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Uncovering the Role of *Momordica charantia* in Diabetes: Therapeutic and Biotechnological Perspectives



"Young people and multidisciplinary research in applied life sciences"

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Abstract: Type 2 diabetes is a serious condition that affects millions of people worldwide. Researchers are continuously working to uncover new insights into this disease. Although various treatments, such as pills and injectable medications, are available, many of these options come with undesirable side effects. As a result, there is a growing interest in medicinal plants as natural alternatives to conventional drugs. *Momordica charantia*, commonly known as bitter melon, has demonstrated significant potential in the treatment of diabetes. This review aims to summarize recent research in the field of biotechnology, highlighting its intersection with medicine. It explores how biotechnological advancements can provide a quick and efficient means to produce the necessary active compounds for managing type 2 diabetes effectively.

Introduction

Momordica charantia, widely recognized as bitter melon or bitter gourd, is a plant of significant global medicinal and biotechnological interest. Known for its pronounced therapeutic properties, this plant plays a vital role in traditional medicine systems across cultures. With its rich repository of bioactive compounds, it has garnered attention in contemporary research, particularly for its potential in managing chronic diseases like type 2 diabetes. Recent advancements have highlighted its applications in biotechnology, emphasizing efficient in vitro cultivation and regeneration protocols. This biotechnological progress enables the large-scale production of the plant's active compounds, offering a promising alternative to conventional drug synthesis. The therapeutic potential of *Momordica charantia* spans diverse fields, including oncology, where its extracts have demonstrated antitumor properties across various cancer types such as breast, colon, liver, and prostate cancers. Key compounds like cucurbitane-type triterpenes and MAP30 contribute to its anticancer efficacy. Furthermore, its applications in treating type 2 diabetes are notable, with evidence supporting its ability to regulate glucose levels and reduce side effects associated with synthetic antidiabetic drugs. This plant represents a nexus of medicine and agriculture, presenting opportunities for innovations in nutraceuticals and functional foods. As research progresses, *Momordica charantia* continues to be a focal point for developing cost-effective and sustainable therapeutic solutions for prevalent health issues. Its biotechnological potential underscores the importance of interdisciplinary research in enhancing its applications and understanding its mechanisms of action. This perspective not only validates its traditional uses but also paves the way for modern therapeutic interventions, underscoring the fusion of ancient wisdom with scientific innovation.

The biotechnological and medicinal potential of *Momordica charantia* underscores its vital role in addressing contemporary health challenges. With its rich array of bioactive compounds and proven therapeutic benefits, particularly in the treatment of type 2 diabetes and various cancers, this plant bridges the gap between traditional medicine and modern science. Recent advancements in in vitro cultivation and regeneration protocols have enhanced its accessibility, enabling large-scale production of its active compounds. These developments not only reinforce its role in medicine but also position it as a key resource in the nutraceutical and functional food industries. As ongoing research continues to explore its applications, *Momordica charantia* serves as a compelling example of the value of integrating traditional knowledge with scientific methodologies. Its versatility across medicine, agriculture, and biotechnology highlights its potential to inspire innovative solutions for global health issues.

Recent research in biochemistry

• Evaluation of the effect of growth regulators on the micropropagation process of medicinal plant (*Momordica charantia*), and identification of secondary compounds of different organs using GC-MS - 2023

A comprehensive review on bitter gourd (*Momordica charantia* L.) as a gold mine of functional bioactive components for therapeutic foods - 2022

• 3 mg/L 2,4-D led to the highest percentage of callus formation
• 2 mg/L BAP resulted in the highest percentage of future plant regeneration
• Following the regeneration, leaves, roots and fruits were obtained which were tested by GC – MS, the results obtained demonstrated the highest number of secondary metabolites were found in the fruit

Review:
✓ nutritional aspects
✓ various bioactive compounds present
✓ important nutraceutical properties

Recent research in medicine

Tumor	Compound(s)	Cells	Animals	References
Breast	Cucurbitane-type triterpene	MCF-7, MDA-MB-231		Weng et al., 2013
	RNase MC2	MCF-7		Fang et al., 2012a
	MC extract	MCF-7, MDA-MB-231		Ray et al., 2010
	Eleostearic acid	MDA-ERu7		Grossmann et al., 2009
	Water MC extract		SHN mice	Nagasawa et al., 2002
Colon	MAP30	MDA-MB-231	SCID mice	Lee-Huang et al., 2000
	α -momorcharin	MCF-7, MDA-MB-231, MDAMB-453	Balb/C mice	Cao et al., 2015
	Methanol MC extract	HT-29, SW480, HFF		Kwatra et al., 2013
	Methanol MC extract	Hone-1, AGS, HCT-116, CL1-0		Li et al., 2012a
	Acid and alkali MC extracts	SGC-7901		Li et al., 2012b
	MAP30	LoVo		Fan et al., 2008
	MC fatty acids	Caco-2		Yasui et al., 2005
	MC extract		Swiss mice	Deep et al., 2004
	MC extract		F344 rats	Kohno et al., 2004
	MAP30	Hep G2	Balb/C nude mice	Fang et al., 2012b
Liver	RNase MC2	Hep G2	Balb/C nude mice	Fang et al., 2012c
	MC lectin	Hep G2, PLC/PRF/5	Nude mice	Zhang et al., 2015
	Cucurbitane-type triterpene glycosides	Hep G2, Hep 3B		Yue et al., 2019
	MC extract	PC3, LNCaP	TRAMP mice	Ru et al., 2011
Prostate	MC leaf extract, Kuguacin J	LNCaP, PNT1A		Pitchakarn et al., 2011
	MC leaf extract	PLS10	Nude mice	Pitchakarn et al., 2010
	MC30	LNCaP, PC-3, RWPE-1, PIN	Nude mice	Xiong et al., 2009
Bladder	48-127/momordin IT	T24		Battelli et al., 1996
Glioma	Transferin/momordin IT	HS583, U251		Gosselaar et al., 2002
Lymphoma	Ber-H2/momordin IT	ALCL	SCID mice	Terenzi et al., 1996
	OM124/momordin IT	Daudi, EHM, BJAB, Raji, BM21	SCID mice	Biolognesi et al., 1998
Leukemia	Ethanol MC extracts	ED, SuGT01, S1T, HUT-102, MT-2, Jurkat, MOLT-4		Kai et al., 2011
	Ethanol MC extracts	HL60	Balb/cAnNCrj-nu/nu mice	Kobori et al., 2008b
	Anti-CD5/momordin IT	Peripheral blood mononuclear cells, Jurkat	nu/nu mice	Porro et al., 1993

Recent research in vitro culture

Plant regeneration from embryogenic callus-derived from immature leaves of *Momordica charantia* L – anul 2023

• The highest percentage of callus formation (95.09%), from leaf explants, was obtained in MSB5 medium with 1.2 mg L⁻¹ ANA and 0.5 mg L⁻¹ TDZ.
• MSB5 medium without growth regulators is the most suitable for shoot and root formation from callus, producing a significant shoot percentage of 90.91 % and 21.53 shoots per explant

Development of in vitro Regeneration Protocol in Bitter Gourd (*Momordica charantia*) –anul 2024

• Sterile seeds were grown on ½ MS medium to obtain explants.
• The combination of MS + 1.0 mg/l BAP was found to be the most effective for shoot induction from axillary buds, producing a maximum number of 3.19 shoots at a minimum interval of 7.30 days for shoot initiation.
• Whereas MS medium with 1.5 mg/l BAP was suitable for shoot induction from apical meristem producing shoot number 2.33 with minimum 7.67 days for shoot initiation.

In vitro Rapid Regeneration of Bitter Melon (*Momordica charantia* L.) Using Direct Organogenesis in Kenya – anul 2022

• Nodal explants were obtained from in vivo seedlings grown for 30 days in a greenhouse and then cultured on MS media with a range of concentrations of BAP or KIN (0.50 - 2.5 mg/L), either alone or in combination.
• Shoots were induced on MS + 0.5 mg/L BAP + 0.5 mg/L Kin medium with a maximum shoot induction frequency of 72.17±2.83%.
• Shoots were inoculated on MS 1/2 media without growth regulators or supplemented with IBA, ANA and AIA at different concentrations (0.5 - 1.5 mg/L) to promote root induction.

Secondary metabolites are chemical compounds produced by plants that are not directly involved in their growth or reproduction but play essential roles in defense, signaling, and adaptation to environmental conditions. In the case of *Momordica charantia* (bitter melon), these metabolites exhibit diverse bioactivities, making the plant highly valuable in medicine and biotechnology.

Antidiabetic Properties: The secondary metabolites in *Momordica charantia* enhance insulin sensitivity, regulate blood glucose levels, and promote glucose uptake in cells, making it effective in managing type 2 diabetes. Charantin, a blend of saponins and alkaloids, is a key compound responsible for these effects.

Anticancer Effects: Extracts of bitter melon rich in cucurbitane-type triterpenes and MAP30 (*Momordica* Anti-HIV Protein 30) have shown efficacy against cancers of the breast, colon, liver, and prostate. These compounds act by inhibiting tumor growth and inducing apoptosis in cancer cells.

Conclusions

The biotechnological potential of *Momordica charantia* is vast, having an important role in different fields (medicine, agriculture), especially in the treatment of type II diabetes, opening new research opportunities and therapeutic applications for this medicinal plant.