Pak. j. sci. ind. res. Ser. B: biol. sci. 2022 **65B**(3) 297-302

Review

Bitter Melon: A Comprehensive Review

Makkia Saleem*, Mian Kamran Sharif and Roma Saleem
National Institute of Food Science and Technology, University of Agriculture, Faisalabad-38040, Pakistan

(received February 25, 2020; revised March 18, 2020; accepted March 26, 2021)

Abstract. Medicinal plants are used widely to prevent, cure and treat health related complications and become popular as an alternative therapy. A wide variety of medicinal plants and their different products have been used in various cultures because of their bioactive components. Since ancient times, medicinal plants with numerous bioactive components have been used traditionally, not only by laymen but also by physicians to treat a variety of human health disorders such as cancer, coronary heart diseases, and diabetes. *Momordica charantia* Linn. (bitter melon) is an example of such a vegetable plant frequently used for medicated purposes. It is a common and traditional food in Asian cuisine. It is known for controlling the blood glucose level in the body and used as a remedy by the practitioner of complementary and alternative medicines (CAM). Bitter melon has bioactive components such as alkaloids, vicine, steroids, charantin and certain protein types (P-insulin, V-insulin) that are responsible for the hypoglycemic response.

Keywords: *Momordica charantia*, bitter melon, CAM, diabetes, bioactive

Introduction

World ethnobotanical information about the medicinal plants reported about 800 plants that are used to control DM, whereas the World Health Organization (WHO) has listed approximately 21000 medicinal plants, out of which 150 species are being used commercially as remedies against various health aliments (Modak *et al*., 2006). Worldwide, approximately 30% of diabetic patients are using CAM, while in Pakistan about 50 percent of patients are using these approaches just based on personal experiences and local communication. There are about 450 experimentally proven medicinal plants that have anti-diabetic properties but only 109 of them known for their complete mechanism of action (Alarcon-Aguilara *et al*., 1998). Medicinal plants have multiple beneficial activities including manipulating the carbohydrate metabolism through various mechanisms such as preventing damage and restoring the integrity and functionality of β-cells, insulin production, improving glucose uptake and its utilization, and antioxidant properties. Seeds, pulp and extracts of various medicinal plants and herbs, and considered cost-effective are safe approaches (Iqbal *et al*., 2015).

Bitter melon is known for its anti-diabetic properties for a long time. It contains various bioactive components such as phenolic, insulin-like molecules (such as polypeptides P or K, V-insulin, momordicin, charantin), alkaloid, steroid and triterpene. Different studies conducted *in vitro* and *in vivo* models revealed the therapeutic and medicinal potential of the bitter melon and its products. It possesses anti-cancer, anti-inflammatory, anti-diabetic, anti-carcinogenic, anti-viral, anti-helminthic, immune-stimulatory, cholesterol-lowering, abortifacient and anti-spermatogenic potential and thus has a positive relationship with health (Sharma *et al*., 2011). In Asia, eastern Africa, the Caribbean and southern America, bitter melon is used to treat diabetes Mellitus and related complications. Polypeptide-P (insulin-mimetic peptide), vicine (glycoalkaloid) and charantin (steroidal glycoside) are the isolated compounds that are derived from the fruit and seeds of bitter melon, are responsible for hypoglycemic activity in both human and animals (Gupta *et al*., 2011a).

*Author for correspondence;
E-mail: makkia.saleem@yahoo.com

Material and Method

Taxonomy and origin. *Momordica charantia*. *Momordica charantia*, in different languages is identified by various names such as Ampalaya, assorossie, Balsam apple, Baramasiya, Bitter gourd, Bitter melon, Corrila, Gurkenahnlicher balsamapfel, Hagala-kayi, Hanzal, Kaipavalli, Kakara, Karela, Karavella, Karavelli, Kareli, Karelo, Kaypa, Kerula, Kho gua, Sora, Nigauri or goya, Pagal, Pakar, Papilla, Pare, Pavakka-chedi, Paval, Pear or Balsamina, Quisaul-barri, Salsamino, Sushavi, Uchchhe and several other names (Sharma *et al*., 2011).

It also has many alternative names included *M. sinensis, M. operculata, M. indica, M. elegans, M. chinensis,* and *Sicyos fauriei* (Gupta *et al*., 2011b). The origins of the species are not known exactly, however, it is native to tropics. It is commonly cultivated in Amazon, China, the Caribbean, tropical areas of Africa and Asia including Pakistan and India. It grows in moist and damp land of tropical countries. *M.charantia* is annual or perennial, cultivated during the summer season and harvested on the 20th day after flowering (Kumar *et al*., 2010).

Botanical and morphological characteristics. Bitter melon is a climber flowering of the family Cucurbitaceae. This herbaceous plant usually grows to 6 meters in length, having elongated fruits with a knobbly surface. Leaves are simple and alternate having a length of 4-12 cm with 5-7 deep separated lobes along with branched or unbranched tendrils. Lobes are blunted with short points on the edge. A stipule is absent (Kumar *et al*., 2010). Bitter melon's flowers are always unisexual, as the plant has female and male flowers of yellow colour with distinct 5 petals. Perianth has a short to prolonged epigynous zone, yellow on short (female) or long (male) peduncles that are short-lived. Stamens are typically solitary with shallow hypanthium along with calyx of 5 lobes and 3 stamens (Gupta *et al*., 2011b). The fruit has a spindle and ovoid-shaped, similar to cucumber but the exterior is ridged and rough. The skin is tender and edible. In cross section, it is hollow having comparatively thin layered flesh that surrounds the seeds' cavity and pith. In unripe fruits, seeds and pith are white and become red when fully ripe. The flesh is watery and crunchy. The variety of sizes and shapes of bitter melon depends upon the genotype. Size varies from as small as 6 cm to as long as 30 cm along with blunt ends to pointed ends. Distinct colours from pale green to bright green, with the gentle warty surface to jagged ridges. Seeds are few to many of 8-13 mm size, usually long but ovate with corrugate margins, pointed ends and both faces covered sculptured surface. Among all vegetables, it has a bitterest taste. Bitter melon's fruit is utilized as a vegetable; however, leaves, roots and seeds are used as medicine (Kumar *et al*., 2010).

Biochemistry and structural composition. Bitter melon is a potentially nutrient-rich fruit having a large number of bioactive compounds, minerals, vitamins and anti-oxidants that showed extraordinary versatility in tackling a broad range of health disorders (Joseph and Jini, 2013). Based on a multitude of actions of bitter melon to treat several medical conditions, the researcher is interested to study its bioactive constitutes and their mode of actions in the body. About 228 diverse bioactive medicinal compounds have been separated from various parts of plants including the endosperm, leaves, pericarp, seeds, stems and unripe fruit (Bakare *et al*., 2010). Fresh bitter melon fruit has 93·2% water and on dry weight basis it is composed of 0·76% lipids and 18·02% protein. However, bitter melon seeds have nearly 45% oils which mainly compose of eleostearic acid (68%) and stearic acid (27%) (Leung *et al*., 2009). From fruit, many glycosides have been isolated and are classified in the cucurbitane-type triterpenoids genera (Tan *et al*., 2008; Chang *et al*., 2006). Four triterpenoids have been known to attenuate the activity of AMP-activated protein kinase that may be credible for the hypoglycemic mechanism in the body (Tan *et al*., 2008). Saponins including momordicine II, 3-hydroxycucurbita-5, 23-di-O-β-glucopyranoside and 24-dien-19-al-7 have been isolated from bitter melon. They showed a significant increase in insulin production in β-cells (Keller *et al*., 2011).

The immature bitter melons' fruit has a good amount of vitamin C and also concentrated with an ample amount of vitamin A, iron and phosphorus. Numerous phytochemicals including multiflorenol, momordolol, momordin, momordicinin, momordicins, momordicilin, momordenol, momorcharins, goyasaponins, goya-glycosides, gentisic acid, galacturonic acids, erythrodiol, elaeostearic acids, diosgenin, cycloartenols, cucurbitins, cucurbitanes, cucurbitacins, cryptoxanthin, chorine and charantin have been extracted. These compounds impart yellow-colour in parts of the plant. These compounds have been classified into various categories including alkaloids, alkanol C5, alkene to C3, benzanoids, carbohydrates, carotenoids, inorganic compounds, lipids, monoterpenes, phenylpropanoids, proteids, steroids, triterpenes, sesquiterpene, sterol and others with the unclear structural composition *e.g*., kakara I-B, II-A and III-B (Grover and Yadav, 2004). The cucurbitane triterpenoids consist of the structures including 23 (E)-dien-19-al, 3-7-25- trihydroxy-cucurbita-55, 25- dim-ethoxycucurbita-6 23-(E)-dien-3-ol, 5, 19-epoxy-19 and 19-epoxycucurbita-6. Momocharin I and momor-dicin II have the same parent structure (Puspawati, 2008).

Fruits of bitter melon consist of alkaloids, fixed oil, free acids, glycosides, phenolic compounds, reducing sugars, resins and saponins. The pulp of the fruit is concentrated with soluble pectin having pectic acid. The fruit is a great source of vitamins B along with

high amounts of vitamin C, vitamin A and vitamin E. The calorific value of the fruit is 241.66 Kcal/100 g (Bakare *et al*., 2010). It is also a rich source of minerals such as zinc, potassium, phosphorus, magnesium, iron, and calcium (Bangash *et al*., 2011). Leaves are also nourishing and reported as a source of many minerals including 3% iron, 1% calcium, 5% phosphorus, 7% potassium and 4% magnesium. Leaves have a good concentration of several vitamins including vitamin B, thiamine 4%, riboflavin 4%, niacin 2%, vitamin B6 3% and folate 13%. The calorific value of the leaf is 213.26 Kcal/100 g (Gupta *et al*., 2011b).

All over the world, especially in developing nations, many herbal remedies have been used in various traditions to manage diabetes. Medicinally, bitter melon and its extracts have a long history of treating several diseases including diabetes. It is one of them that has been inspected comprehensively for its anti-diabetic potential. People used bitter melon in different ways to get their benefits. Stem and green leaves are boiled and served as tea. Others cooked the fruit with potatoes or meat, whereas many others used it in salad or make a healthy liquid tonic. However, in addition to other fruit juices like mango, papaya are common to neutralize the bitter taste. Commercially, bitter melon's plant powder is available as a tea or in capsule form (Joseph and Jini, 2013). Many clinical studies have reported the anti-diabetes potential of bitter melon. The potent hypoglycemic agents are insulin-like peptides, alkaloids and steroidal sapogenins known as charantin (Daniel *et al*., 2014).

Proposed modes of action of bitter melon and its extract. Bitter melon's leaves, seed, and fruit extracts along with other extracted compounds are supposed to pose their hypoglycemic potential through various biochemical, physiological and pharmacological modes (Azam *et al*., 2016). Up till now, about 140 research studies have investigated the bitter melon for its anti-hyperglycemic effects both in human and animal models. The potential hypoglycemic actions of bitter melon are through stimulation or increase uptake and utilization of the glucose in the skeletal and peripheral muscle (Akhtar *et al*., 2011; Cummings *et al*., 2004), hindrance in the uptake of glucose through intestinal cells (Uebanso *et al*., 2007), lower differentiation in adipocyte (Nerurkar *et al*., 2010), suppression of enzymes of gluconeogenesis (Singh *et al*., 2011) stimulation of the hexose mono-phosphate pathway's enzymes and most important is it protects the β cells of islet structure and its functions (Gadang *et al*., 2011). Dose (2-6 g) of bitter melon's pulp, fruits and seeds per day for four weeks can lower the fasting and postprandial plasma glucose and HbA1c level in type 2 DM patients (Peter *et al*., 2019; Krawinkel *et al*., 2018).

Effect on insulin secretion and pancreatic β cells structure. Oral administration of bitter melon has been responsible for increased insulin secretion from endocrine β cells (Cortez-Navarrete *et al*., 2018) and prompt glucose intake by the hepatocytes (Jeong *et al*., 2008). Alcoholic extract of the fruit of bitter melon showed a significant effect on the regeneration of the cells of the pancreas as the number of cells have been increased (Singh *et al*., 2008). Therefore, evidence revealed that the subsequent rise in the number of β cells and insulin production might be part of the other mechanism through which bitter melon has its anti-diabetic effects. Also, extract possess cell growth and proliferation properties that are similar to insulin (Parmar *et al*., 2011).

Phytochemicals related to anti-diabetic activity. Alkaloids, charantins (steroidal saponins), and peptides having similar structure or function to the insulin are mainly hypoglycemic components of bitter melon and these compounds are more concentrated in the fruit parts compare to the seeds, therefore fruit has shown the most effective glycemic control (Paul and Raychaudhuri, 2010).

Alkaloids, vicine. Isolated alkaloid from the bitter melon's seeds contained a pyrimidine nucleoside known as "vicine" (Haixia *et al*., 2004). It has been considered a hypoglycemic compound as it lowered the blood glucose when injected intraperitoneally in the diabetic animal model (Dutta *et al*., 1981) as well as in non-diabetic animals (Ham and Wang, 2009). However, vicine of fava bean has been responsible for inducing favism, an acute disorder that is characterized by genetic loss of the glucose-6-phosphate dehydrogenase enzyme and anemia (Basch *et al*., 2003).

Steroids, charantin. Charantin is considered a hypoglycemic component that is separated from *Momordica charantia*'s fruit. It is a fusion of 2 steroidal saponin components included sitosteryl- and stigmasteryl-glucoside (Desai and Tatke, 2015). Charantin has a molecular weight of 9.7 kDa. Other investigators classified the charantin as a cucurbitane-type triterpenoid. Various methods are used to extract charantin. High performance thin layer chromatography (HPTLC) is

used to separate and quantify the charantin (Thomas *et al*., 2012). Charantin is responsible for produces antihyperglycemic effects in rabbits, either taken orally or intravenously (Lolitkar and Rao, 1966). Charantin can potentially use as a drug to treat diabetes and it could replace glibenclamide (Pitiphanpong *et al*., 2007). 14 different kuguacins, cucurbitane triterpenoids, along with an octanorcucurbitacin, 2 pentanorcucurbitacins and 2 trinorcucurbitacins plus six other analogs have been isolated from the leaf of bitter melon's plant (Chen *et al*., 2009). In another experiment, two charantin's aglycones have been isolated and recognized as stigmastadienol and sitosterol glycosides. Both were investigated separately in an *in-vivo* setting for their hypoglycemic potential, results showed that these compounds are not notably effective in lowering blood glucose (Harinantenaina *et al*., 2006). This indicated more investigation is required to identify other specific compounds that are truly responsible for the hypoglycemic action.

Protein, P-insulin. Polypeptide-P or protein, P-insulin is a bioactive compound having 11,000 D molecular weight and composed of 166 amino acids with insulin-like properties (Khanna *et al*., 1981). Besides the fruits of bitter melon, P insulin is also concentrated in tissue cultures and seeds (Ng *et al*., 1986; Khanna and Mohan, 1973). P-insulin shows to has the potential to lower blood glucose when administered subcutaneously in humans and animal models too. Clinical trials exposed that the polypeptide-p-$ZnCl_2$ has a glucose lowering effect in the blood. It works by mimicking insulin action in the human body. Thus, it might be a source of plant-based insulin that will replace the animal-originated insulin (Paul and Raychaudhuri, 2010). Recently, the 498 bp gene has cloned that is coded for polypeptide p in bitter melon and further tested for its hypoglycemic action in alloxan-induced diabetic mice. Results revealed the anti-hyperglycemic effect of the polypeptide (Wang *et al*., 2011). Extract of seeds of bitter melon induces hypoglycemia in streptozotocin-induced diabetic rats when taken orally (Wehash *et al*., 2012). This indicated that other compounds are also present in bitter melon seeds which are responsible for that type of action.

Other components. Various other compounds have been isolated by different extraction methods and tested in an *in-vivo* setting for hypoglycemic activity by Japanese researchers. Eleven compounds were isolated by methanol from dried fruits of the bitter melon. Three cucurbitane triterpenoids were identified structurally and tested for their potential to control glucose levels and results showed that blood glucose level reduced significantly in mice (Lee *et al*., 2009). Momordicines I and II and momordicosides L and K are those four components that are considered to impart a bitter taste in the plant. The former compounds are sitosterol and stigmastadienol, the aglycones of charantin (Harinantenaina *et al*., 2006).

Conclusion

Vegetables and other herbaceous plants can be used as medicines to prevent and treat various health ailments. As these vegetables are part of daily cuisine in most of the countries that's why no difficulty will be faced to increase their consumption and utilization to derive specific health benefits. Because of the unique composition of bioactive components responsible for blood glucose control, increased utilization of bitter melon should be appreciated.

Conflict of Interest. The authors declare no conflict of interest.

References

Akhtar, N., Khan, B.A., Majid, A., Khan, S., Mahmood, T., Gulfishan, Saeed, T. 2011. Pharmaceutical and bio-pharmaceutical evaluation of extracts from different plant parts of indigenous origin for their hypoglycemic responses in rabbits. *Acta Poloniae Pharmaceutica*, **68:** 919-925.

Alarcon-Aguilara, F.J., Roman-Ramos, R., Perez-Gutierrez, S., Aguilar-Contreras, A., Contreras-Weber, C.C., Flores-Saenz, J.L. 1998. Study of the anti-hyperglycemic effect of plants used as antidiabetics. *Journal of Ethnopharmacology*, **61:** 101-110.

Azam, M., Saerang, C.O., Rahayu, S.R., Indrawati, F., Budiono, I., Fibriana, A.I., Azinar, M., Sa'dyah, N.A.C., Cahyono, E.B., Lesmana, R. 2016. A doubled blind, crossover-RCT in T2DM for evaluating hypoglycemic effect of *P. indicus, M. charantia, P. vulgaris* and *A. Paniculata* in central Java. *Journal of Natural Remedies*, **16:** 108-114.

Bakare, R.I., Magbagbeola, O.A., Akinwande, A.I., Okunowo, O.W. 2010. Nutritional and chemical evaluation of *Momordica charantia*. *Journal of Medicinal Plants Research*, **4:** 2189-2193.

Bangash, J.A., Arif, M., Khan, F., Khan, F., Rahman, A., Hussain, I. 2011. Proximate composition,

minerals and vitamins content of selected vegetables grown in Peshawar. *Journal of the Chemical Society of Pakistan*, **33:** 118-122.

Basch, W.E., Gabardi, S., Ulbricht, C. 2003. Bitter melon (*Momordica charantia*): a review of efficacy and safety. *American Journal of Health-System Pharmacy*, **60:** 356-359.

Chang, C.I., Chen, C.R., Liao, Y.W., Cheng, H.L., Chen, Y.C., Chou, C.H. 2006. Cucurbitane-type triterpenoids from *Momordica charantia*. *Journal of Natural Products*, **71:** 1327-1330.

Chen, J.C., Liu, W.Q., Lu, L., Qiu, M.H., Zheng, Y.T., Yang, L.M., Zhang, X.M., Zhou, L., Li, Z.R. 2009. Kuguacins F-S, cucurbitane triterpenoids from *Momordica charantia*. *Phytochemistry*, **70:** 133-140.

Cortez-Navarrete, M., Martínez-Abundis, E., Pérez-Rubio, K.G., González-Ortiz, M., Villar, M.M. 2018. *Momordica charantia* administration improves insulin secretion in type 2 diabetes mellitus. *Journal of Medicinal Food,* **21:** 672-677.

Cummings, E., Hundal, H.S., Wackerhage, H., Hope, M., Belle, M., Adeghate, E., Singh, J. 2004. *Momordica charantia* fruit juice stimulates glucose and amino acid uptakes in L6 myotubes. *Molecular and Cellular Biochemistry*, **261:** 99-104.

Daniel, P., Supe, U., Roymon, M.G. 2014. A review on phytochemical analysis of *Momordica charantia*. *International Journal of Advances in Pharmacy, Biology and Chemistry*, **3:** 214-220.

Desai, S., Tatke, P. 2015. Charantin: an important lead compound from *Momordica charantia* for the treatment of diabetes. *Journal of Pharmacognosy and Phytochemistry*, **3:** 163-166.

Dutta, P.K., Chakravarty, A.K., Chowdhury, U.S., Pakrashi, S.C. 1981. Vicine, a favism-inducing toxin from *Momordica charantia* Linn. *Journal of Chemistry*, **20:** 669-671.

Gadang, V., Gilbert, W., Hettiararchchy, N., Horax, R., Katwa, L., Devareddy, L. 2011. Dietary bitter melon seed increases peroxisome proliferator activated receptor-γ gene expression in adipose tissue, down-regulates the nuclear factor-κB expression and alleviates the symptoms associated with metabolic syndrome. *Journal of Medicinal Food*, **14:** 86-93.

Grover, J.K., Yadav, S.P. 2004. Pharmacological actions and potential uses of *Momordica charantia*: a review. *Journal of Ethnopharmacology*, **93:** 123-132.

Gupta, A., Sethi, J., Sood, S., Dahiya, K., Singh, G., Gupta, R. 2011a. Evaluation of hypoglycemic and anti-atherogenic effect of aloevera in diabetes mellitus. *International Journal of Comprehensive and Advance Pharmacology*, **8:** 1-4.

Gupta, M., Sharma, S., Gautam, S., Bhadauria, R. 2011b. *Momordica charantia* Linn. (karela): Nature's silent healer. *International Journal of Pharmaceutical Sciences Review and Research*, **11:** 32-37.

Haixia, Z., Xiaozuo, Z., Yawei, W., Mancanq, L., Zhide, H. 2004. Analysis of vicine in bitter melon samples by polyglycol-C8 solid phase with high performance liquid chromatography. *Chinese Journal of Analytical Chemistry*, **3:** 408-108.

Ham, C., Wang, J. 2009. Optimization of conditions for charantin extraction in PEG/salt aqueous two phase systems using response surface methodology. *The Open Complementary Medicine Journal*, **1:** 46-50.

Harinantenaina, L., Tanaka, M., Takaoaka, S., Oda, M., Mogami, O., Uchida, M., Asakawa, Y. 2006. *Momordica charantia* constituents and anti-diabetic screening of the isolated major compounds. *Chemical and Pharmaceutical Bulletin*, **54:** 1017-1021.

Iqbal, M.S., Iqbal, M.Z., Iqbal, M.W., Bahari, M.B. 2015. Complementary and alternative medicines (CAM) among diabetes patients: a prospective study from Pakistan. *Value Health*, **18:** 620.

Jeong, J., Lee, S., Hue, J., Lee, K., Nam, S.Y., Yun, Y.W., Jeong, S.W., Lee, Y.H., Lee, B.J. 2008. Effect of bitter melon (*Momordica charantia*) on anti-diabetic activity in C57BL/6J db/db mice. *Korean Journal of Veterinary Research*, **48:** 327-336.

Joseph, B., Jini, D. 2013. Anti-diabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. *Asian Pacific Journal of Tropical Medicine*, **3:** 93-102.

Keller, A.C., Ma, J., Kavalier, A., He, K., Brillantes, A.M., Kennelly, E.J. 2011. Saponins from the traditional medicinal plant *Momordica charantia* stimulate insulin secretion *in vitro*. *Phytomedicine*, **19:** 32-37.

Khanna, P., Jain, S.C., Panagariya, A., Dixit, V.P. 1981. Hypoglycemic activity of polypeptide-p from a plant source. *Journal of Natural Product*, **44:** 648-655.

Khanna, P., Mohan, S. 1973. Isolation and identification of diosgenin and sterols from fruits and *in vitro* cultures of *Momordica charantia* Linn. *Indian Journal of Experimental Biology*, **11:** 58-60.

Krawinkel, M.B., Ludwig, C., Swai, M.E., Yang, R., Chun, K.P., Habicht, S.D. 2018. Bitter gourd reduces

elevated fasting plasma glucose levels in an intervention study among prediabetics in Tanzania. *Journal of Ethnopharmacology*, **216:** 1-7.

Kumar, D.S., Sharathnath, K.V., Yogeswaran, P., Harani, A., Sudhakar, K., Sudha, P., Banji, V. 2010. A medicinal potency of *Momordica charantia*. *International Journal of Pharmaceutical Sciences Review and Research*, **1:** 95-100.

Lee, S.Y., Eom, S.H., Kim, Y.K., Park, N.I., Park, S.U. 2009. Cucurbitane-type triterpenoids in *Momordica charantia* Linn. *Journal of Medicinal Plants Research*, **3:** 1264-1269.

Leung, L., Birtwhistle, R., Kotecha, J., Hannah, S., Cuthbertson, S. 2009. Anti-diabetic and hypoglycaemic effects of *Momordica charantia* (bitter melon): a mini review. *British Journal of Nutrition*, **102:** 1703-1708.

Lolitkar, M.M., Rao, M.R.R. 1966. Pharmacology of a hypoglycemic principle isolated from the fruits of *Momordica charantia*. Linn. *Indian Journal of Pharmaceutical*, **28:** 129-133.

Modak, M., Dix, P., Londhe, J., Ghaskadbi, S., Devesagayam, T.P.A. 2007. Indian herbs and herbal drugs used for the treatment of diabetes. *Journal of Clinical Biochemistry and Nutrition*, **40:** 163-173.

Nerurkar, P.V., Lee, Y.K., Nerurkar, V.R. 2010. *Momordica charantia* (bitter melon) inhibits primary human adipocyte differentiation by modulating adipogenic genes. *BMC Complementary and Alternative medicine*, **10:** 34-40.

Ng, T.B., Wong, C.M., Lib, W.W., Yeung, H.W. 1986. Insulin-like molecules in *Momordica charantia* seeds. *Journal of Ethnopharmacology*, **15:** 107-111.

Parmar, K., Patel, S., Patel, J., Patel, B., Patel, M.B. 2011. Effects of bitter gourd (*Momordica charantia*) fruit juice on glucose tolerance and lipid profile in type-II diabetic rats. *International Journal of Drug Development and Research*, **3:** 139-146.

Paul, A., Raychaudhuri, S.S. 2010. Medicinal uses and molecular identification of two *Momordica charantia* varieties-a review. *Electronic Journal of Biology*, **6:** 43-51.

Peter, E.L., Kasalia, F.M., Deyno, S., Mtewa, A., Nagendrappa, P.B., Tolo, C.U., Ogwang, P.E., Sesaazi, D. 2019. *Momordica charantia* L. lowers elevated glycaemia in type 2 diabetes mellitus patients, systematic review and meta-analysis. *Journal of Ethnopharmacology*, **231:** 311-324.

Pitiphanpong, J., Chitprasert, S., Goto, M., Jiratchariyakul, W., Sasaki, M., Shotipruk, A. 2007. New approach for extraction of charantin from *Momordica charantia* with pressurized liquid extraction. *Separation and Purification Technology*, **52:** 416-422.

Puspawati, N.M. 2008. Isolation and identification momordicin I from leaves extract of *Momordica charantia* L. *Jurnal Kimia*, **2:** 53-56.

Sharma, S., Tandon, S., Semwal, B., Singh, K. 2011. *Momordica charantia* Linn. A comprehensive review on bitter remedy. *Journal of Pharmaceutical Research and Opinion*, **1:** 42-47.

Singh, J., Cumming, E., Manoharan, G., Kalasz, H., Adeghate, E. 2011. Medicinal chemistry of the anti-diabetic effects of *Momordica charantia*: active constituents and modes of actions. *The Open Medical Chemistry Journal*, **5:** 70-77.

Singh, N., Gupta, M., Sirohi, P., Varsha. 2008. Effects of alcoholic extract of *Momordica charantia* (Linn.) whole fruit powder on the pancreatic islets of alloxan diabetic albino rats. *Journal of Environmental Biology*, **29:** 101-106.

Tan, M.J., Ye, J.M., Turner, N., Hohnen-Behrens, C., Ke, C.Q., Tang, C.P., Chen, T., Weiss, H.C., Gesing, E.R., Rowland, A. 2008. Anti-diabetic activities of triterpenoids isolated from bitter melon associated with activation of the AMPK pathway. *Chemistry and Biology*, **15:** 263-273.

Thomas, C.T., Reddy, P.Y., Devanna, N. 2012. Impact of cooking on charantin estimated from bitter melon fruits using high performance thin layer chromatography. *International Research Journal of Pharmacy*, **3:** 149-154.

Uebanso, T., Arai, H., Taketani, Y., Fukaya, M., Yamamoto, H., Mizuno, A., Uryu, K., Hada, T., Takeda, E. 2007. Extracts of *Momordica charantia* supress postprandial hyperglycemia in rats. *Journal of Nutritional Science and Vitaminology*, **53:** 482-486.

Wang, B.l., Zhang, W., Zhao, J., Wang, F., Fan, L., Hu, Z. 2011. Gene cloning and expression of a novel hypoglycemic peptide from *Momordica charantia*. *Journal of the Science of Food and Agriculture*, **91:** 2443-2448.

Wehash, F.E., Abpo-Ghanema, I.I., Saleh, R.M. 2012. Some physiological effects of *Momordica charantia* and *Trigonella foenum-graecum* extracts in diabetic rats as compared with cidophage. *International Journal of Animal and Veterinary Sciences*, **6:** 222-230.