



ISSN (E): 2277- 7695

ISSN (P): 2349-8242

NAAS Rating: 5.23

TPI 2021; 10(7): 93-96

© 2021 TPI

[www.thepharmajournal.com](http://www.thepharmajournal.com)

Received: 13-05-2021

Accepted: 23-06-2021

**Arun HR**

Department of Processing and Food Engineering, College of Technology and Engineering, Udaipur, Rajasthan, India

**GP Sharma**

Department of Processing and Food Engineering, College of Technology and Engineering, Udaipur, Rajasthan, India

**Nagarathna SB**

Department of Processing and Food Engineering, College of Technology and Engineering, Udaipur, Rajasthan, India

**RC Verma**

Department of Processing and Food Engineering, College of Technology and Engineering, Udaipur, Rajasthan, India

**Arun Kumar Goyal**

College of Dairy and Food Technology, MPUAT, Udaipur, Rajasthan, India

**Corresponding Author:****Arun HR**

Department of Processing and Food Engineering, College of Technology and Engineering, Udaipur, Rajasthan, India

## An overview of bitter gourd: Nutritional and therapeutic benefits

**Arun HR, GP Sharma, Nagarathna SB, RC Verma and Arun Kumar Goyal**

**Abstract**

Bitter gourd (*Momordica charantia* L.) belongs to the family *Cucurbitaceae*. It has significant prominence in providing basic nutritional and medicinal values. It contains various bioactive components including antioxidants, catechin, gallic acid, genetic acid, chlorogenic acid, polysaccharides, triterpenoids, alkaloids, flavonoids, quinine etc., also good source of vitamins and minerals. The present review paper has presents the pharmacological effects like antidiabetic, antibacterial, anti-HIV, Anti-cancer and Anti-tumor properties, and antioxidant activities an insight to understand the mechanism of action.

**Keywords:** Bitter gourd, nutritional value, bioactive compounds, therapeutic properties

**Introduction**

*Momordica charantia* L. generally known as bitter gourd, bitter melon, karela or balsam pear (Satzkar *et al.*, 2013) [37] belongs to a family *Cucurbitaceae*. It is one of the important vegetable because of its rich nutrition and medicinal properties (Islam *et al.*, 2011) [18]. The major growing regions of bitter gourd are South, Southeast and East Asia, Caribbean, South America, Middle East and Africa (Cefalu *et al.*, 2008; Cousins *et al.*, 2008) [8, 10] and it is grown for its medicinal values and also for the ornamental purpose (Heiser, 1979) [15]. They are rich source of Vitamin A and C, essential amino acids, folic acid, thiamine, riboflavin, carotenoids and minerals (Horax *et al.*, 2010; Sandra *et al.*, 2011) [16, 34] because of its rich source; it plays an vital role in human diet. The intake of bitter gourd is increasing day by day due to its therapeutic value like catechin, gallic acid, genetic acid, chlorogenic acid (Budrat and Shotipruk, 2009) [5], polysaccharides, triterpenoids, alkaloids, flavonoids, quinine (Grover and Yadav, 2004) and saponin compounds (Tan *et al.*, 2014) [40]. The polysaccharides of the bitter gourd contains bioactive constituents like antioxidant, antidiabetic, immune enhancing, neuroprotective, antitumor and antimicrobial (Zhang *et al.*, 2016) [48]. It also contains principal component "Momordican" *i.e.* Momordin I is having tumour protective effects; momordicines I and II also having antimicrobial, acylglucosylsterols antimutagenic, and chitinase bacteriostatic effects (Nerurkar *et al.*, 2008) [29].

**Botanical Description**

Bitter gourd is grown in different varieties in different countries. In India the main varieties are India long green, India long white and Hybrid India baby whereas Japan is famous for Japan Green Spindle, China is for Green lover and Hong Kong for its Hong Kong Green. In Bangladesh mainly two varieties are grown *i.e.* Uchee (small) and Korolla (long) (Alam *et al.*, 2015) [1]. The bitter gourd plant is perennial with climbing and flowering vine grows up to 5 m and fruits are elongated with ridges on surface (Lee *et al.*, 2009) [27]. The young fruit is emerald green and later changes to orange-yellow when it is ripened (Kandangath *et al.*, 2015) [22]. The shape and size of bitter gourds vary due to varieties, climatic factors, regions but in general bitter gourds are 1.0 to 9.8 inch long and 1.0 to 5.9 inch wide with round, oval, oblong and club in shape and color varies from dark green to white. In India the length of bitter gourd ranges from 2.4 to 3.9 inch and dark green in color with ridges on its surface (Kumar *et al.*, 2016) [25]. The bitter gourd fruit gets mature after 45-80 days and harvesting is carried out after 60 days and continues up to 150 days from the planting (Islam *et al.*, 2011) [18]. The shelf life of fresh bitter gourd is only 4 days at natural conditions and it can be stored up to 3-4 weeks in cold storage (0 to 7 °C) (Wang *et al.*, 2007) [43].

### Nutritional composition of bitter gourd

The bitter gourd is highly nutritious due to presence higher amount of protein, ascorbic acid, calcium, iron and phosphorus (Assubaie and EI-Garawany, 2004, Dandawate *et al.*, 2016) [2, 11], also important source of glucosides, carbohydrate, charantin, steroidal, saponin, momordium, vitamins, protein and minerals. The protein content in bitter gourd is fractioned into albumin (49.3 per cent), globulin (29.3 per cent) and glutelin (3.1 per cent) (Horax *et al.*, 2010) [16]. Nutritional composition of bitter gourd fruit are shown in Table 1 and 2. The seeds of the bitter gourd contain 35 to 40 per cent of oil and fatty acid *i.e.* 3.33 per cent MUFA (monosaturated fatty acid) and 36.71 per cent SFA (saturated fatty acids) (Grossmann *et al.*, 2009; Liu *et al.*, 2010) [14, 26]. Bitter gourd contains high amount of Vitamin A, Vitamin C and vitamins B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub> and B<sub>12</sub> (Joseph and Jini, 2013) [20]. Bitter gourd seeds are good source of minerals such as potassium, magnesium, calcium, sodium and phosphorus being the most abundant and highest among the other minerals in fruits and leaves (Liu *et al.*, 2010) [26]. The total phenolic content in bitter gourd was examined by HPLC method, found that for immature, mature and ripe bitter gourd contains 6.9 to 15.7, 6.4 to 14.8 and 4.3 to 14.9 mg GAE/g ethanol extract, respectively and identified phenolic components are gallic acid, epicatechin, catechin, chlorogenic acid and genistic acid is also reported (Horax *et al.*, 2010; Ibrahim *et al.*, 2010; Yadav *et al.*, 2010; Tan *et al.*, 2014) [16, 17, 45, 40]. The bitter gourd contains range of bioactive compounds in which saponins contains two classes *i.e.* oleanane and cucurbitane-type triterpenoids (Popovich *et al.*, 2010) [32] along with momordicoside U, momordicine I, momordicine II (Pandit *et al.*, 2016; Sabourian *et al.*, 2016) [30, 33]. The presence of galacturonic acid in the pulp is also reported. The bitterness of bitter gourd is due to presence of Momordicine and Charantin which is responsible for health encouraging effect (Kumar *et al.*, 2010) [24].

**Table 1:** Proximate composition of bitter gourd

Parameter	Fruit	Leaf	Seed
Moisture (%)	10.74 ± 2.29	17.95 ± 1.00	20.64 ± 5.85
Total ash (%)	7.36 ± 0.52	15.42 ± 2.08	9.73 ± 2.34
Crude fibre (%)	6.11 ± 0.42	3.68 ± 0.68	11.50 ± 1.77
Fiber (%)	1.7 ± 0.5	3.31 ± 1.25	29.60 ± 1.25
Crude protein (%)	27.88 ± 3.75	27.46 ± 1.60	19.50 ± 0.73
Carbohydrate (%)	34.31 ± 0.30	32.34 ± 0.24	9.18 ± 0.86
Calorific value (kcal/100g)	241	213	176

(Source: Bakare *et al.*, 2010) [3]

**Table 2:** Mineral composition of bitter gourd

Components	Concentration (ppm)
Calcium	20510 ± 5.77
Magnesium	255 ± 0.69
Sodium	2200 ± 1.15
Potassium	413 ± 1.45
Iron	98 ± 0.23
Zinc	120 ± 1.15
Manganese	156 ± 0.33
Copper	32 ± 1.85
Vitamin C	66000 ± 141
Vitamin B <sub>12</sub>	5355 ± 7.10
Folic acid	20600 ± 42.43

Source: Bakare *et al.*, 2010 [3]

### Therapeutic aids of bitter gourd

The various researchers studied the therapeutic properties of

bitter gourd, they are anti-diabetic, anti-ulcerogenic, anti-mutagenic, anti-leukemic, antioxidant, anti-HIV, anti-bacterial, anti-tumor, immune-modulatory activities *etc.*, (Uebanso *et al.*, 2007; Kandangath *et al.*, 2015) [42, 22]. Some important therapeutic effects are described as follows:

#### a) Antidiabetic activity

Many research studies proven that the intake of bitter gourd fruit, juice, dried powder and extracts acts as a antidiabetic medicine by lowering of blood sugar level (Lawrence *et al.*, 2009). Ali *et al.* (1993) found that after consumption of saponin free methanolic extract of bitter gourd juice by insulin-dependent diabetes mellitus (IDDM) rats and normal rats showed that significant hypoglycemic effect in fasting and post-prandial states than non-insulin-dependent diabetes mellitus (IDDM). The consumption of bitter gourd extracts about 13.33 g pulp per kg body weight/day by diabetic rats they observed reduce in body weight and high level of fasting blood glucose (Chaturvedi *et al.*, 2010; Klomann *et al.*, 2010) [23]. In alloxan diabetic albino rats, the acetone extract of bitter gourd about 50, 25 and 75 mg per 100 g body weight lowered the level of glucose in blood from 13.30 to 50 per cent after treatment for 8 to 30 days (Singh *et al.*, 2007; Jiang *et al.*, 2016) [38, 19]. The anti-hyperglycemic property of bitter gourd is due to presence of compounds like oleanolic acid 3-O-glucuronide, charantin, polypeptide-p, oleanolic acid 3-O-monodesmoside and momordicin and these compounds enhance the production of insulin and promote the growth and repair of beta cells in pancreatic beta cells (Wang *et al.*, 2010) [44]. The bitter gourd acts as vegetable insulin (Leung *et al.*, 2009) [28] and also increases the use of glucose in liver and muscle (Sarkar *et al.*, 1996) [36].

#### b) Anti-bacterial activity

Bitter gourd is a basis for natural products which is derived from plant with antifungal-modifying and antieipimastigote activity (Santos *et al.*, 2012) [35] and presence of Alpha-momorcharin has ability to inhibit the fungal growth and bacterial growth due its Ribosome Inactivating Protein (RIP) (Zhu *et al.*, 2013) [49]. The extract of whole plant has antiprotocol action and extracts of bitter gourd leaf *viz.* methanol, water and ethanol has antibacterial action against *Salmonella*, *Pseudomonas aeruginosa*, *E. coli*, *Bacillus* and *Streptococcus* (Brandao *et al.*, 2016). In Colombia and Panama tea from leaves of bitter gourd leaves was used for treatment of malaria and by laboratory studies was confirm that species associated with bitter gourd has anti-microbial activity (Olasehinde *et al.*, 2014).

#### c) Anti-HIV activity

The fruit, seeds and leaves of bitter gourd has  $\alpha$  and  $\beta$ -momorcharin protein and these protein acts as an anti-HIV activity *in-vitro* (Zheng *et al.*, 1999) and also suppress the HIV-1 integrase (Au *et al.*, 2000). The bitter gourd also contains MRK29 protein which has ability to inhibit the viral reverse transcriptase (Wang and Ng, 2001).

#### d) Anti-cancer and Anti-tumor properties

The bitter gourd has several components which exhibit anticancer properties they are, momordin I, *i.e.* and Id, Alpha and beta momorcharin, cucurbitacin B and MAP-30 (Fan *et al.*, 2015) [12]. The anti-proliferative action of bitter gourd extract used to inhibits the growth breast cancer by encouraging autophagic cell death (170). The growth of

prostate cancer inhibited by the Kuguacin J which is extracted from bitter gourd (Pitchakarn *et al.*, 2011, Brennan *et al.*, 2012) [31, 4]. From *in-vivo* and *in-vitro* studies stated that MAP-30 is efficient and safe against liver cancer (Fang *et al.*, 2012a) [13]. The bioactive components of bitter gourd inhibit the DNA, RNA and cellular protein synthesis and it also suppress the cell cycle G2. It inhibit the uptake of thymidine, uridine and leucine into DNA through M phase (Clafin *et al.*, 1978) [9] and also induction of apoptosis can be observed by treatment of bitter gourd (Sun *et al.*, 2001) [39].

#### e) Anti-oxidant activity

The anti-oxidant activity of bitter gourd from phenolic extracts has been reported (Horax *et al.*, 2005). The leaf extract has highest value of DPPH radical-scavenging activity and ferric reducing power whereas bitter gourd fruit has highest value of hydroxyl radical-scavenging activity, beta-carotene-linoleate bleaching assay and total anti-oxidant capacity (Yadav *et al.*, 2016) [46]. The anti-oxidants are capable of damaging and contracting free radicals (Kamal *et al.*, 2011; Yehye *et al.*, 2016) [21, 47]. The stress-induces lipid peroxidation is inhibited by bitter gourd by increasing the catalase activity and levels of reduces glutathione (Chaturvedi, 2009, Alam *et al.*, 2015) [6, 1]. So bitter gourd should be used in human diet.

#### Conclusion

The main reason for the interest in bitter gourd is its medicinal and nutritional properties. Bitter gourd is bitter in taste but not bitter for health. Because the presences of many bioactive components are naturally present in this bitter gourd and have potentially act as therapeutic benefits. This review provides the information about pharmacological effects like antidiabetic, antibacterial, anti-HIV, anti-cancer and anti-tumor properties, and antioxidant activities.

#### References

1. Alam MA, Uddin R, Subhan N, Rahman MM, Jain P, Reza HM. Beneficial Role of Bitter Melon Supplementation in Obesity and Related Complications in Metabolic Syndrome. *Journal of Lipid* 2015;1-18.
2. Assubaie NF, El-garawany MM. Evaluation of some important chemical constituents of *Momordica charantia* cultivated in Hofuf, Saudi Arabia. *Journal of Biological Science* 2004;4:628-630.
3. Bakare RI, Magbagbeola OA, Akinwande AI, Okunowo OW. Nutritional and chemical evaluation of *Momordica charantia*. *Journal of Medicinal Plants Research* 2010;4:2189-2193.
4. Brennan VC, Wang CM, Yang WH. Bitter melon (*Momordica charantia*) extract suppresses adrenocortical cancer cell proliferation through modulation of the apoptotic pathway, steroidogenesis, and insulin-like growth factor type 1 receptor/RAC- $\alpha$  serine/threonine-protein kinase signaling. *Journal of Medicinal Food* 2012;15(4):325-334.
5. Budrat P, Shotipruk A. Enhanced recovery of phenolic compounds from bitter melon (*Momordica charantia*) by subcritical water extraction. *Separation and Purification Technology* 2009;66:125-129.
6. Chaturvedi P. Bitter melon protects against lipid peroxidation caused by immobilization stress in albino rats. *International Journal for Vitamin and Nutrition Research* 2009;79(1):48-56.
7. Chaturvedi P, George S. *Momordica charantia* maintains normal glucose levels and lipid profiles and prevents oxidative stress in diabetic rats subjected to chronic sucrose load. *Journal of medicinal food* 2010;13(3):520-7.
8. Cefalu WT, Ye J, Wang ZQ. Efficacy of dietary supplementation with botanicals on carbohydrate metabolism in humans. *Endocrine, Metabolic and Immune Disorders-Drug Targets* 2008;8:78-81.
9. Clafin AJ, Vesely DL, Hudson JL, Bagwell CB, Lehotay DC, Lo TM *et al.* Inhibition of growth and guanylate cyclase activity of an undifferentiated prostate adenocarcinoma by an extract of the balsam pear (*Momordica charantia* abbreviata). *Proceedings of the National Academy of Sciences USA* 1978;75:989-993.
10. Cousins G. There is a cure for diabetes: the tree of life 21 day program, California: North Atlantic Books 2008,191-192p.
11. Dandawate PR, Subramaniam D, Padhye SB, Anant S. Bitter melon: a panacea for inflammation and cancer. *Chinese Journal of Natural Medicines* 2016;14(2):81-100.
12. Fan X, He L, Meng Y, Li G, Li L, Meng Y. A-MMC and MAP30, two ribosomeinactivating proteins extracted from *Momordica charantia*, induce cell cycle arrest and apoptosis in A549 human lung carcinoma cells. *Molecular Medicine Reports* 2015;11(5):3553-8.
13. Fang EF, Zhang CZ, Wong JH, Shen JY, Ng TB. The MAP30 protein from bitter gourd (*Momordica charantia*) seeds promotes apoptosis in liver cancer cells *in vitro* and *in vivo*. *Cancer Letters* 2012a;324(1):66-74.
14. Grossmann ME, Mizuno NK, Dammen ML, Schuster T, Ray A, Cleary. M.P. Eleostearic Acid inhibits breast cancer proliferation by means of an oxidation-dependent mechanism. *Cancer prevention research* 2009;2(10):879-86.
15. Heiser CB. The gourd book. University of Oklahoma Press, Norman, OK 1979.
16. Horax R, Hettiarachchy N, Chener P. Extraction, Quantification, and Antioxidant Activities of Phenolics from Pericarp and Seeds of Bitter Melons (*Momordica charantia*) Harvested at Three Maturity Stages (Immature, Mature, and Ripe). *Journal of Agricultural and Food Chemistry* 2010;58:4428-4433.
17. Ibrahim TA, El-Hefnawy HM, El-Hela AA. Antioxidant potential and phenolic acid content of certain cucurbitaceous plants cultivated in Egypt. *Natural Product Research* 2010;24(16):1537-45.
18. Islam S, Jalaluddin M, Hettiarachchy NS. Bioactive compounds of bitter melon genotypes (*Momordica charantia* L.) in relation to their physiological functions. *Functional Foods in Health and Disease* 2011;2:61-74.
19. Jiang B, Ji M, Liu W, Chen L, Cai Z, Zhao Y *et al.* Antidiabetic activities of a ucubitane type triterpenoid compound from *Momordica charantia* in alloxan induced diabetic mice. *Molecular Medicine Reports* 2016.
20. Joseph B, Jini D. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. *Asian Pacific Journal of Tropical Disease* 2013;3:93-102.
21. Kamal R, Yadav S, Mathur M, Katariya P. Antiradical efficiency of 20 selected medicinal plants. *Journal of Natural Products* 2011.
22. Kandangath RA, Garlapati PK, Nallamuthu I. Nutritional, pharmacological and medicinal properties of *Momordica*

- charantia*. International Journal of Nutrition and Food Sciences 2015;4:75-83.
23. Klomann SD, Mueller AS, Pallauf J, Krawinkel MB. Antidiabetic effects of bitter melon extracts in insulin-resistant db/db mice. British journal of nutrition 2010;104(11):1613-20.
  24. Kumar R, Balaji S, Sripriya R, Nithya N, Uma TS, Sehgal PK. *In vitro* evaluation of antioxidants of fruit extract of *Momordica charantia* L. on fibroblasts and keratinocytes. Journal of Agricultural and Food Chemistry 2010;58(3):1518-22.
  25. Kumar AM, Naik KM, Pathare J, Balfour D, Kotecha PM. Studies on osmo-air drying of bitter melon chips-physica, chemical composition. International Journal of Advanced Scientific Technical Research 2016;3:175-196.
  26. Liu XR, Deng ZY, Fan YW, Li J, Liu ZH. Mineral elements analysis of *Momordica charantia* seeds by ICP-AES and fatty acid profile identification of seed oil by GCMS. Guang Pu Xue Yu Guang Pu Fen Xi 2010;30(8):2265-8.
  27. Lee SY, Eom SH, Kim YK, Park NI, Park SU. Cucurbitane-type triterpenoids in *Momordica charantia* Linn. Journal of Medicinal Plants Research 2009;3(13):1264-1269.
  28. 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.
  29. Nerurkar PV, Lee YK, Motosue M, Adeli K, Nerurkar VR. *Momordica charantia* (bitter melon) reduces plasma apolipoprotein B-100 and increases hepatic insulin receptor substrate and phosphoinositide-3 kinase interactions. British Journal of Nutrition 2008;100:751-759.
  30. Pandit S, Kanjilal S, Awasthi A, Chaudhary A, Banerjee D, Bhatt BN *et al.* Evaluation of herbdrug interaction of a polyherbal Ayurvedic formulation through high throughput cytochrome P450 enzyme inhibition assay. Journal of ethno pharmacology 2016;16:304-308.
  31. Pitchakarn P, Suzuki S, Ogawa K, Pompimon W, Takahashi S, Asamoto M *et al.* Induction of G1 arrest and apoptosis in androgen-dependent human prostate cancer by Kuguacin J, a triterpenoid from *Momordica charantia* leaf. Cancer Letters 2011;306(2):142-50.
  32. Popovich DG, Li L, Zhang W. Bitter melon (*Momordica charantia*) triterpenoid extract reduces preadipocyte viability, lipid accumulation and adiponectin expression in 3T3-L1 cells. Food and Chemical Toxicology 2010;48(6):1619-26.
  33. Sabourian R, Karimpour-Razkenari E, Saeedi M, Bagheri MS, Khanavi M, Sadati N *et al.* Medicinal Plants Used in Iranian Traditional Medicine (ITM) as Contraceptive Agents. Current Trends in Biotechnology and Pharmacy 2016;17(11):974-85.
  34. Sandra DH, Veronica K, Silvia R, Christian B, Andreas SM, Joseph P *et al.* Quantification of antidiabetic extracts and compounds in bitter melon varieties. Food Chemistry 2011;126:172-176.
  35. Santos KK, Matias EF, Sobral-Souza CE, Tintino SR, Morais-Braga MF, Guedes GM *et al.* Trypanocidal, cytotoxic, and antifungal activities of *Momordica charantia*. Pharmaceutical Biology 2012;50(2):162-6.
  36. Sarkar S, Pranava M, Marita R. Demonstration of the hypoglycemic action of *Momordica charantia* in a validated animal model of diabetes. Pharmacological Research 1996;33:1-4.
  37. Satkar KP, Kulthe AA, Chalke PR. Preparation of bitter melon ready to serve beverage and effect of storage temperature on its keeping quality 2013;8:115-117.
  38. Singh N, Gupta M. Regeneration of beta cells in islets of Langerhans of pancreas of alloxan diabetic rats by acetone extract of *Momordica charantia* (Linn.) (*Bitter melon*) fruits. Indian Journal of Experimental Biology 2007;45(12):1055-62.
  39. Sun Y, Huang PL, Li JJ, Huang YQ, Zhang L, Huang PL *et al.* Anti-HIV agent MAP30 modulates the expression profile of viral and cellular genes for proliferation and apoptosis in AIDS-related lymphoma cells infected with Kaposi's sarcoma associated virus. Biochemical Biophysical Research Communication 2001;287:983-994.
  40. Tan, Parks, Stathopoulos. Greenhouse-grown bitter melon: production and quality characteristics. Journal of the Science Food and Agriculture 2014;94:1896-1903.
  41. Tan SP, Stathopoulos C, Parks S, Roach P. An Optimised Aqueous Extract of Phenolic Compounds from Bitter Melon with High Antioxidant Capacity. Antioxidants (Basel) 2014;3(4):814-29.
  42. Uebanso T, Arai H, Taketani Y, Fukaya M, Yamamoto H, Mizuno A *et al.* Extracts of *Momordica charantia* suppress postprandial hyperglycemia in rats. Journal of Nutritional Science Vitaminology 2007;53:482-488.
  43. Wang L, Li Q, Cao J, Cai T, Jiang W. Keeping quality of fresh-cut bitter melon (*Momordica charantia*) at low temperature of storage. Journal of Food Processing and Preservation 2007;31:571-582.
  44. Wang BL, Zhang WJ, Zhao J, Wang FJ, Fan LQ, Wu YX *et al.* Gene cloning and expression of a novel hypoglycemic peptide from *Momordica charantia*. Journal of the Science of Food and Agriculture 2010;91(13):2443-2448.
  45. Yadav M, Lavania A, Tomar R, Prasad GB, Jain S, Yadav H. Complementary and comparative study on hypoglycemic and antihyperglycemic activity of various extracts of *Eugenia jambolana* seed, *Momordica charantia* fruits, *Gymnema sylvestre*, and *Trigonella foenum graecum* seeds in rats. Biotechnology and Applied Biochemistry 2010;160(8):2388-400.
  46. Yadav BS, Yadav R, Yadav RB, Garg M. Antioxidant activity of various extracts of selected gourd vegetables. Journal of Food Science 2016;53(4):1823-33.
  47. Yehye WA, Abdul Rahman N, Saad O, Ariffin A, Abd Hamid SB, Alhadi AA *et al.* Rational Design and Synthesis of New, High Efficiency, Multipotent Schiff Base-1,2,4-triazole Antioxidants Bearing Butylated Hydroxytoluene Moieties. Molecules 2016;21(7):84-87.
  48. Zhang F, Lin L, Xie J. A mini-review of chemical and biological properties of polysaccharides from *Momordica charantia*. International Journal of Biological Macromolecules 2016;92:246-253.
  49. Zhu F, Zhang P, Meng YF, Xu F, Zhang DW, Cheng J *et al.* Alpha-momocharin, a RIP produced by bitter melon, enhances defense response in tobacco plants against diverse plant viruses and shows antifungal activity *in vitro*. Planta 2013;237(1):77-88.