than 100 *in vivo* studies have demonstrated the blood sugar-lowering effect of

bitter gourd. The fruit has also shown the ability to enhance cells' uptake of glucose, to promote insulin release, and to potentiate the effect of insulin. The bioactive compounds present in bitter gourd activate a protein called AMPK (AMP-activated protein kinase α), which is well known for regulating fuel metabolism and enabling glucose uptake processes which are impaired in patients with diabetes. In a study Viridi *et al* [16] observed that extract or powder of fresh and dried whole fruit remarkably lowered the blood sugar in diabetic rats. Treatment resulted in decreased level of total sugar content in liver, spleen, and brain while an increase in amount was observed in heart and lungs. Uronic acid content got decreased in liver, spleen and brain, and a marginal increase was also observed in testis. Amino sugar content decreased in liver, spleen, lungs and heart in patients with diabetes. Decrease in sulfation of glycoconjugates was observed in liver, spleen, lungs and heart during diabetes and this effect was significantly ameliorated by treatment with bitter gourd and spent turmeric, except in brain tissues. The studies clearly showed the ameliorative properties by slowing down the release of glucose from fiber in the gastrointestinal tract (GI) and short-chain fatty acid production from fiber by colon microbes[17].

The bitter gourd is specifically used as a folk medicine for the management of diabetes. Studies have shown that it contains a hypoglycemic or insulin-like principle, designated as 'plant-insulin', which has been found highly beneficial in lowering the blood and urine sugar levels[18]. Effect of bitter gourd on streptozotocin-induced diabetic rats with particular emphasis on kidney heparin sulfate (HS) was studied by Sureshkumar *et al.*[19] which showed a partial reversal of the diabetes effects. Increase in the components of glycol-conjugates during diabetes was significantly decreased by the feeding of bitter gourd. Diabetes associated elevation in the enzyme activities of involved in the synthesis and degradation of glycosaminoglycans (GAGs), were significantly lowered by bitter gourd supplementation. GAGs composition revealed decrease in amino sugar and uronic acid contents during diabetes and bitter gourd feeding was effective in countering this reduction. Decrease in sulfate content in the GAGs due to diabetes was ameliorated by the intake of bitter gourd. These results clearly indicated the beneficial role of bitter gourd in controlling glyco-conjugate and heparin sulfate related kidney complications during diabetes thus prolonging late complications of diabetes.

Batran *et al.* [7] observed that bitter gourd extracts show anti-diabetic, hepato-renal protective and

hypolipidemic effects in alloxan-induced diabetic rats. In numerous studies, at least three different groups of constituents found in all parts of bitter gourd have clinically shown the hypoglycemic properties (blood sugar lowering) or other actions of potential benefit against diabetes mellitus. These hypoglycemic chemicals include a mixture of steroidal saponins known as charantins, insulin-like peptides, and alkaloids. The hypoglycemic effect is more pronounced in the fruit part where these chemicals are in greater abundance [20]. Lectin of bitter gourd has insulin-like activity which is due to its linking together of two(2) insulin receptors. This lectin lowers blood glucose concentrations by acting on peripheral tissues and, similar to insulin's effects in the brain, suppressing the appetite. Lectin is likely a major contributor to the hypoglycemic effect that develops after bitter gourd consumption it may be a way of managing adult-onset diabetes. Lectin binding is non-protein specific, and this is likely why bitter gourd has been credited with immunostimulatory activity - by linking receptors that modulate the immune system, thereby stimulating the said receptors.

Krawinkel and Keding[3] reported bitter gourd treatments of cell cultures or feeding trials on laboratory animals such as mice or rats, show bitter gourd is having blood glucose lowering properties. Most animal studies have shown a blood glucose lowering effect of the bitter gourd fruit when fed orally as a single dose. He also reported that Polypeptide-p is an unidentified insulin-like protein similar to bovine insulin found in *M. charantia* fruit, seed and tissue cultures.

Fernandes *et al.*[21] recorded that the juice formulations of bitter gourd have proven to be more effective in lowering blood sugar level and HbA1c levels than its dried fruit products. Bitter gourd has also been shown to be effective in treating Type I diabetes in rats or mice by increasing production of pancreatic insulin.

Nadkarni[22] mentions that leaf tea employed as per folk wisdom helps to prevent or counteract type-II diabetes. A study at Jawaharlal Institute of Postgraduate Medical Education and Research, India, proved that consumption of bitter gourd significantly increased the insulin sensitivity.

Oishi *et al.*[23] found that the main active component related to the anti-diabetic effect of *M. charantia* is present in butanol fraction and it may be saponin. The antidiabetic mechanisms of bitter gourd also have been proposed. Bitter gourd reduces the amount

of glucose that is released into the blood by inhibiting the enzymes that break down disaccharides into two monosaccharides. The blood glucose lowering effects of *M.charantia* were closely associated with its inhibitory activity against disaccharidase.

Vijayalakshmi *et al.* [17] studied the changes in glycol-conjugate metabolism during the development of diabetic complications and their modulation by feeding bitter gourd and spent turmeric as a fiber-rich source. Charantin is one of the hypoglycemic compounds consisting of a mixture of (1:1) sitosteryl glucoside ($C_{35}H_{60}O_6$) and stigmasteryl glucoside ($C_{35}H_{58}O_6$), belongs to steroidal saponins. Lolitkar and Rao (2010) have shown that charantin, when taken either orally or intravenously in rabbits, produces hypoglycemic effects. Protein P- insulin is another hypoglycemic agent of polypeptide in nature with the molecular weight of about 11,000 Da and consists of 166 amino acids. Clinical study revealed that the polypeptide-p-ZnCl₂ is responsible for blood sugar lowering effect.

Leung *et al.*[24]found the hypoglycemic effect of bitter gourd was less than metformin 1,000 mg/day. They mentioned the need for better-designed clinical trials with sufficient sample size and statistical analysis support the acclaimed efficacy of bitter gourd as a natural nutritional treatment for diabetes mellitus. 'Plant insulin' refers to the chemical substances similar to animal insulin existing in plants[25]. With the traditional use supported by modern scientific evidence of the beneficial function of *M. charantia*, it is one of the most promising plants for diabetes today. Investigation of the traditional uses of *M. charantia* in India revealed that it is one of the most important plant for lowering blood glucose levels in patients with diabetes[26]. The use of bitter gourd (*M. charantia*) for diabetes was reported long back in the Ayurvedic and Chinese systems of medicine. But effect was only explained recently that active constituents to act in a way similar to insulin. The only difference is that insulin stops the use of fat as an energy source by inhibiting the release of glucagon while bitter gourd inhibits action of key carbohydrate hydrolysing enzymes viz., α -amylase and α -glucosidase[27],[28] and lowers the blood-sugar levels effectively[29],[30].

In 2007, Department of Health (Philippine) stated that bitter gourd is one of the best scientifically validated plant for lowering the elevated blood sugar levels[31]. In this study a dose of 100 mg per kilo dose per day was comparable to 2.5 mg of the anti-diabetes drug glibenclamide taken twice per day.

Bitter gourd is sold in the Philippines as a food supplement and marketed under the trade name Charantia. These capsules and tea are being exported to the United States, Canada, Europe, Mexico, Japan, Korea and parts of the Middle East. In Mexico the entire plant is used for controlling diabetes and dysentery. In Nicaragua the leaf is commonly used for stomach pain and diabetes[26]. Fuangchan *et al.*[32]effectively demonstrated the hypoglycemic effect of bitter gourd in type 2 diabetic individuals having 2,000 mg/day of dried bitter gourd powder.

A study in mice [33] revealed that lipid and saponin extracts of bitter gourd to be more effective in lowering glycated haemoglobin levels and excessive body weight gain than the hydrophilic aqueous extract or the whole fruit. The lipid extract contained higher amounts of conjugated linoleic and linolenic acids i.e up to 65.89%. White bitter gourd varieties were found to contain significantly lower saponin (0.25%) as compared to the green varieties (0.67%).

Wehash *et al.* [34] reported that bitter gourd appears to be exerting upon reducing capillary permeability than the fenugreek extract. In general, the increase in capillary permeability is a sign of microvascular dysfunction at the arteriolar and capillary level, which is a common and severe complication of diabetes.

Zhu *et al.*[6]2012) identified the hypoglycemic potential components in bitter gourd as glycosides, saponins, alkaloids, triterpenes, polysaccharides, proteins, and steroids and reported that bitter gourd stimulated glycogen storage by liver and insulin secretion by islets of Langerhans. Although several pure chemicals were isolated from bitter melon and applied for investigating their antidiabetic mechanisms, the mixture of these hypoglycemic chemicals such as saponins or charantins seemed to present a significantly higher bioactivity.

It stimulates the synthesis and release of thyroid hormones and adiponectin and enhances the activity of AMP-activated protein kinase (AMPK). Effects of *M. charantia* like transport of glucose in the cells, transport of fatty acids in the mitochondria, modulation of insulin secretion and elevation of protein levels in adipose and skeletal muscles are similar to those of AMPK and thyroxine [35].

Among hypoglycemic constituents in bitter gourd momordicilin, the study showed that momordicilin was found to be the most active compound in the respective target site [36],[37]. Hamissou *et*

al.[38]further evidenced bitter gourd may decrease hepatic gluconeogenesis, increase hepatic glycogen synthesis and increase peripheral glucose oxidation in erythrocytes and adipocytes.

Charantin-rich extract is a potential agent for increasing insulin-sensitivity in type 2 diabetic (T2D) patients. Recently, 8 new cucurbitane-type glycosides have been isolated by bioactivity-guided fractionation that also exhibited a hypoglycemic effect *in vitro*[39],[40].

CONCLUSION:

M. charantia has been in use as food and dietary supplements since time immemorial for relieving symptoms and conditions of diabetes. There is a vast scope in the Industry but only fewer items like concentrated fruit, seed extracts in the form of capsules, tablets, herb/vine powders are available. Many more dietary supplements products can be prepared for improvement of human life. *In vitro* and animal studies suggested its hypoglycemic activity. Since diabetes mellitus is a chronic condition long-term treatment and assessment of the adverse effect and controlled trials are needed for product brought to the market.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgment

Authors are thankful to the Amity University Haryana for the facilities and constant encouragement.

REFERENCES:

1. Sing P. Tan, Tuyen C. Kha, Sophie E. Parks & Paul D. Roach. Bitter melon (*Momordica charantia* L.) bioactive composition and health benefits: A review. *Journal Food Reviews International*;2016; 32(2): 181-202.
2. Bown D. The Herb Society of America Encyclopedia of Herbs & Their Uses. (1st ed.)1995; Dorling Kindersley Publishing Inc, New York. p:135.
3. Krawinkel MB and Keding GB. Bitter Gourd (*Momordica charantia*): A dietary approach to hyperglycemia. *Nutrition reviews*;2006; 64(7):331-7.
4. Lolitkar MM, Rajarama-Rao MR. Pharmacology of a hypoglycaemic principle isolated from the fruits of *Momordica charantia*. Linn. *Ind J Pharmacy*.2010; 28: 129-133.
5. Platel K, Srinivasan K. Plant foods in the management of diabetes mellitus: vegetables as potential hypoglycaemic agents. *Nahrung* ;1997;41: 68-74.

6. Zhu Y, Dong Y, Qian X, Cui F, Guo Q, Zhou X, Wang Y, Zhang Y, Xiong Z. Effect of superfine grinding on antidiabetic activity of bitter melon powder. *Int J of Mol Sci* ;,2012;13: 14203-18.

7. Bakare RI, Magbagbeola OA, Akinwande AI, & Okunowo OW. Nutritional and chemical evaluation of *Momordica charantia*. *J Medicinal Plants Res.* ;2010;4:2189-2193.

8. Sneer LS, Nerurkar VR, Dooley DA, Efirid JT, Shovic AC, Nerurkar PV. Strategies to improve palatability and increase consumption intentions for *Momordica charantia* (bitter melon): A vegetable commonly used for diabetes management. *Nutr J.*;2011; 10:78.

9. Baldwa VS, Bhandari CM, Pangaria A, Goyal RK. Clinical trial in patients with diabetes mellitus of an insulin-like compound obtained from plant source. *Upsala J Med Sci* ;1977;82: 39-41.

10. Satyavati GV, Raina MK, Sharma M. Medicinal Plants of India. Vol I, ICMR, New Delhi, India; 1987;p. 317-320.

11. Leslie Taylor. In: Herbal Secrets of the Rainforest;2002; 2nd edition, Sage Press, Inc.

12. Khanna P, Mohan S. Isolation and identification of diosgenin and sterols from fruits and *in vitro* cultures of *Momordica charantia* Linn. *Ind Journal Exp Biol.*;1973; 11: 58-60.

13. Dutta PK, Chakravarty AK, Chowdhury US, Pakrashi SC. Vicine, a favism-inducing toxin from *Momordica charantia* Linn. *Ind Journal Chem.*;1981; 20B: 669-667.

14. Barron D, Kaouadji M, & Mariotte AM. Etude comparative de deux cucurbitacees a usage medicinal. *Planta Medica.*;1982; 46: 184-186.

15. Head KA. Herbal remedies that may help control blood sugar. In: Bratman S, Kroll D, eds.;1993; The Natural Pharmacist, Everything You Need to Know About Diabetes. New York, NY: Prima Publications, Inc.;pp 51-53.

16. Viridi J, Sivakami S, Shahani S, Suthar AC, Banavalikar MM & Biyani MK. Antihyperglycemic effects of three extracts from *Momordica charantia*. *J Ethnopharmacol.*;2003; 88: 107-111.

17. Vijayalakshmi B, Kumar SG & Salimath PV. Effect of bitter gourd and spent turmeric on glycoconjugate metabolism in streptozotocin-induced diabetic rats. *J Ethnopharmacol.*;2003; 11: 276-283.

18. Abascal K & Yarnell E. Using bitter gourd to treat diabetes. *Altern Complement Ther.*;2005;11(4): 179-184.

19. Sureshkumar G, Shetty AK & Salimat PV. Modulatory effect of bitter gourd (*Momordica charantia* Linn.) on alterations in kidney heparin sulfate in streptozotocin-induced diabetic rats. *J Ethnopharmacol.*;2003; 115: 276-283.

20. Chopra RN, Nayar SL, & Chopra IC. Glossary of Indian Medicinal Plants. NISCAIR, (7th ed). CSIR, New Delhi; 2006; .p. 151-152.
21. Fernandes NP, Lagishetty CV, Panda VS, Naik SR. An experimental evaluation of the antidiabetic and antilipidemic properties of a standardized *Momordica charantia* fruit extract. *BMC Complement Altern Med* .;2007;7(29):doi:10.1186/1472-6882-7-2.
22. Nadkarni KM. In: Indian Materia Medica ;2007; Vol. II. Popular Prakashan, Mumbai., 296.
23. Oishi Y, Sakamoto T, Udagawa H, Taniguchi H, Kobayashi-Hattori K, Ozawa Y, Takita, T. (2007) Inhibition of increases in blood glucose and serum neutral fat by *Momordica charantia* saponin fraction. *Biosci Biotechnol Biochem* .;2007;71(3):735-40.
24. Leung L, Birtwhistle R, Kotecha J, Hannah S, Cuthbertson S. Anti-diabetic and hypoglycaemic effects of *Momordica charantia* (bitter melon): a mini review. *British Journal of Nutrition* .;2009;102:1703-1708.
25. Koon SJ, Kudipudi S, Sridhar GR, Rao SB, Apparao A. Plant insulin: An in silico approach. *Inter J of Diabetes in Developing Countries*;2010; 30(4): 191-3.
26. Paul A, Raychaudhuri SS. Medicinal Uses and Molecular Identification of Two *Momordica charantia* Varieties – a review. *Electronic J Biol*;2010; 6: 43-51.
27. Mahomoodally MF, Subratty AH, Gurib-Fakim A, Choudhary MI, Nahar Khan S. Traditional medicinal herbs and food plants have the potential to inhibit key carbohydrate hydrolyzing enzymes in vitro and reduce postprandial blood glucose peaks in vivo. *ScientificWorldJournal*;2012; 285284. doi: 10.1100/2012/285284.
28. Hasan I, Khatoon S. Effect of *Momordica charantia* (bitter melon) tablets in diabetes mellitus: Type 1 and Type 2. *Prime Res Med (PROM)*;2012; 2(2):72-74.
29. Qixuan, C, Laureen QC, Chen LY, Edmund TS. Bitter melon (*M.charantia*): reduces adiposity lowers serum insulin and normalizes glucose tolerance in rats fed a high fat diet. *J Nutrition*;2003;133: 1088-1093.
30. Jadeja G, Katwala R. Effect of anti diabetic powder (Fenugreek leaves + Bitter melon) and green tea on blood sugar status of diabetic patient. *J of Cell & Tissue Research* .;2012;12(1):3125-31
31. Kumar DS, Sharathnath KV, Yogeswaran P, Harani A, Sudhakar K, Sudha P & Banji D. A medicinal potency of *Momordica charantia*. *International Journal of Pharmaceutical Sciences Review and Research*.;2010; 1(2): 95-100.
32. Fuangchan A, Sonthisombat P, Seubnukarn T, Chanouan R, Chotchaisuwat P, Sirigulsatien V, Ingkaninan K, Plianbangchang P, Haines ST. Hypoglycemic effect of bitter melon compared with metformin in newly diagnosed type 2 diabetes patients. *J Ethnopharmacol.*;2011;134(2):422-428.
33. Habicht D, Kind V, Rudloff S, Borsch C, Mueller AS, Pallauf J, Yang R, & Krawinkel MB. Quantification of antidiabetic extracts and compounds in bitter melon varieties. *Food Chem.*;2011; 126: 172-176.
34. Wehash FE, Abo-Ghanema I & Saleh RM. (2012) Some physiological effects of *Momordica charantia* and *Trigonella foenum-graecum* extracts in diabetic rats as compared with *Cidophage*®World. *Academy of Science, Engineering and Technology*;2012; 64: 1206-1214.
35. Chaturvedi P. (2012) Antidiabetic potentials of *Momordica charantia*: multiple mechanisms behind the effects. *J Med Food.*;2012;15(2):101-7.
36. Hazarika R, Parida P, Neog B, Yadav RN. Binding Energy calculation of GSK-3 protein of Human against some anti-diabetic compounds of *Momordica charantia* linn (Bitter melon). *Bioinformation.*;2012; 8(6): 251-254.
37. Joseph B, Jini D. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. *Asian Pac J Trop Dis.*;2013; 3: 93-102.
38. Hamissou M, Smith AC, Carter RE, Triplett JK. Antioxidative properties of bitter melon (*Momordica charantia*) and zucchini (*Cucurbita pepo*). *Amir J of Food Agri.*;2013; 25(9):349-62.
39. Wang H, Kan W, Cheng T, Yu S, Chang L & Chuu J. Differential anti-diabetic effects and mechanism of action of charantin-rich extract of Taiwanese *Momordica charantia* between type 1 and type 2 diabetic mice. *Food and Chemical Toxicology.*;2014; 69:347-356.
40. Zhang L, Liaw C, Hsiao P, Huang H, Lin M, Lin Z, Hsu F, Kuo Y. Cucurbitane-type glycosides from the fruits of *Momordica charantia* and their hypoglycaemic and cytotoxic activities. *Journal of Functional Foods* .;2014;6: 564-574.