Review Article

Medicinal and health promoting properties of Bitter gourd *(Momordica charantia)* and its extracts

Abstract

Numerous documented researches have been conducted in order to evaluate the potential of using different plants and herbs as traditional medicines. Bitter gourd (*Momordica charantia*) is an agricultural commodity belonging to plant kingdom and family Cucurbitaceae. Besides having higher content of calcium and iron, this plant also possesses considerable numbers of vitamins such as B_1, B_2, B_3, and C. These are great sources of some biologically active compounds such as momordicin I, II and cucurbitacin B. The salutary perceptions have been also emphasized as they are useful in providing protection from cardiovascular conditions such as atherosclerosis thereby, regulating the blood cholesterol level in the body. Bitter gourd entire fruit, seeds and leaves are helpful in lowering the fat accumulation and also control the impaired antioxidant status. Though, this plant could facilitate the balance effect of anti-HIV drugs, but the contents of ration amino sugar variate by declined and inclined, observed lungs, heart, liver, and spleen during diabetes.

Key Words: *Bitter gourd, medicinal usage, curing potential*

1. Introduction

Traditionally, herbs and natural substances in plants are utilized as medicinal purposes because of having higher contents of plant-based antioxidant compounds. Recent pharmacological researches have explained that bitter gourd due to its health benefits and functional activities considered as a “medicine food homology” plant [1][2].Plants have high ability to produce aromatic substances in aerobic cellular conditions by the interaction of oxygen with the polyphenols. Mostly, these interactions played an important role in producing immunity against molecular and herbivours [1,3]. The production of organic matter such as DNA, proteins, carbohydrates and lipids are damaged by reactive oxygen species (ROS). Various compounds are present in ROS such as hydrogen peroxide, superoxide (O_2) and hydroxyl (OH) radicals. The harmful reactions caused by ROS can be controlled by enzymatic and non-enzymatic antioxidants, eradicating pro-oxidants and scavenging free radicals [4]. Several synthetic antioxidants including Butylated hydroxytoluene (BHT) and BHA (hydroxyanisole), which are usually used in many foods but have some negative influence on body. Moreover, it has been proposed that intake of antioxidant enriched remarkably reduces the disease attack.

Bitter gourd is a vegetable also termed as balsam pear or Karela, (*Momordica charantia*; *Cucurbitaceae* family) originated in sub-tropical and tropical areas of South America and Asia (Fig.1). The literal meanings of *Momordica is* “to bite” presenting the leaf edges taste in bitterness after chewing of fruiting part. The bitter gourd is green colored, having cucumber-resembling shape in resemblance of cucumber, and it changes color to orange-yellow upon ripen [5,6]. Besides having several gastric and therapeutic benefits, the bitter gourd is also considered to have beneficial impacts for various spleen

and liver diseases including gout, rheumatism and blood purification. Sun et al. [7] found that bitter gourd contained significant level of hypoglycemic influence. This study also identified several health beneficial pharmacological properties of bitter gourd, including antibiotics, antiviral, antibacterial and anti-tumor etc. [7].

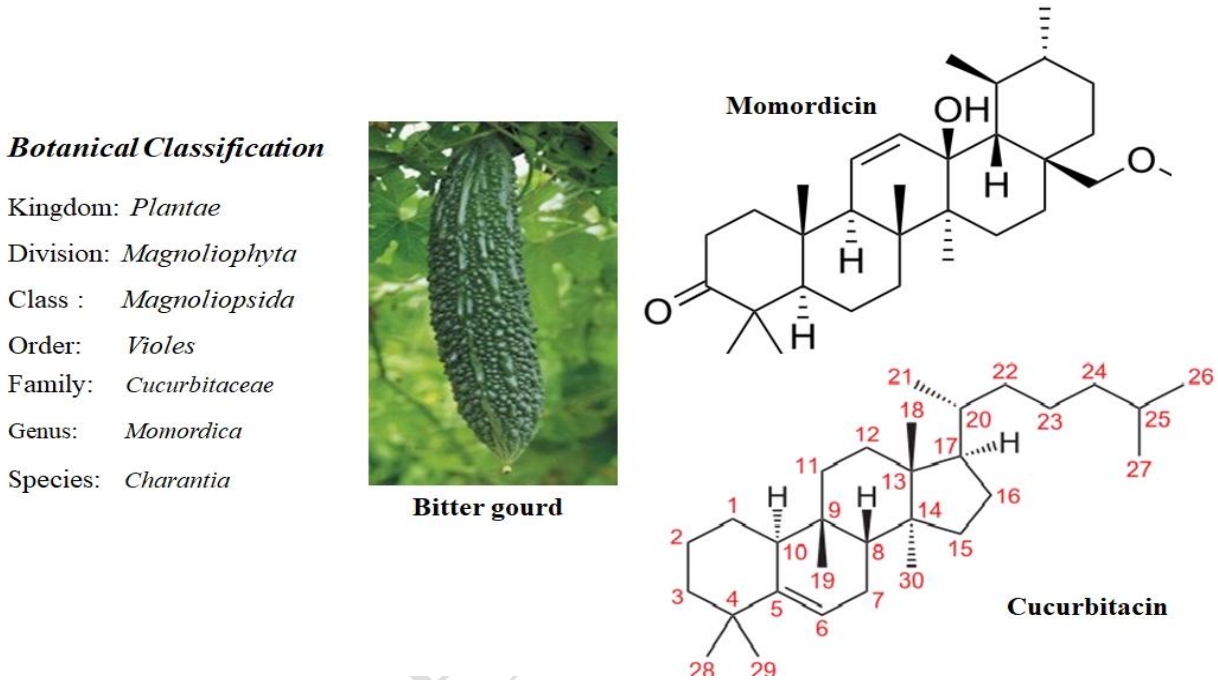

Fig. 1 Bitter gourd botanical classification and its structure a) Momordicin b) Cucurbitacin

Bitter gourd provides variety of amino acids including glutamine, valine, arginine, lysine, leucine, alanine, asparagines, tryptophan, histidine, threonine, methionine (Table.3). It has been reported that intake of bitter gourd in different form is beneficial to reduce blood glucose level. It contains a large number of hypoglycemic compounds such as charantin, olanolic acid 3-O-monodesmoside, polysaccharides. Previous study showed that bitter gourd contained several health beneficial compounds, including carbohydrates, lipids, proteins, saponins, flavonoids, triterpenoids and alkaloids (Table. 1) [8,9]. Polysaccharides which accounts almost 2.6–3.5g per 100 g of bitter gourd, are considered as the major bioactive compounds in bitter gourd, therefore, have attained much

consideration due to its numerous bioactivities such as antidiabetic, immune-regulation, antioxidant, antimicrobial and antitumor activities (Fig.2) [10–12].Several polysaccharides with different structural behaviors were extracted from bitter gourd [13].

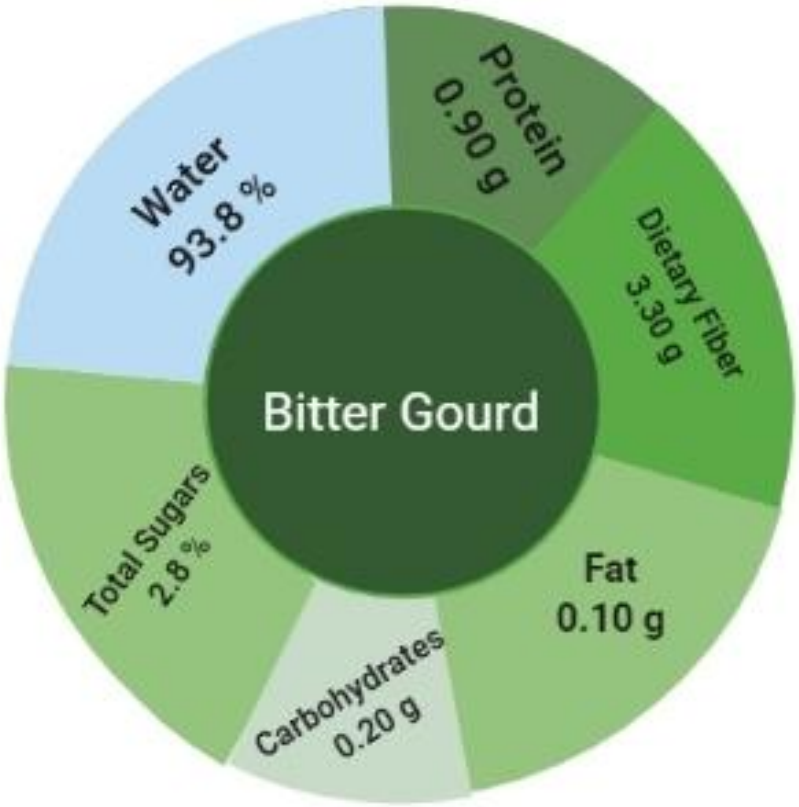

Fig.2 Nutritional Composition of bitter gourd (adopted from[8]).

Previous studies proved that the consumption of saponin free methanolic extract remarkably reduced the glucose content in normal and insuline-dependant diabetes (IDDM) [14]. It also contains insulin-substitute compounds polypeptide P, which can be useful for diabetic patients [15]. Previously researches showed the anti-diabetic characteristics of bitter gourd after feeding animals with bitter gourd[16–18]. In the present review, we have elucidated the possible medicinal potential of bitter gourd

(Fig.3), and its extract against several diseases (Table.2). The health promoting benefits of bitter gourd with reference to previous studies were also shown in this study. Moreover, the mechanism behind the effectiveness of bitter gourd against diseases were also explained in our current review.

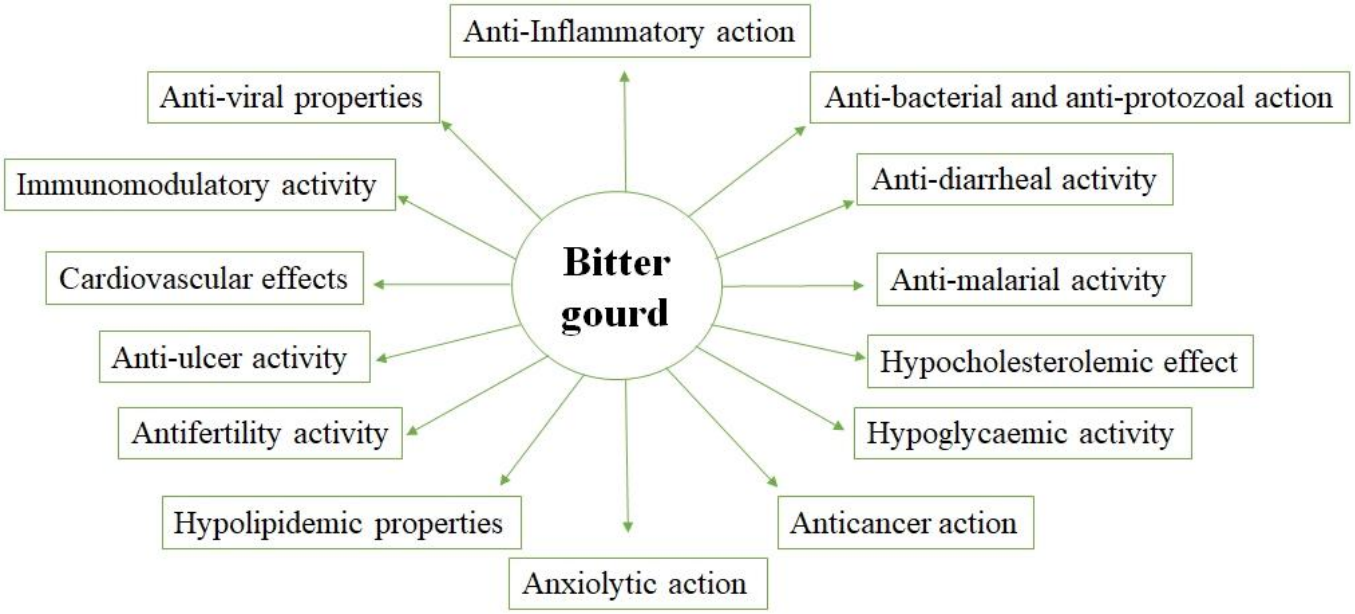

Fig. 3. Medicinal properties illustration of bitter gourd.

2. Biological active substances in bitter gourd

The availability of various biological active compounds in bitter gourd could enhance its potential use in food to intake several health promoting substances such asmomordicin I and II, and cucurbitacin B. However, bitter gourd comprises with numerous bioactive glycosides along with other terpenoid compounds. There are various chemical compounds such as cytotoxic (ribosome-inactivating), momordin and momorcharin found in bitter gourd are utilized for medicinal purposes. Cucurbitacin is a class of biochemical compound that is found in plants of the family of Cucurbitaceae. It is cytotoxic and poisonous for some animals and bitter taste for humans.

2.1. Medicinal perspectives of bitter gourd

The presence of bioactive molecules in bitter melon as natural product has the capability to delay the aging process. A number of phytochemical constituents as functional ingredients were found in bitter melon for example tannins, alkaloids, flavonoids, glycosides, phenolic and terpenoids. A variety of saponins were found in the plant of Momordica charantia including karavilagenin momordin, momordicin, kuguacin, karaviloside, and momordicoside [19]. In another research, the lifespan of obese rats fed on bitter melon increased significantly in contrast to controlled rats [20]. Because of the functional ingredients, bitter gourd has numerous pharmacological properties, including antifungal [11], antioxidant [21], anti-diabetic[22] , anti-obesity, hypotensive, stomachic, blood cholesterol lowering effects and anticancer properties [23]. Diabetes mellitus and accompanying problems were correct instance of lifestyle interrelated ailments. The inactive routine, increased consumption of alimentary energy, and obesity were among the numerous reasons for diabetes mellitus and metabolic syndrome [24]. The medications which are used for the diabetes mellitus management have various side effects, therefore, there is a need to substitute these medications. Hence, the bitter gourd having several health benefits can be a potential candidate to improve the diabetic situation, thereby, lowering the burden on anti-diabetic medicines [25].

2.1.1 Bitter gourd helps in prevention of Malaria

Conventionally, bitter melon was used to treat in Asia and other regions. However, its leaves were also used to make tea in Panama and Colombia, while it cooked with garlic and onion in Guyana. The mixture of garlic, onion and bitter gourd leaves

known as corilla, which has been used for the prevention of malaria. In-vitro studies proved that bitter melon species hold anti-malarial activity while unclear in respect to in-vivo results [5]. Previous studies found that leave extract of this plant excellent fight against the bacterial and viral attacks by improvising antibodies of S. typhi infected mouse, decrease infection proportion in blood. Traditionally, this plant is effective against different viral diseases (chickenpox and measles). The extraction with ethanol from bitter melon leaves and stems prevents viral attacks of HSV-1 and SINV [7].

2.1.2 Anti-hyperlipidemic activities of Bitter gourd

Anti-hyperlipidemic effect has been significantly observed by utilization of Momordica charantia. In recent times, it has been described that altered mechanism of bitter melon could repair the impaired beta cells consequently aggregating the insulin level and its sensitivity [26]. It hinders the glucose absorption by constraining the functionality of glucosidase hence also arouses the release and production of adiponectin and thyroid hormones. Bitter melon improves the action of adenosine-5-monophosphate kinase that is associated with uptake of glucose level and proclamation of fat (fatty tissues), hence, triggering in the reduction of weight [27]. Another research also showed that significant reduction of blood lipid level of diabetic rats treated with extract of *Momordica charantia*. Triglycerides (hepatic production) also cause the hyperlipidemic influence of HIV-1-protease inhibitors, which are having the lipoprotein instead of lipoprotein clearance[28].

2.1.3 Bitter gourd against HIV diseases

Bitter gourd possesses a lot potential proteins incorporated in lectin, type I RIP, type II RIP and ribonuclease which have strong positive impacts against HIV and tumor. Proteins class lectins or glycoproteins binding properties with erythrocyte-agglutinating and carbohydrate are useful as anti-HIV and antitumor agents [29]. In vivo studies reported that bitter melon seeds were helpful in cardio protection through down-regulating of NF-κB inflammatory process. Another characteristic of non-protein binding with insulin is due to presence of lctine in bitter melon. Lectin effects on peripheral tissues and brain appetition signals and promote hypoglycemic effect of blood glucose. The hypoglycemic properties in bitter melon developd because of the stimulation of lectin with the bitter melon ingestion[30]. While, in vitro studies showed that two compounds known as α-eleostearic acid in seeds and 15,16-dihydroxy-α-eleostearic acid in fruit observed to stimulate apoptosis of leukemia cells. Chong et al. [31] found another disease prevention in rat of colon disease with the help of 0.01% bitter melon oil (0.006% as α-eleostearic acid) presence in diet [31].

Bitter gourd (*Momordica charantia*) has been traditionally used to treat various diseases, while some wild species of bitter gourd such as *Momordica charantia Linn. var. abbreviata ser*. (WBG), are more potent in disease prevention. Moreover, only limited bio-physiological impacts were observed in WBG. Similarly, bitter gourd was also found to have remarkably anti-inflammatory impacts by decreasing prostaglandin E2 (PGE2), interleukin (IL)-7 and tumor necrosis aspect and intensifications conversion growth attribute and IL-10 secretion in RAW 264.7 macrophages, Caco-2 cells and THP- 1 cells [18,32]. The feeding of fruiting part of bitter gourd significantly improved the T helper 2 hormonal responses and T helper 1 cellular immunity [33].

Currently, the chemical compounds showed significantly resolved health issues in the presence of phytochemicals in bitter gourd. It has been reported that Charantins comprising of steroidal-saponins were abundantly present, indicating the hypoglycemic and anti-hyperglycemic activity [34]. Furthermore, several phenolic compounds including gallic acid, gentisic acid (2,5-dihydroxyl benzoic acid) and catechins are presented in bitter gourd. Cyclooxygenase-2 (COX-2) mRNA expression was also found to be successfully inhibited after bitter gourd treatment due to enhancing anti-inflammation property of gentisic acid which is a metabolite of salicylic acid and PGE2 [35,36].

2.1.4. Role of bitter Gourd against diabetic disease

Diabetes is a health issue caused by the consumption of high level of carbohydrate, fat and protein, and can be addressed by delaying digestion and expanded fasting and post-prandial glucose levels. Sathishsekar et al. [37] found the decrease the diabetes level after feeding rodents with bitter gourd. Oral feeding of around 150 mg/kg for 30 day's duration demonstrated a significant decrease in fasting blood glucose level, hepatic and renal thiobarbituric corrosive responsive substances and hydro-peroxides. The treatment likewise brought about a critical expansion in diminished glutathione, catalase, superoxide dismutase, glutathione-s-transferase and glutathione peroxidase in liver and kidney of diabetic rodents. This study showed that seeds of *Momordica charantia* may adequately standardize the disabled cell reinforcement status in streptozotocin instigated diabetes. This feeding caused the quick defensive impacts against lipid peroxidation by searching of free extremists there by decreasing the danger of diabetic inconveniences [37].

Zimmet et al. [38] found that diabetes is an illness of extraordinary worry to large population around the world and is known for its difficulties of incorporating diabetic neuropathy, nephropathy and retinopathy. During diabetic nephropathy, storm cellar film thickening is known to happen in the kidney. The cellar layer thickening during nephropathy caused the establishment of heparin sulfate a sulfated proteoglycan, laminin a high-atomic weight glycoprotein, and Type IV collagen a perplexing glycoprotein. These are interlinked in a fine design for typical filtration to occur during diabetes, thereby, lessening the content of heparin and sulphate and laminin, which are also associated with the expansion of type IV collagen, consequently influencing the pore size to cause kidney harm. Modifications in the storm cellar layer in various tissues during diabetes are of major concern and would require an immediate examination. Besides insulin or medicine, diet is also a major element to consider while the management of diabetes [39].

Spent turmeric is a side-effect from curcumin processing, which stays after curcumin was extracted from turmeric. The spent turmeric is rich in dietary filaments and contains both soluble and insoluble dietary strands. Dietary filaments are grounded to assume useful part against different illnesses such as diabetes, colon malignant growth, coronary illness, and so on [40]. They are consumed as source of insoluble lattice to slower down the ingestion of glucose, therefore, enhancing the gastrointestinal health. Conversion of complex dietary fiber to short chain fatty acid could increase their health beneficial properties. The body weight diminished significantly in diabetic rodents, but the loads of spleen and heart did not have any significant changes. The unpleasant gourd

and spent turmeric were found to be beneficial in controlling diabetics conditions and these symptoms[41].

Fukami et al. [42] found that total the sugar contents could damage liver, spleen, and mind. Uronic corrosive substance in liver, spleen, and mind could also diminish, while minimal increment was seen in testis. Amino sugar contents also diminished the liver, spleen, lungs and heart health during diabetes. The decline in sulfation of glycol-conjugates was also seen in diabetic patients which was enhanced by harsh gourd and spent turmeric, apart from cerebrum. Protein contents were observed to diminish in liver, while an increment was seen in brain organ. The examinations obviously showed the adjustment in glycol digestion during diabetes and enhancement to various degrees by taking care of severe gourd and spent turmeric for rodents.

Fukami et al. [42] found that diabetes influenced a significant number of the metabolic occasions prompting the underlying changes inside the cells and their vascular framework, therefore prompting long haul confusions of diabetes. Diabetic nephropathy is one of the main sources of end-stage renal turmoil (ESRD) and records to huge mortality in diabetic patients. Structural changes in diabetic nephropathy in Type 1 diabetic patients are very transcendent with the thickening of glomerular cellar layer (GBM) and mesangial extension. During diabetes, serious super underlying and practical adjustments in the GBM might be due to significant physiological changes causing end-stage renal turmoil. The overwhelming macromolecules associated with the design of GBM are glycoconjugates compounds such as fibronectin, heparan sulfate and laminin, type IV collagen. These are connected to each other to frame a boundary to charged particles, thereby, going about an obvious organic channel. Analyses of GBM during

diabetes have showed the decline and undersulfation of heparan sulfate (HS) [a significant glycosaminoglycan consists of a dynamically sulfated disaccharide rehash with an uronic corrosive (glucuronic or iduronic corrosive) and a glucosamine] which fills in as charge specific obstruction in the filtration of macromolecules. These progressions are typically connected with upgraded penetrability to macromolecules prompting ESRD.

2.1.5. Role of bitter gourd in preventing diabetes mellitus type II

Jayasooriya et al. [43] studied the therapeutic utilization of bitter gourd against diabetes and found that the bitter gourd and its extracts could display a powerful hypoglycemic action in normoglycemic and streptozotocin-prompted diabetic rodents. The westernization of dietary propensities observed in Japan has caused the increase of infection risks such as fatty liver, diabetes and hyperlipidemia. Therefore, there is an enhanced interest in seeing plant-based substitute to improve such conditions. Habicht et al.[44] found that the diverse bioactive mixtures are associated with the hypoglycemic impact of bitter gourd's extracts. Moreover, lipids and saponins were helpful for diabetic patients. The white bitter gourd has lower saponin fixation, thereby could be having less compelling. Absolute lipids and fatty corrosive synthesis appear to rely more upon the development of the natural products rather than the contrasts between assortments. Consequently, green bitter gourd at young maturity level which is tenderly handled can be considered for the anticipation and treatment of diabetes mellitus. Moghadasian and Frohlich. [45] studied that bitter melon had specific parts which could improve the lipid problems including fatty liver and hyperlipidemia. Currently, a very few detailed studies

are available explaining the dietary impact of bitter gourd on serum and liver lipids, but several studies found the positive impact of bitter gourd on type II diabetes mellitus.

2.1.6. Role of bitter gourd in preventing renal failure

Traditionally, plants have been an excellent source of medication, and several plants extract have been utilized to control the Diabetes Mellitus in numerous nations. Among these plants, the varieties having dietary filaments were considered major food parts to administer in diabetic patients. Bitter gourd was considered one of the major medicinal plants against diabetes. Harsh gourd (*Momordica charantia* LINN.) from Cucurbitaceae family is generally a devoured vegetable in India, and its products are widely utilized in fables medication in the administration of various infections including diabetes [46]. There is an incredible need to recognize treatments that could help in curing the end-stage renal disease. Moreover, the best remedy for diabetes might also be to permit the patient to stay safe from the side effects, as well as healthy conditions with normal metabolic state and to get away from long haul intricacies.

2.1.7. Role of bitter gourd in lowering liver cholesterols

Gamarallage et al. [47] observed that Koimidori is the best bitter melon assortment regarding its capability to bring down the hepatic fatty substance fixation; the subsequent investigation was also performed to discover the dynamic component(s) by fractionation of its powder with natural solvents such as methanol and n-hexane. The impacts on reducing serum and liver fatty substance showed that liver fatty substance focuses in rodents could be taken care of diets containing 1% methanol and 3% Koimidori powder. These two different parts extricated by n-hexane and CH3)2CO, or the lingering division could expand the hepatic fatty oil levels. Along these lines, the

powerful dynamic component(s) of Koimidori could bring down the liver fatty substances due to bitter melon extract. One more fascinating perception in this analysis was that methanol portion can effectively bring down the liver cholesterol. As free cholesterol stays unaltered, these impacts are to some degree because of the diminished collection of cholesterol esters. Therefore, this proposes that some useful components in methanol part of Koimidori could bring down the fatty substance just like cholesterol in the liver.

2.1.8. Role of bitter gourd against cancer

Alam et al. [48] found that the fatty corrosive arranged from BGO rich in 9c, 11t, 13t-CLN displayed a huge apoptosis in Caco-2 cells via the reduction of Bcl-2 proteins which are an apoptosis silencer. The 9c, 11t, 13t-CLN decontaminated from BGOFFA additionally surprisingly decreased the cell feasibility and prompted the apoptosis reactions in Caco-2 cells (information not shown). These outcomes demonstrated that the impact of BGO is mostly dependent on the apoptosis prompted by 9c, 11t,13t-CLN. Moreover, 9c,11t-CLA didn't influence the cell reasonability nor the apoptosis of Caco-2 cells in the current review, albeit 9c,11t-CLA has been accounted for to restrain cell multiplication or incite apoptosis in colon malignant growth cell lines [48].

Girnun et al. [49] reported that the apoptosis and anti-proliferative actions of BGOFFA rich in 9c, 11t,13t-CLN were significantly higher than that of 9c,11t-CLA in Caco-2 cells. The GADD45 and p53 played significant role in the development of hindrances and apoptosis acceptance in many kinds of malignant growth cells, therefore, PPARg has been considered beneficial in forestalling disease [49].

Kohno et al.[50] also reported overexpression of PPARg proteins in rats administered with BGO compounds. PPARg ligands such as 15d-prostaglandin (PG) J2 and troglitazone were reported to influence the growth inhibition and caused the apoptosis in cancer cells. Furthermore, PPARg protein ligands inhibited the development of ACF, that are the main putative precursor lesions for colonic adenocarcinoma, which could be influenced by the treatment with azoxymethane (AOM) and dextran sodium sulfate in rats. They also found that BGO-FFA could improve themRNA and PPARg protein levels in Caco-2 cells. Kohno et. [50] also found that the improvement of expression (PPARg) by BGO-FFA may be beneficial in preventing carcinogenesis of colon.

Tsuzuki et al. [51] have found that 9c,11t,13t-CLN caused apoptosis in the cells (DLD-1) through peroxidation of lipids. Though, it was not clearly mentioned whether lipid peroxidation and signaling (GADD45, p53 and PPARg) reactions occurred during apoptosis or through multiple signaling pathways. Further research is needed to assess the apoptosis induction mechanisms in Caco-2 cells by purifying 9c,11t,13t-CLN as well as BGO-FFA [51].

3. Conclusion

Modern lifestyle is major reason of unhealthiness and could be major cause of sever disease such as diabetes, cancer, HIV etc. Consumption of plant-based natural resources couldenhance the immunity against diseases. Undoubtedly bitterness and phytochemicals presented in bitter gourd (*Momordica charantia*) has significant positive effect in curing diseases against inflammation and diabetic patient. This improvement might be due to the slower release of glucose in gastrointestinal track and the production

of short-chain fatty acids from the fiber compounds through colon microbes. This review provides a comprehensive information concerning medicinal plant potential in human life. This review is never draw borderlines of bitter gourd usage but also delivers desirable future studies to describe clinical effects on human consumption.

Ethical guidelines

Ethics approval was not required for this research.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Table 1: Estimated Minerals and Vitamins contents in bitter gourd

Minerals	Value mg/100g	Reference
Calcium (Ca)	84	[8]
Magnesium (Mg)	85	
Phosphorus (P)	99	
Potassium (K)	608	
Sodium (Na)	11	
Zinc (Zn)	0.30	
Manganese (Mn)	0.53	
Selenium (Se)	0.9	
Iron (Fe)	2.04	
Vitamins	**Value mg/100g**	
Vitamin C*	88	[8]
Thiamin	0.181	
Riboflavin	0.326	
Niacin	1.110	
Pantothenic acid	0.063	
Vitamin B-6	0.806	
Folate (µg)	128	

*** total ascorbic acid**

Table 2: Over-view of diseases prevention by Bitter gourd

Diseases	Model	Reference
HIV	Human study	[52]
	Rat study	[30]
	Rat study	[31]
Diabetic	Human case study	[39]
	Rat study	[37]
	Rat study	[41]
	Rat study	[6]
	Human case study	[42]
Renal failure	Human case study	[53]
Mellitus type II	Rat study	[43]
	Rat study	[45]
	Rat study	[44]
Liver Cholesterols	Rat study	[54]
Cancer	Rat study	[55]
	Rat study	[49]
	Rat study	[50]
	Rat study	[51]
	Rat study	[56]

Table 3. Quantification of amino acid in immature and mature seeds of bitter gourd (adopted by Sorifa. [14])

Amino Acids	Immature Seed	Mature Seed
Arg	48.8	80.8
His	70.2	40.9
Met	26.3	23.6
Ala	49.8	46.7
Val	42.8	36.7
Cys	21.3	16.5
Asx	91.3	16.5
Thr	24.9	17.4
Glx	95.9	124
Tyr	56.5	44.7
Lys	107	98.7

***Quantity in mg/100g**