Research Article

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Phytochemical analysis of *Momordica balsamina* L. fruits

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ABSTRACT

Momordica balsamina L., commonly known as balsam apple or African pumpkin, is a vegetable with high nutritional value. It contains bioactive compounds with medicinal properties and has been extensively used in traditional medicine to treat a range of ailments, including malaria, fevers, and diabetes. This study focused on analyzing the bioactive compounds in *Momordica balsamina* fruits using GC-MS/MS. A total of 100 bioactive compounds were detected in the green fruits, while 109 were identified in the ripe fruits. These compounds exhibit significant pharmacological properties and have the potential to be used in the treatment of various human diseases.

Introduction

The balsam apple, also known as the African pumpkin (*Momordica balsamina* L.), is considered one of the most significant medicinal plants, widely used as a source of life-saving treatments for people around the world (Hassan and Umar, 2006; Thakur *et al.*, 2009 and Souda *et al.*, 2018). This crop can be consumed as a vegetable to supplement protein and potassium in the diets of poor rural communities. Its high potassium content is also associated with the treatment of hypertension and other cardiovascular diseases (Souda *et al.*, 2018). *M. balsamina* is useful in the production of dietary supplements because of its high protein and fat content and low fibre level.

The extracts from *Momordica* spp. are known for their reputed bioactivities, including antidiabetic, antimicrobial, anthelmintic, abortifacient, antibacterial, and antiviral properties. Various parts of *Momordica* species are rich in both primary and secondary metabolites. The primary metabolites derived from *Momordica* spp. include sugars, proteins, and chlorophyll (Hassan and Umar, 2006 and Muronga *et al.*, 2021), while the secondary metabolites consist of alkaloids, flavonoids, and tannins (Madala *et al.*, 2016; Muronga *et al.*, 2021; Jadhav and Kamble, 2022 and Choudhary *et al.*, 2022). *Momordica* spp. contain "Momordin", a therapeutic agent known for its ability to inhibit the replication of HIV and other viruses. Additionally, it functions as both an anti-diabetic and anti-cancer agent (Thakur *et al.*, 2009).

Fully exploring the effectiveness of *Momordica balsamina* plant extracts could lead to new drug discoveries or enhance the use of indigenous herbal medicines in conventional treatments for certain diseases (Karumi *et al.*, 2003; Bhardwaj *et al.*, 2010 and Rahmatullah *et al.*, 2012). The aim of this study was to analyze the biochemical and medicinal properties of

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Momordica balsamina, assessing its potential as a promising and innovative source of natural bioactive compounds for future pharmaceutical applications and promotion/ popularization of this neglected crop.

Material and Methods

Mature, green and full-ripened fruits of *M. balsamina* genotype CIAHMB-1 were harvested at peak fruiting season during August 2020, from the Experimental Farm of the ICAR Central Institute for Arid Horticulture, Bikaner, Rajasthan, India, at a latitude of 28°N and longitude of 73°18'E and an altitude of 234.84 m amsl. After the fruits were harvested, they were sun-dried for 6 days at room temperature. After drying, they were ground into a powder and stored at -20°C until further analysis. The samples were analyzed in January 2021 in the Food Testing Laboratory, Department of Biotechnology, Junagadh Agricultural University, Junagadh, Gujarat.

For analysis, 200 mg of the dried and powdered fruit sample was homogenized in a pre-chilled mortar and pestle with 3 ml of ice-cold HPLC-grade methanol (100%). The homogenate was incubated in a water bath at 70°C for 10 minutes, with continuous shaking at 950 rpm. After that, the mixture was centrifuged at 11,000 g for 10 minutes. The supernatant resulting from this step was divided into two aliquots. One portion was used in TAA determinations, and the other portion was transferred to a Schott GL14 glass tube. To this, were added 1.5 ml pre-chilled chloroform and 3 ml ice-cold deionized water (4°C), and then mixed on a vortex for 20 seconds. After centrifugation at 2200 g for 15 minutes, the top (polar) and bottom (non-polar) phases were transferred into separate test tubes and dried to dryness under a stream of nitrogen. All reagents and chemicals used in this present study were standard make and quality. Ultrapure water of 18.2 MΩ·cm was used in all assays through the Milli-Q Simplicity, Millipore, France.

Bioactive compounds of the methanolic extract were quantified using GC-MS/MS (GCMSQP2010Plus, Shimadzu). An aliquot of 4 µl was injected into the DB 17MS capillary column 30 m x 0.25 mm. Injection temperature at 280°C with a 5-minute solvent delay and an initial GC oven temperature of 65°C, which was raised after 2 minutes to 290°C. The temperature of the ion source was 230°C. Helium was used as the carrier gas at a constant flow of 1 ml/min. Measurements were obtained with electron impact ionization at a setting of 70 eV and in full scan mode (m/z 50–900) at a rate of 2000. Tentative identification of the phytochemicals was determined based on the retention times and mass spectra of the standards compared to the NIST 14 library. Baseline correction, alignment, peak picking, and integration on the total ion chromatograms were performed using ACD/Spec Manager v. 12.00, while data analysis was done with CSV comma-delimited files.

Result and Discussion

The non-targeted phytochemical profiling of *Momordica balsamina* through GC-MS/MS analysis of methanolic extracts from dried fruits (both green and ripe) led to the detection and identification of numerous compounds. These compounds were verified by matching their mass spectra with entries from the NIST 14 library. Tables 1 and 2 provide detailed information on the compounds identified, including retention time (in minutes), peak area percentage, compound names, molecular formulas, and molecular weights. The height of each peak corresponds to the relative concentration of the bioactive compounds. The GC-MS/MS chromatograms revealed a total of 100 compounds in the green fruits (Table 1) and 109 compounds in the ripe fruits (Table 2).

The analysis identified several key phytochemicals in *Momordica balsamina* fruits, including 3',5'-Dimethoxyacetophenone, Ar-tumerone, Ascorbic acid, Heptadecanoic acid, Cyclopropanedecanoic acid 2-hexyl, Cyclononasiloxane (octadecamethyl-), 4,7,10-Hexadecatrienoic acid, 8,11,14-Eicosatrienoic acid (Z,Z,Z), 2-(Dimethylamino) ethyl adamantanecarboxylate, Dotriacontane, 2,6,10,14,18,22-Tetracosahexaene, 6,9,12,15-Docosatetraenoic acid, and Bisabolen-12-OL. According to the literature, many of these compounds exhibit biological activity and have been linked to nutraceutical and pharmaceutical applications, with potential therapeutic effects against major diseases such as cancer, diabetes, cardiovascular disorders, and other chronic conditions (Bot *et al.*, 2007; Spengler *et al.*, 2009; Thakur *et al.*, 2009; Souda *et al.*, 2018; Muronga *et al.*, 2021 and Choudhary *et al.*, 2022).

Among the detected compounds, a substantial portion (approximately 60%) consisted of fatty acids, including monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), and some unusual fatty acids with odd-numbered carbon chains. Many of these compounds have demonstrated notable bioactivities, including antimicrobial, anti-inflammatory, anticancer, analgesic, antipyretic, antidiabetic, hepatoprotective, cardiovascular, antioxidant, and anti-mutagenic effects (Souda *et al.*, 2018; Muronga *et al.*, 2021; Choudhary *et al.*, 2022). Several studies have also highlighted the bioactive compounds in *M. balsamina*, such as Cucurbitane glycoside and Kuguacin J, which have proven anti-diabetic properties (Spengler *et al.*, 2009), and Karavilagenin C, Balsaminagenin A, and Balsaminoside B, known for their anti-cancer potential (Ramalhete *et al.*, 2009). Additionally, Momordin I and Momordin II have been shown to possess antiviral activity (Thakur *et al.*, 2009), while Balsaminapentaol has demonstrated anti-malarial effects (Ramalhete *et al.*, 2009).

Table 1: Compounds detected in methanolic extract of *M. balsamina* (dried green fruits) through GC-MS/MS analysis

Peak No.	R. Time (minute)	Area (%)	Height (%)	Compound	Molecular formula	Molecular weight
1	3.778	0.22	0.29	3,3-Dimethoxy-2-butanone	$C_6H_{12}O_3$	132
2	5.162	0.04	0.07	1,2-Cyclopentanedione	$C_5H_6O_2$	98
3	6.158	0.49	0.21	Ethane, 1,1,1-triethoxy-	$C_8H_{18}O_3$	162
4	6.285	1.06	0.49	Phenol	C_6H_6O	94
5	6.688	0.44	0.28	Decane	$C_{10}H_{22}$	142
6	6.875	0.27	0.16	Glycerin	$C_3H_8O_3$	92
7	8.300	0.05	0.03	2-Pyrrolidinone	C_4H_7NO	85
8	8.775	0.05	0.05	3,3-Diethoxy-1-propyne	$C_7H_{12}O_2$	128
9	8.892	0.07	0.07	Phenol, 2-methoxy-	$C_7H_8O_2$	124
10	10.470	0.38	0.41	Silane, triethylmethoxy-	$C_7H_{18}OSi$	146
11	11.475	0.03	0.05	Dimethyl, fluoromethyl, phenylsilane	$C_9H_{13}FSi$	168
12	12.095	0.63	0.52	1,4:3,6-Dianhydro-.alpha.-d-glucopyranose	$C_6H_8O_4$	144
13	12.636	0.04	0.05	1-Dimethyl(octyl)silyloxypropane	$C_{13}H_{30}OSi$	230
14	13.081	0.17	0.17	1-Butanone, 1-phenyl-	$C_{10}H_{12}O$	148
15	14.175	0.13	0.11	Cyclohexasiloxane, dodecamethyl-	$C_{12}H_{36}O_6Si_6$	444
16	14.466	0.19	0.31	2-Methoxy-4-vinylphenol	$C_9H_{10}O_2$	150
17	15.861	0.22	0.31	DL-Proline, 5-oxo-, methyl ester	$C_6H_9NO_3$	143
18	15.953	0.07	0.11	Benzoic acid, 4-methoxy-, methyl ester	$C_9H_{10}O_3$	166
19	17.220	0.04	0.06	5-Dimethylsilyloxytetradecane	$C_{16}H_{36}OSi$	272
20	18.050	0.14	0.12	Cycloheptasiloxane, tetradecamethyl-	$C_{14}H_{42}O_7Si_7$	518
21	18.367	0.22	0.11	Ethanone, 1-(4-hydroxy-3-methoxyphenyl)-	$C_9H_{10}O_3$	166
22	18.612	0.65	0.25	1,6-Anhydro-.beta.-D-glucopyranose (levoglucosan)	$C_6H_{10}O_5$	162
23	18.879	0.03	0.05	Phenol, 2,4-bis (1,1-dimethylethyl)-	$C_{14}H_{22}O$	206
24	19.232	0.07	0.10	Dodecanoic acid, methyl ester	$C_{13}H_{26}O_2$	214
25	20.009	0.20	0.28	3’,5’-Dimethoxyacetophenone	$C_{10}H_{12}O_3$	180
26	21.462	0.03	0.07	Cyclooctasiloxane, hexadecamethyl-	$C_{16}H_{48}O_8Si_8$	592
27	22.157	0.14	0.17	Ar-tumerone	$C_{15}H_{20}O$	216
28	22.389	0.08	0.15	1-Pentadecanol	$C_{15}H_{32}O$	228
29	22.667	0.04	0.08	Cycloheptasiloxane, tetradecamethyl-	$C_{14}H_{42}O_7Si_7$	518
30	22.821	0.16	0.22	E-7-Tetradecen-1-ol	$C_{14}H_{28}O$	212
31	23.139	0.22	0.37	Tridecanal	$C_{13}H_{26}O$	198
32	23.286	0.32	0.63	Methyl tetradecanoate	$C_{15}H_{30}O_2$	242
33	23.930	0.27	0.41	Tetradecanoic acid	$C_{14}H_{28}O_2$	228
34	24.401	0.03	0.06	Cyclononasiloxane, octadecamethyl-	$C_{18}H_{54}O_9Si_9$	666
35	25.170	0.30	0.45	Pentadecanoic acid, methyl ester	$C_{16}H_{32}O_2$	256
36	25.492	0.09	0.15	2-Pentadecanone, 6,10,14-trimethyl-	$C_{18}H_{36}O$	268

37	25.736	0.23	0.25	Cyclopropane, 1-methyl-1-(1-methylethyl)-2-nonyl-	$C_{16}H_{32}$	224
38	26.308	0.03	0.06	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270
39	26.509	0.06	0.11	9-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	268
40	26.587	0.46	0.69	9-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	268
41	26.756	0.03	0.06	2-Dodecen-1-yl(-)succinic anhydride	$C_{16}H_{26}O_3$	266
42	26.980	5.14	6.86	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270
43	27.221	0.20	0.14	Cyclopentadecanone, 2-hydroxy-	$C_{15}H_{28}O_2$	240
44	27.655	6.23	4.51	l-(+)-Ascorbic acid 2,6-dihexadecanoate	$C_{38}H_{68}O_8$	652
45	28.267	0.10	0.20	Cyclopropaneoctanoic acid, 2-hexyl-, methyl ester	$C_{18}H_{34}O_2$	282
46	28.668	0.26	0.48	Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	284
47	28.933	0.03	0.05	BISABOLEN-12-OL <BETA-> DB5-2242	$C_{15}H_{26}O$	222
48	29.003	0.19	0.35	Hexadecanoic acid, 2-hydroxy-, methyl ester	$C_{17}H_{34}O_3$	286
49	29.357	0.05	0.07	2-Cyclohexen-1-one, 4-hydroxy-3,5,5-trimethyl-4-(3-oxo-1-butenyl)-	$C_{13}H_{18}O_3$	222
50	29.822	8.25	8.62	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	$C_{19}H_{34}O_2$	294
51	29.922	6.32	7.81	9-Octadecenoic acid, methyl ester, (E)-	$C_{19}H_{36}O_2$	296
52	30.316	3.84	5.75	Octadecanoic acid, methyl ester	$C_{19}H_{38}O_2$	298
53	30.499	7.23	5.30	9,12-Octadecadienoic acid (Z,Z)-	$C_{18}H_{32}O_2$	280
54	30.597	7.68	5.51	Octadec-9-enoic acid	$C_{18}H_{34}O_2$	282
55	30.834	0.74	0.99	9,12,15-Octadecatrienoic acid, ethyl ester, (Z,Z,Z)-	$C_{20}H_{34}O_2$	306
56	30.929	3.12	2.08	Octadecanoic acid	$C_{18}H_{36}O_2$	284
57	31.182	0.82	0.87	Hexadecanamide	$C_{16}H_{33}NO$	255
58	31.442	0.61	0.55	Cyclopropanedecanoic acid, 2-hexyl-, methyl ester	$C_{20}H_{38}O_2$	310
59	31.507	0.42	0.56	9-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	268
60	31.575	0.53	0.55	Cyclononasiloxane, octadecamethyl-	$C_{18}H_{54}O_9Si_9$	666
61	31.667	0.96	0.62	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	296
62	32.057	11.01	8.74	9,12,15-Octadecatrienoic acid, methyl ester	$C_{19}H_{32}O_2$	292
63	32.242	0.95	1.10	4,7,10-Hexadecatrienoic acid, methyl ester	$C_{17}H_{28}O_2$	264
64	32.595	3.18	2.68	8,11,14-Eicosatrienoic acid, (Z,Z,Z)-	$C_{20}H_{34}O_2$	306
65	32.714	3.00	3.03	9,12,15-Octadecatrienoic acid, methyl ester	$C_{19}H_{32}O_2$	292
66	32.901	0.51	0.64	Hexadecanoic acid, 2-hydroxy-1,3-propanediyl ester	$C_{35}H_{68}O_5$	568

67	32.992	1.19	1.34	11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324
68	33.272	0.28	0.30	Dodecanoyl chloride	$C_{12}H_{23}ClO$	218
69	33.366	1.16	1.53	Eicosanoic acid, methyl ester	$C_{21}H_{42}O_2$	326
70	33.770	0.53	0.80	METHYL LINOLEATE DB5-2915 (=METHYL (Z,Z)-9,12-OCTADECADIENOATE)	$C_{19}H_{34}O_2$	294
71	33.856	0.40	0.55	9-Octadecenamide, (Z)-	$C_{18}H_{35}NO$	281
72	34.211	0.23	0.16	Octadecanamide	$C_{18}H_{37}NO$	283
73	34.679	0.20	0.16	9,12-Tetradecadien-1-ol, acetate, (Z,E)-	$C_{16}H_{28}O_2$	252
74	34.800	0.13	0.17	Heneicosanoic acid, methyl ester	$C_{22}H_{44}O_2$	340
75	34.907	0.14	0.21	1,9,12,15-Octadecatetraene, 1-methoxy-	$C_{19}H_{32}O$	276
76	35.073	0.17	0.22	1H-Benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-, cis-	$C_{15}H_{26}O$	222
				77 35.152		
77	35.152	0.39	0.55	Carbamic acid, 2-(dimethylamino) ethyl ester	$C_5H_{12}N_2O_2$	132
78	35.225	0.15	0.26	Ethanamine, 2,2’-oxybis[N,N-dimethyl-	$C_8H_{20}N_2O$	160
79	35.378	0.25	0.42	Bicyclo[10.1.0]tridec-1-ene	$C_{13}H_{22}$	178
80	35.445	0.23	0.33	Cyclopentadecanone, 2-hydroxy-	$C_{15}H_{28}O_2$	240
81	35.807	0.75	0.88	Octadecane, 1-chloro-	$C_{18}H_{37}Cl$	288
82	35.944	1.47	1.51	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester	$C_{19}H_{38}O_4$	330
83	36.182	0.82	1.30	Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	354
84	36.516	0.15	0.13	Methyl (Z)-5,11,14,17-eicosatetraenoate	$C_{21}H_{34}O_2$	318
85	36.912	0.08	0.12	2-Oxabicyclo[3.3.0]oct-7-en-3-one, 7-(1-hydroxypentyl)-	$C_{12}H_{18}O_3$	210
86	37.056	0.28	0.26	2-(Dimethylamino) ethyl adamantanecarboxylate	$C_{15}H_{25}NO_2$	251
87	37.192	0.14	0.12	Cyclononasiloxane, octadecamethyl-	$C_{18}H_{54}O_9Si_9$	666
88	37.287	0.14	0.15	Docosahexaenoic acid, 1,2,3-propanetriyl ester	$C_{69}H_{98}O_6$	1022
89	37.509	0.28	0.53	Tricosanoic acid, methyl ester	$C_{24}H_{48}O_2$	368
90	37.918	0.17	0.20	Docosanoic acid, 2-hydroxy-, methyl ester	$C_{23}H_{46}O_3$	370
91	38.309	2.10	2.98	9,12-Octadecadienoic acid (Z,Z)-, 2,3-dihydroxypropyl ester	$C_{21}H_{38}O_4$	354
92	38.356	2.90	2.97	Oleic anhydride	$C_{36}H_{66}O_3$	546
93	38.657	0.66	0.78	Octadecanoic acid, 2,3-dihydroxypropyl ester	$C_{21}H_{42}O_4$	358
94	38.791	0.81	1.33	Tetracosanoic acid, methyl ester	$C_{25}H_{50}O_2$	382
95	39.467	0.26	0.12	7,10-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	294
96	39.667	0.17	0.10	Dotriacontane	$C_{32}H_{66}$	450

97	39.863	0.86	1.24	2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-	$C_{30}H_{50}$	410
98	40.064	2.10	1.02	6,9,12,15-Docosatetraenoic acid, methyl ester	$C_{23}H_{38}O_2$	346
99	40.406	0.25	0.15	BISABOLEN-12-OL <BETA-> DB5-2242	$C_{15}H_{26}O$	222
100	40.502	0.39	0.52	Docosanoic acid, 2-hydroxy-, methyl ester	$C_{23}H_{46}O_3$	370

Table 2: Compounds detected in methanolic extract of *M. balsamina* (dried ripe fruits) through GC-MS/MS analysis

Peak No.	R. Time (minute)	Area (%)	Height (%)	Compound	Molecular formula	Molecular weight
1	3.752	0.46	0.44	3,3-Dimethoxy-2-butanone	$C_6H_{12}O_3$	132
2	3.908	0.29	0.24	1H-Pyrrole, 2,4-dimethyl-	C_6H_9N	95
3	5.000	0.09	0.11	Pyrrolidine	C_4H_9N	71
4	5.172	0.47	0.29	1,2-Cyclopentanedione	$C_5H_6O_2$	98
5	5.542	0.13	0.08	DL-Arabinitol	$C_5H_{12}O_5$	152
6	6.165	0.54	0.24	Glycerin	$C_3H_8O_3$	92
7	6.297	0.79	0.54	Phenol	C_6H_6O	94
8	8.333	0.08	0.06	2-Pyrrolidinone	C_4H_7NO	85
9	8.910	0.11	0.12	Phenol, 2-methoxy-	$C_7H_8O_2$	124
10	9.142	0.57	0.36	4-Pyridinol	C_5H_5NO	95
11	9.767	0.14	0.09	Hexyl n-valerate	$C_{11}H_{22}O_2$	186
12	9.967	0.09	0.09	Methylene asparagine	$C_5H_8N_2O_3$	144
13	10.306	0.41	0.52	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	144
14	10.481	0.24	0.33	Silane, diethoxymethyl-	$C_5H_{14}O_2Si$	134
15	10.692	0.11	0.11	Benzoic Acid	$C_7H_6O_2$	122
16	11.076	0.11	0.09	3-[N'-(3H-Indol-3-ylmethylene)-hydrazino]-5-methyl-[1,2,4]triazol-4-ylamine	$C_{12}H_{13}N$	255
17	11.308	0.16	0.17	(S)-(+)-2',3'-Dideoxyribonolactone	$C_5H_8O_3$	116
18	11.519	0.13	0.18	1,2-Benzenediol	$C_6H_6O_2$	110
19	12.048	0.14	0.17	3-Thiopheneethanol	C_6H_8OS	128
20	12.140	0.61	0.86	Benzofuran, 2,3-dihydro-	C_8H_8O	120
21	12.271	0.31	0.38	2-Furancarboxaldehyde, 5-(hydroxymethyl)-	$C_6H_6O_3$	126
22	12.682	0.10	0.10	1-Dimethyl(octyl)silyloxypropane	$C_{13}H_{30}OSi$	230
23	12.830	0.12	0.10	Silane, [3-(2,3 epoxypropoxy)propyl] ethoxydimethyl-	$C_{10}H_{22}O_3Si$	218
24	13.864	0.14	0.10	2-Decanynoic acid	$C_{10}H_{16}O_2$	168
25	14.163	0.18	0.21	Cyclohexasiloxane, dodecamethyl-	$C_{12}H_{36}O_6Si_6$	444
26	14.472	0.28	0.39	2-Methoxy-4-vinylphenol	$C_9H_{10}O_2$	150
27	15.862	0.55	0.82	DL-Proline, 5-oxo-, methyl ester	$C_6H_9NO_3$	143
28	16.484	0.14	0.21	3,8-Dioxa-2,9-disiladec-5-ene, 2,2,9,9-tetramethyl-, (E)-	$C_{10}H_{24}O_2Si_2$	232

29	17.233	0.19	0.14	Cyclooctanecarboxylic acid, 4,5-dimethyl-, methyl ester	$C_{12}H_{22}O_2$	198
30	17.342	0.16	0.23	2-Formyl-9-[.beta.-d-ribofuranosyl] hypoxanthine	$C_{11}H_{12}N_4O_6$	296
31	17.482	0.59	0.30	Xanthosine	$C_{10}H_{12}N_4O_6$	284
32	17.969	0.29	0.17	Cycloheptasiloxane, tetradecamethyl-	$C_{14}H_{42}O_7Si_7$	518
33	19.108	0.06	0.05	Quinoline, 5,6,7,8-tetrahydro-	$C_9H_{11}N$	133
34	20.013	0.09	0.14	3’,5’-Dimethoxyacetophenone	$C_{10}H_{12}O_3$	180
35	20.508	0.23	0.13	6-Methyl-2-pyrazinylmethanol	$C_6H_8N_2O$	124
36	20.679	0.24	0.18	Ethyl N-(o-anisyl)formimidate	$C_{10}H_{13}NO_2$	179
37	21.200	0.61	0.32	Ethyl .alpha.-d-glucopyranoside	$C_8H_{16}O_6$	208
38	21.458	0.08	0.13	Cyclooctasiloxane, hexadecamethyl-	$C_{16}H_{48}O_8Si_8$	592
39	22.385	0.07	0.07	Trichloroacetic acid, undecyl ester	$C_{13}H_{23}Cl_3O_2$	316
40	22.825	0.11	0.19	E-10-Methyl-11-tetradecen-1-ol propionate	$C_{18}H_{34}O_2$	282
41	23.284	0.08	0.18	Methyl tetradecanoate	$C_{15}H_{30}O_2$	242
42	23.919	0.15	0.22	Tetradecanoic acid	$C_{14}H_{28}O_2$	228
43	23.992	0.12	0.14	5-Ethoxy-2-oxiran-2-yl-pyridine	$C_9H_{11}NO_2$	165
44	25.406	0.18	0.32	2-Dodecen-1-yl(-)succinic anhydride	$C_{16}H_{26}O_3$	266
45	26.959	2.25	4.53	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270
46	27.383	1.23	0.57	.alpha.-D-Glucopyranoside, .alpha.-D-glucopyranosyl	$C_{12}H_{22}O_{11}$	342
47	27.572	2.70	3.45	l-(+)-Ascorbic acid 2,6-dihexadecanoate	$C_{38}H_{68}O_8$	652
48	27.704	0.36	0.33	10-Octadecynoic acid, methyl ester	$C_{19}H_{34}O_2$	294
49	28.058	2.12	0.93	.beta.-D-Mannofuranoside, 1-O-(10-undecenyl)-	$C_{17}H_{32}O_6$	332
50	28.744	0.82	0.57	26,27-Dinorergost-5-ene-3,24-diol, (3.beta.)-	$C_{26}H_{44}O_2$	388
51	28.841	0.48	0.52	.alpha.-D-Glucopyranoside, .alpha.-D-glucopyranosyl	$C_{12}H_{22}O_{11}$	342
52	29.023	1.49	0.71	4,8,13-Cyclotetradecatriene-1,3-diol, 1,5,9-trimethyl-12-(1-methylethyl)-	$C_{20}H_{34}O_2$	306
53	29.235	1.12	0.60	Stigmasta-5,24(28)-dien-3-ol, (3.beta.)-	$C_{29}H_{48}O$	412
54	29.400	0.30	0.35	Cyclooctasiloxane, hexadecamethyl-	$C_{16}H_{48}O_8Si_8$	592
55	29.500	0.47	0.31	L-Lyxose	$C_5H_{10}O_5$	150
56	29.775	1.73	3.38	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	$C_{19}H_{34}O_2$	294
57	29.879	3.91	6.63	11,14,17-Eicosatrienoic acid, methyl ester	$C_{21}H_{36}O_2$	320
58	30.014	0.73	0.78	Tricyclo[4.2.1.0(2,5)]non-3-en-9-endo-ol, 9-exo-ethyl-, endo-	$C_{11}H_{16}O$	164
59	30.301	1.92	3.00	Octadecanoic acid, methyl ester	$C_{19}H_{38}O_2$	298
60	30.488	4.15	3.72	cis,cis,cis-7,10,13-Hexadecatrienal	$C_{16}H_{26}O$	234
61	30.717	0.38	0.62	Cyclohexadecanone	$C_{16}H_{30}O$	238
62	30.784	0.46	0.69	Benzeneacetic acid, phenylmethyl ester	$C_{15}H_{14}O_2$	226
63	30.848	1.39	1.04	Octadecanoic acid	$C_{18}H_{36}O_2$	284
64	31.112	0.67	0.64	Hexadecanamide	$C_{16}H_{33}NO$	225

65	31.247	1.69	0.71	9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate, (3.beta.,4. alpha.,5.alpha.)-	$C_{32}H_{52}O_2$	468
66	31.700	1.95	0.83	beta.-Sitosterol	$C_{29}H_{50}O$	414
67	31.908	0.36	0.42	Formamide, N-phenyl-	C_7H_7NO	121
68	31.989	0.99	1.38	Hexadecatrienoic acid, methyl ester	$C_{17}H_{28}O_2$	264
69	32.086	0.92	1.36	Hexadecatrienoic acid, methyl ester	$C_{17}H_{28}O_2$	264
70	32.304	0.68	1.08	Hexadecatrienoic acid, methyl ester	$C_{17}H_{28}O_2$	264
71	32.567	0.35	0.35	Hexadecatrienoic acid, methyl ester	$C_{17}H_{28}O_2$	264
72	32.698	1.82	2.72	1,9,12,15-Octadecatetraene, 1-methoxy-	$C_{19}H_{32}O$	276
73	32.886	0.93	1.46	Hexadecanoic acid, 2-hydroxy-1,3-propanediyl ester	$C_{35}H_{68}O_5$	568
74	32.983	0.28	0.36	Tetrapentacontane, 1,54-dibromo-	$C_{54}H_{108}Br_2$	914
75	33.092	0.09	0.14	Hexadecanoic acid, 2-propyl-, methyl ester	$C_{20}H_{40}O_2$	312
76	33.158	0.06	0.11	Palmidrol	$C_{18}H_{37}NO_2$	299
77	33.247	0.15	0.24	3-(2-Oxocyclohexyl)propionaldehyde	$C_9H_{14}O_2$	154
78	33.358	0.26	0.40	Eicosanoic acid, methyl ester	$C_{21}H_{42}O_2$	326
79	33.572	0.78	0.37	Naphthalene, decahydro-1,6-dimethyl-4-(1-methylethyl)-	$C_{15}H_{28}$	208
80	33.837	0.54	0.48	Methyl (Z)-5,11,14,17-eicosatetraenoate	$C_{21}H_{34}O_2$	318
81	34.189	0.46	0.18	9-Octadecenamide, (Z)-	$C_{18}H_{35}NO$	281
82	34.670	0.14	0.18	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	$C_{19}H_{32}O_2$	292
83	34.773	0.15	0.19	Nonanoic acid, 9-(3-hexenylidenecyclopropylidene)-, 2-hydroxy-1-(hydroxymethyl)ethyl	$C_{21}H_{36}O_4$	352
84	34.983	0.24	0.14	Vitamin A aldehyde	$C_{20}H_{28}O$	284
85	35.245	0.90	1.26	Carbamic acid, 2-(dimethylamino)ethyl ester	$C_5H_{12}N_2O_2$	132
86	35.375	1.09	1.68	9,12-Octadecadienoyl chloride, (Z,Z)-	$C_{18}H_{31}ClO$	298
87	35.455	3.54	2.72	1-Heptatriacotanol	$C_{37}H_{76}O$	536
88	35.796	0.67	1.08	1-Octanol, 2-butyl-	$C_{12}H_{26}O$	186
89	35.941	4.80	5.62	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330
90	36.176	0.37	0.48	Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	354
91	36.534	0.43	0.31	.beta.-Sitosterol	$C_{29}H_{50}O$	414
92	36.849	2.22	1.16	Olean-12-en-28-oic acid, 3-(acetyloxy)-, methyl ester, (3.beta.)-	$C_{33}H_{52}O_4$	512
93	36.967	0.48	0.84	Olean-12-en-28-oic acid, 3-oxo-, methyl ester	$C_{31}H_{48}O_3$	468
94	37.061	1.03	0.78	1,2,6a,6b,9,9,12a-Heptamethyl-1,3,4,5,6,6a,6b,7,8,8a,9,12,12a,12b,13,14b-hexadecahydro-2H	$C_{31}H_{48}O_2$	452
95	37.343	2.22	1.02	Androstan-3-one, 17-hydroxy-1,17-dimethyl-, (1.alpha.,5.alpha.,17.beta.)-	$C_{21}H_{34}O_2$	318
96	37.499	0.31	0.50	Tricosanoic acid, methyl ester	$C_{24}H_{48}O_2$	368

97	37.974	2.55	1.90	5,8,11,14-Eicosatetraenoic acid, ethyl ester, (all-Z)-	$C_{22}H_{36}O_2$	332
98	38.292	2.72	4.26	9,12-Octadecadienoic acid (Z,Z)-, 2,3-dihydroxypropyl ester	$C_{21}H_{38}O_4$	354
99	38.404	8.27	6.12	Methyl (Z)-5,11,14,17 eicosatetraenoate	$C_{21}H_{34}O_2$	318
100	38.654	3.69	4.46	Octadecanoic acid, 2,3 dihydroxypropyl ester	$C_{21}H_{42}O_4$	358
101	38.785	0.45	0.70	Tetracosanoic acid, methyl ester	$C_{25}H_{50}O_2$	382
102	38.867	0.61	0.50	Alloaromadendrene oxide-(1)	$C_{15}H_{24}O$	220
103	39.193	1.63	0.67	Rhodopin	$C_{40}H_{58}O$	554
104	39.496	1.42	0.74	9,19-Cyclolanostan-3-ol, acetate, (3.beta.)-	$C_{32}H_{54}O2$	470
105	39.667	0.15	0.21	Tetratetracontane	$C_{44}H_{90}$	618
106	39.855	1.24	1.62	2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-	$C_{30}H_{50}$	410
107	40.116	3.87	1.81	1H-Indene, 1-ethylideneoctahydro-7a-methyl-, cis-	$C_{12}H_{20}$	164
108	4.391	1.64	1.09	1R,3Z,9s-4,8,11,11-Tetramethylbicyclo[7.2.0]undeca-3,7-diene	$C_{15}H_{24}$	204
109	40.823	1.42	1.71	11,11-DIMETHYL-SPIRO[2,9] DODECA-3,7-DIEN	$C_{14}H_{22}$	190

Conclusion

The methanolic extract of *Momordica balsamina* fruits, analyzed via Gas Chromatography-Mass Spectrometry (GC-MS/MS), revealed a diverse range of bioactive phytochemicals with notable therapeutic potential. These compounds include alkaloids, phenols, flavonoids, saponins, tannins, terpenoids, cardiac glycosides, carbohydrates, and steroids. In total, 100 bioactive compounds were identified in the green fruits and 109 in the ripe fruits. The detected constituents exhibit a wide array of pharmacological properties, establishing *M. balsamina* as a promising candidate for the treatment of various human diseases. This comprehensive phytochemical analysis not only underscores the plant's medicinal value but also highlights its potential in pharmaceutical development. Additionally, the non-targeted profiling provides a foundation for future targeted studies of specific bioactive compounds in *M. balsamina*, allowing for a deeper investigation into its therapeutic applications.

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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