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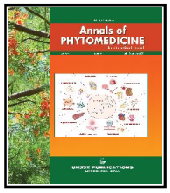

Original Article : Open Access

Biochemical and phytochemical analysis of Yardlong bean (*Vigna unguiculata* (L.) Verdc. subsp. *sesquipedalis*) using gas chromatography and mass spectroscopy (GC-MS)

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Abstract

Yardlong bean is rich in phytonutrients that are essential for maintaining good health in human beings. It is the most widely adapted drought-tolerant legume vegetable that possess high nutritive and biochemical values. The research studies in this direction are very meagre. So, the present study was conducted at Western Block, Department of Vegetable Science, Horticultural College and Research Institute, Periyakulam from 2022 to 2024 with the aim to quantify the major compounds present in yardlong bean which may pave the way for developing new value added products in future. The study was planned in a complete randomized block design with two replications.The study material included six parents and one check variety. Results showed that among the parents, the genotype EC-769247 recorded high level of crude fibre (11.51%), protein (8.43%), manganese (10.88 ppm), iron (15.55 ppm), zinc (12.74 ppm) and copper (5.27 ppm). Major bioactive compounds identified in the genotype EC-769247 are friedooleanan-3-ol (10.89%), friedelan-3-one (7.68%), 9,12,15-octadecatrienoic acid (7.45%), stigmasterol (4.91%), 1,2-epithio-3-hexanol (4.25%), n-hexadecanoic acid (3.77%), olean-12-ene (3.68%), cyclononanone (3.02%), 1,4-benzenediol (2.35%), campesterol (2.09%), pyridine (1.98%), isopropyl linoleate (1.90%), androstan-4-one (1.83%), nonanoic acid (1.80%), 2-amino-3-hydroxypyridine (1.75%), acetate (1.28%), benzoic acid, isopropyl-4-hydroxybenzoate (1.31%), ergost-5-en-3-ol (1.28%) and methoxyacetic acid (1.09%). Among six parents and one standard check, genotype EC-769247 is deemed to have the highest mineral content and enhance the phytochemical quality of yardlong bean.

1. Introduction

Yardlong bean (*Vigna unguiculata* (L.) Verdc. subsp. *sesquipedalis*) otherwise called asparagus bean, chinese bean, snake bean and string bean. It is a popular leguminous vegetable grown for its tender immature pods. The delicious immature pod is rich in nutrients and neutraceuticals (Hazra *et al.,* 2007). Yardlong bean contains moderate amount of fibre and good amount of protein. Consumption of fibre helps in lowering the blood cholesterol, aids in the absorption of minerals and nutrients in the gut and reduces the risk of heart diseases, diabetes, color and breast cancer, constipation and hypertension (Aggarwal *et al.,* 2022). Yardlong beans also rich in essential amino acids and low in fat (Abebe and Alemayehu, 2022). A high amount of fibre present in yardlong beans protects the colon and also prevents multiple cancerogenic diseases. It also helps to build a strong immunity system. A good amount of vitamin A and carotene present in yardlong bean helps to maintain beautiful skin, improves night vision and maintains mucosal integrity. They do contain bioactive components such as phenolic acids, flavonoids, and saponins. These compounds have several biological functions, including anti-inflammatory and antioxidant properties. The existence of these bioactive chemicals in yardlong beans also shows their potential use in the pharmaceutical and nutraceutical sectors (Ha *et al.,* 2010). Information about the nutritional content of other plant parts is limited.The metabolic composition of immature pods from various cultivars is essential for developing superior yardlong bean cultivars. This helps improve nutrition, taste, disease resistance, shelf-life, and adaptation to the environment, leading to better crop varieties (Perchuk *et al.,* 2020).

Phytochemical screening plays an essential role in revealing new sources of therapeutically and industrially important chemicals with medicinal value, allowing for the most efficient and effective use of natural resources. Gas chromatography-mass spectroscopy (GC-MS) is a sophisticated analytical method for finding chemicals in extracts at very small concentrations. It is especially useful for determining the identities of bioactive substances such as nitro compounds, alcohols, acids, esters, alkaloids, steroids, and long-chain hydrocarbons. This study aims to investigate the phyto-chemicals present in the ethanolic pod extract of yardlong bean and to identify and characterize the bioactive constituents using GC-MS analysis.

2. Materials and Methods

The experiment was carried out at Horticultural College and Research Institute, TNAU, Periyakulam during 2022-2024. Totally sixty yardlong bean genotypes were assessed for growth and yield

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characteristics. Among the sixty genotypes, the best performing six genotypes were selected based on the yield characters. The experimental material comprises a total of seven yardlong bean genotypes including a standard check (Arka Mangala). The seven genotypes were raised with a row-to-row spacing of 0.5 m and plant-to-plant spacing of 1.5 m. Standard plant production and protection were taken up to get good crop. The immature pods were collected from individual lines when it achieved physiological maturity.

2.1 Authentication of plant material

Dr. R. Ramasubbu, Associate Professor, Department of Biology, Gandhigram Rural Institute, Gandhigram, Dindigul, conducted the entire botanical authentication and identification of the Plant Specimen. The Plant Specimen is catalogued under Collection 318 and stored at the GUD Herbarium.

2.2 Collection of sample

The tender immature pods from all six genotypes along with check Arka Mangala were collected and allowed to dry in the hot air oven at 75°C. The oven-dried pods were ground into powder and digested with triple acid. After digestion, the resultant produce was used for biochemical and mineral composition analysis. The details of yardlong bean accessions/genotypes and their characters are represented in Table 1.

Table 1: Details of genotypes and their characters

Genotypes	Source	Important characters	Pod yield/hac (tons)
EC-769240	ICAR - NBPGR, New Delhi	Long pods and high yield	38.51
EC-769247	ICAR - NBPGR, New Delhi	Pods are long and high yield	43.15
EC-769251	ICAR - NBPGR, New Delhi	More number of pods per plant and high yield	41.16
EC-769255	ICAR - NBPGR, New Delhi	More number of pods and high yield	35.81
IC-471931	ICAR - NBPGR, New Delhi	More number of pods per plant and high yield	37.37
IC-471951	ICAR - NBPGR, New Delhi	Long pods and more number of pods per plant	38.29
Arka Mangala	ICAR - IIHR, Bangalore	Long pods, stringless, tender with crisp texture	25.00

Figure 1: Powdered bean sample.

Figure 2: Yardlong bean pod.

2.3 Biochemical analysis

The biochemical components of yardlong bean pods, comprising protein and crude fibre, were determined three times using the Association of Official Analytical Chemists (AOAC, 1990). The protein content was measured by the Biuret method (Plummer, 1988), while crude fibre was measured using the Maynard method (1970). Micronutrient content, *viz.,* iron, zinc, copper and manganese were assessed through an atomic absorption spectrophotometer method (Jackson, 1973).

2.4 Extraction process

Powdered beans (10 g) (Figure 1and Figure 2) were mixed with 30 ml ethanol and kept overnight and then the extract was filtered. By adding bubbling nitrogen to the mixture, the extract was concentrated to 1 ml. To identify phytochemical components, GC-MS analysis was performed using 2 µl of the ethanolic extract (Merlin *et al.*, 2009).

2.5 GC-MS analysis

After measuring and placing the required quantity of yardlong bean powder into a sealed flask, ethanol was added to start the extraction process. The mixture was allowed to infuse for 24 h, then filtered and dried using a vacuum distillation apparatus. The resulting residue was subsequently analyzed using a GC-MS system. A gas chromatography and mass spectrometer (GC-MS) equipped with an Elite-I fused RMS 6 silica capillary column constructed of dimethylpolysiloxane was utilized to conduct the analysis. Thermo GC Ultra Clarus 550 equipment was used for this study. Detection was performed with an electron ionization device set to an ionizing energy of 60 eV. A 12:1 split ratio was used to inject 1 µl of sample, using helium (99.9%) as the carrier gas at a constant flow rate of 2 ml/min. The temperature of the injector and ion source were adjusted to 240°C and 230°C, respectively. The oven temperature was programmed to start at 90°C, increase by 5°C per min until it reached 240°C, and then remain isothermal for 3 min. At 0.5 sec scan intervals, mass spectra were obtained for pieces having a mass between 50 and 650 Da. By comparing the average peak area of each component to the overall peak area, the percent composition of each component was determined by the analysis of the mass spectra and chromatograms using Turbo Mass software (Dutta *et al.,* 2020).

2.6 Identification of bioactive components

The National Institute of Standards and Technology (NIST) database was used to analyze and interpret the GC-MS mass spectra at 70 eV and fragments ranging in size from 45 to 450 Da. The MS detection process took 36 min to complete. Unknown components were matched to recognized chemicals using spectra from both the NIST and Wiley libraries. This method allowed the test materials to be identified, weighed, and analyzed for composition.

2.7 Biological activity of identified substances

PASS (Prediction of Activity Spectra for Biologically Active Substances) was used to anticipate the biological effects of the chemicals based on their structural formulas. According to the PASS online database (Filimonov *et al.,* 2014 and Kamaljeet *et al.,* 2024), this approach involves anticipating various pharmacological effects, probable toxicities, and plausible mechanisms of action for the substances.

3. Results

3.1 Biochemical analysis

The results obtained from the biochemical analysis of yardlong beans are mentioned in Table 2.

3.1.1 Crude fibre (%)

From Table 2 and Figure 3, it was observed that the crude fibre content ranged from 6.59 per cent to 11.51 percent. The highest crude fibre content of 11.51 per cent was recorded by the culture EC-769247. It was followed by IC-471951 (10.41 per cent). However, the genotype EC-769255 registered the lowest crude fibre content of 6.59 per cent.

3.1.2 Protein (%)

Regarding the protein content, the values ranged from 3.57 per cent to 8.43 per cent (Figure 3). The highest protein content of 8.43 per cent was recorded with EC-769247. It was followed by IC-471951 (7.15 per cent). Meanwhile, the lowest protein content of 3.57 per cent was recorded in the culture EC-769255.

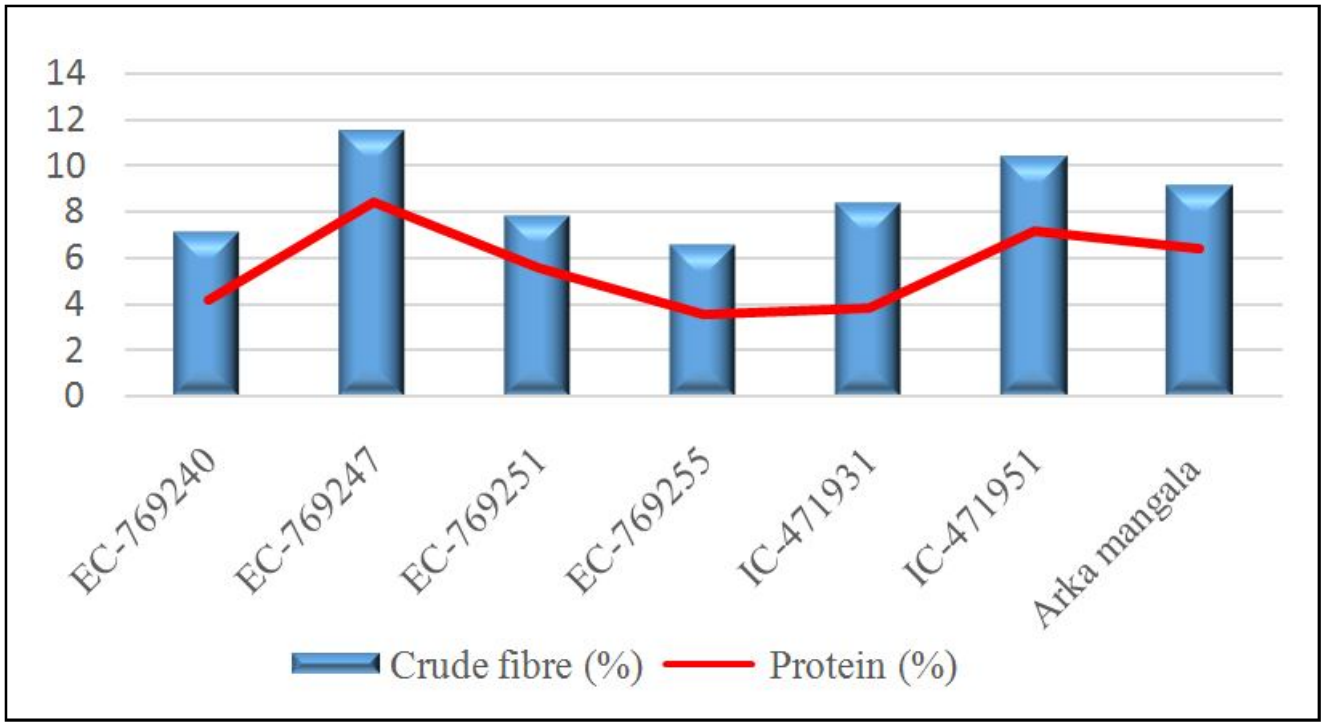

Figure 3: Crude fibre and protein content in yardlong bean pod.

3.1.3 Zinc content (ppm)

Results of the zinc content of yardlong bean genotypes from Figure 4 revealed that mean values of zinc ranged from 8.45 ppm to 12.74 ppm. Among the genotypes and one standard check evaluated the genotype EC-769247showed the highest zinc content of 12.74 ppm and was followed by IC-471951 (10.37 ppm). Whereas, the genotype EC-769255 exhibited the lowest zinc concentration of 8.45 ppm.

3.1.4 Copper content (ppm)

From the results, it was observed that the yardlong bean genotypes exhibited significant differences in the copper content. The copper content varied from 3.08 ppm and 5.27 ppm as depicted in Figure 4. Among the six genotypes and one standard check evaluated, the genotype EC-769247 exhibited the highest copper content of 5.27 ppm and was followed by IC-471951 (4.44 ppm). Meanwhile, the genotype EC-769255 expressed the lowest copper content of 3.08 ppm.

3.1.5 Iron content (ppm)

Regarding iron content, the results obtained from Table 2 and Figure 4, the yardlong bean genotypes exhibited a range from 11.10 ppm to 15.55 ppm. The genotype EC-769247 recorded the highest iron content (15.55 ppm) and it was followed by IC-471951(14.77 ppm), while the lowest iron content was recorded byEC-769255 with a value of 11.10 ppm.

3.1.6 Manganese content (ppm)

From Figure 4 and Table 2, it was noticed that the mean value of manganese content varied between 6.64 ppm to 10.88 ppm. Among different genotypes, the genotype EC-769247 registered the highest manganese content (10.88 ppm) and was followed by IC-471951(9.86 ppm). Whereas, the culture EC-769255, exhibited a low manganese content of 6.64 ppm.

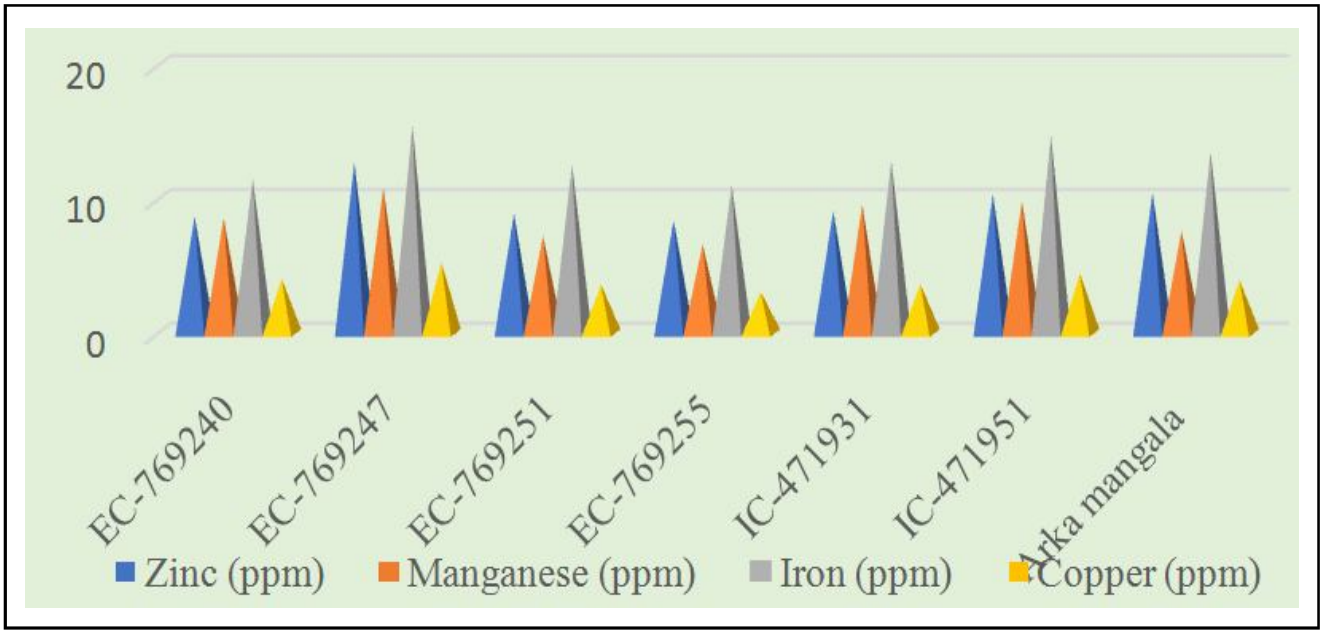

Figure 4: Micronutrients in yardlong bean pod.

Table 2: Effect of different accessions on protein (%), crude fibre (%), zinc (ppm), manganese (%), iron (ppm) and copper (ppm)

Accessions	Crude fibre (%)	Protein (%)	Zinc (ppm)	Manganese (ppm)	Iron (ppm)	Copper (ppm)
EC-769240	7.10	4.20	8.69	8.62	11.57	4.02
EC-769247	11.51	8.43	12.74	10.88	15.55	5.27
EC-769251	7.84	5.61	8.93	7.29	12.61	3.61
EC-769255	6.59	3.57	8.45	6.64	11.10	3.08
IC-471931	8.34	3.86	9.14	9.61	12.88	3.67
IC-471951	10.41	7.15	10.37	9.86	14.77	4.44
Arka Mangala	9.14	6.40	10.48	7.64	13.55	3.94
SE (d)	0.2046	0.1144	0.1839	0.2061	0.2620	0.0809
CD (*p*=0.05)	0.4458**	0.2493**	0.4007**	0.4491**	0.5709**	0.1763**

3.2 Metabolite profiling using GC-MS analysis

Among the seven genotypes, the best performing genotype EC-769247 was used in metabolite profiling using GC-MS analysis. The chromatogram and mass spectrum (Figures 5 to 8) indicate that the yardlong bean contains various compounds. The identified compounds, along with their retention time (RT), peak area (%), and molecular formula, are presented in Table 3. Totally, 130 compounds found in yardlong beans, the significant compounds such as friedooleanan-3-ol (10.89%), friedelan-3-one (7.68%), 9,12,15-octadecatrienoic acid (7.45%), stigmasterol (4.91%), 1,2-epithio-3-hexanol (4.25%), n-hexadecanoic acid (3.77%), olean-12-ene (3.68%), cyclononanone (3.02%), 1,4-benzenediol (2.35%), campesterol (2.09%), pyridine (1.98%), isopropyl linoleate (1.90%), androstan-4-one (1.83%), nonanoic acid (1.80%), 2-amino-3-hydroxypyridine (1.75%), acetate (1.28%), benzoic acid, ethylparaben, isopropyl-4-hydroxybenzoate (1.31%), ergost-5-en-3-ol (1.28%) and methoxy aceticacid (1.09%) were identified.

Table 3: Different bioactive compounds present in yardlong bean pod EC-769247 with their IUPAC name, molecular weight, peak area and retention time

Compound name	IUPAC name	Molecular weight (g/mol)	Peak area (%)	Retention time (min)
Friedooleanan-3-ol	4,4a,6a,6b,8a,11,11,14a-octamethyl-1,2,3,4,5,6,6a,7,8,9,10,12,12a,13,14,14b-hexadecahydropicen-3-ol	428.7	10.89	18.663
2-amino-3-hydroxypyridine	2-aminopyridin-3-ol	110.11	1.75	11.841
Cyclohexanone	cyclohexanone	98.14	0.95	17.596
Eicosane	icosane	282.5	0.63	20.329
Pyridine	pyridine	79.1	1.98	11.497
Acetate	acetate	59.04	1.28	11.797
Friedelan-3-one	(4R,4aS,6aS,6aS,6bR,8aR,12aR,14aS,14bS)-4,4a,6a,6b,8a,11,11,14a-octamethyl-2,4,5,6,6a,7,8,9,10,12,12a,13,14,14b-tetradecahydro-1H-picen-3-one	426.7	7.68	19.040
9,12,15-octadecatrienoic acid	(9Z,12Z,15Z)-octadeca-9,12,15-trienoic acid	278.4	7.45	14.363
Stigmasterol	(3S,8S,9S,10R,13R,14S,17R)-17-[(E,2R,5S)-5-ethyl-6-methylhept-3-en-2-yl]-10,13-dimethyl-2,3,4,7,8,9,11,12,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	412.7	4.91	22.307
1,2-epithio-3-hexanol	1-(thiiran-2-yl) butan-1-ol	132.23	4.25	9.308
n-hexadecanoic acid	hexadecanoic acid	256.42	3.77	13.208
Olean-12-ene	(4aS,6aR,6bS,8aR,12aR,14aR,14bS)-4,4,6a,6b,8a,11,11,14b-octamethyl-1,2,3,4a,5,6,7,8,9,10,12,12a,14,14a-tetradecahydropicene	410.7	3.68	15.230
Cyclononanone	cyclononanone	140.22	3.02	16.507
1,4-benzenediol	benzene-1,4-diol	110.11	2.35	12.119
Campesterol	(3S,8S,9S,10R,13R,14S,17R)-17-[(2R,5R)-5, 6-dimethylheptan-2-yl]-10,13-dimethyl-2,3,4,7,8,9,11,12,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	400.7	2.09	21.996
Isopropyl linoleate	propan-2-yl (9Z,12Z)-octadeca-9,12-dienoate	322.5	1.90	17.452
Androstan-4-one	10,13-dimethyl-1,2,3,5,6,7,8,9,11,12,14,15,16,17-tetradecahydrocyclopenta[a]phenanthren-4-one	274.4	1.83	18.341
Nonanoic acid	nonanoic acid	158.24	1.80	17.496
Benzoic acid	benzoic acid	122.12	1.31	10.053
Ergost-5-en-3-ol	(8S,9S,10R,13R,14S,17R)-17-[(2R,5S)-5,6-dimethylheptan-2-yl]-10,13-dimethyl-2,3,4,7,8,9,11,12,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	400.7	1.28	11.797
Methoxyacetic acid	2-methoxyacetic acid	90.08	1.09	11.397
3-methoxyergost-8(14)-ene	(9R,10S,13R,17R)-17-[(2R,5S)-5,6-dimet-hylheptan-2-yl]-3-methoxy-10,13-dimethyl-2,3,4,5,6,7,9,11,12,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthrene	414.7	1.03	11.719

Pentanedioic acid	pentanedioic acid	132.11	0.99	15.308
Octadecanoic acid	octadecanoic acid	284.5	0.95	17.596
L-arabinitol	(2S,4S)-pentane-1,2,3,4,5-pentol	152.15	0.87	4.576
Ethylparaben	ethyl 4-hydroxybenzoate	166.17	1.31	10.053
Methenamine	methenamine	31.057	0.87	4.576
Cholest-7-en-3-ol	(3S,5S,9R,10S,13R,14R,17R)-10,13-dimethyl-17-[(2R)-6-methylheptan-2-yl]-2,3,4,5,6,9,11,12,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	386.7	1.03	11.719
Butyl 9,12,15-octadeca-trienoate	butyl (9E,12E,15E)-octadeca-9,12,15-trienoate	334.5	0.57	16.330
1,4 benzodioxan-6-amine	2,3-dihydro-1,4-benzodioxin-6-amine	151.16	0.58	9.642
1,4-benzodioxin	1,4-benzodioxine	134.13	0.55	15.474
5-methyl-2-phenylindolizine	5-methyl-2-phenylindolizine	207.27	0.52	19.463
Gamma - Tocopherol	(2R)-2,7,8-trimethyl-2-[(4R,8R)-4,8,12-trimethyltri-decyl]-3,4-dihydrochromen-6-ol	416.7	0.54	19.974
3,7-decadien-2-one	(3E,7E)-10-(3,3-dimethyloxiran-2-yl)-4,8-dimethyl-deca-3,7-dien-2-one	250.38	0.55	15.474
Cyclotrisiloxane	1,3,5,2,4,6-trioxatrisilinane	138.3	0.52	19.463

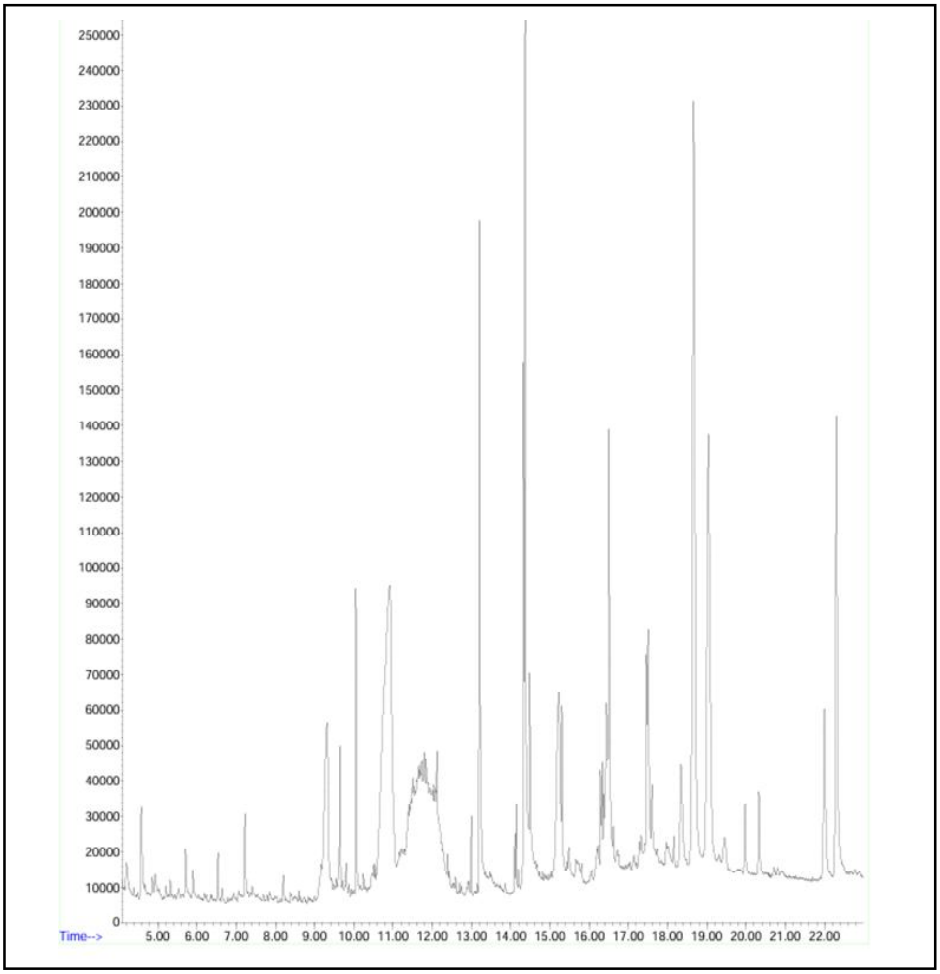

Figure 5: Chromatogram of ethanolic extract of Yardlong beans by GC-MS.

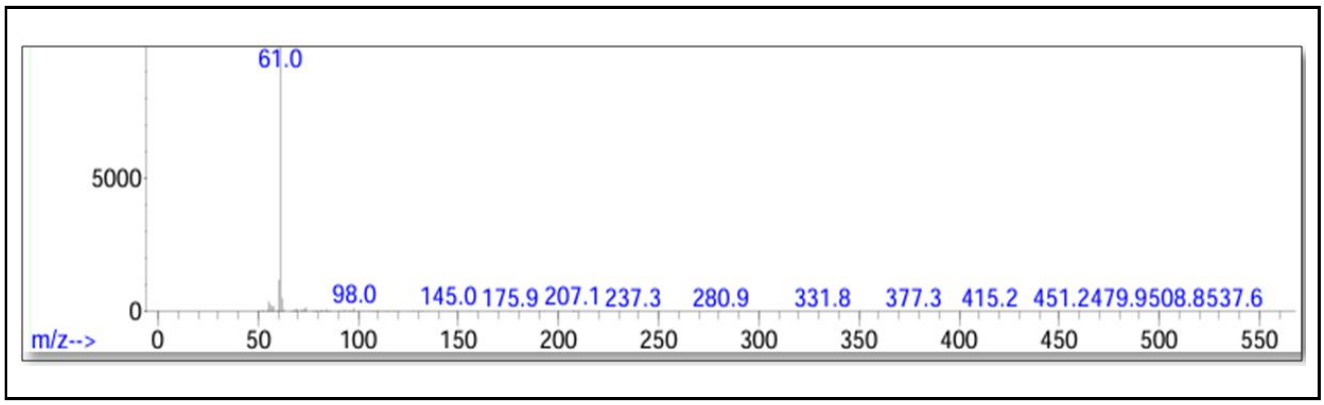

Figure 6: Mass spectrum of L- arbinitol (0.87 %).

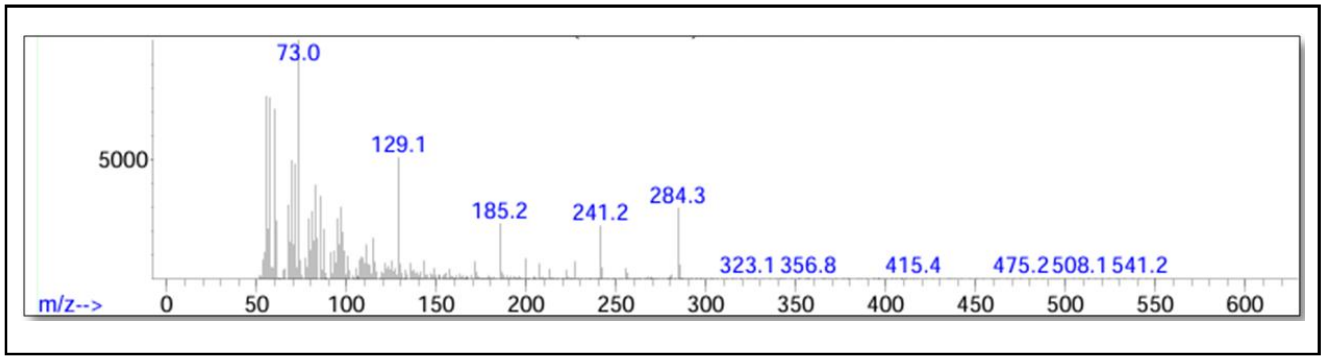

Figure 7: Mass spectrum of octadecanoic acid (0.95 %).

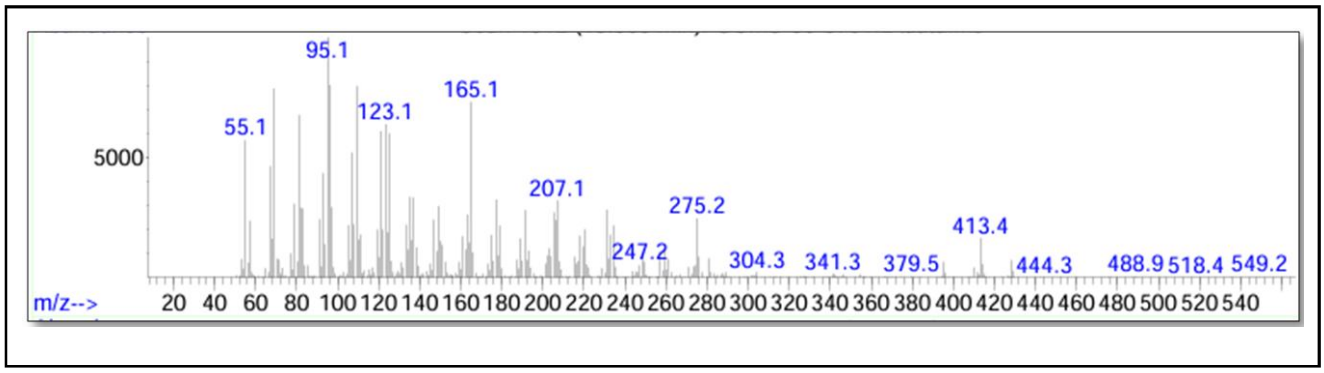

Figure 8: Mass spectrum of friedooleanan-3-ol (10.89 %).

4. Discussion

In recent decades, legumes have become a well-balanced source of nutrients. However, the quality characters of yardlong beans are significantly influenced by the genotypes and environment over other legumes (Romero *et al.,* 2016). There is limited literature source on the biochemical and phytochemical analysis of yardlong beans (Li *et al.,* 2021). Yardlong bean pods are high in both soluble and insoluble fiber, which is found in the edible green pod. When compared to other legume crops like beans the crude fibre content ranged from 0.11% in dry heated beans whereas 0.12% in steamed beans, the crude fibre content of six genotypes and one standard check varied from 11.15% to 6.59% (China *et al.,* 2019). Legume plants are used to treat diseases like smallpox, measles, burns and adenitis. Similarly, cowpeas are used to cure liver and skin problems, menstrual abnormalities and intestinal cramps (Apea-Bah *et al.,* 2017).It has been observed that 5-37% of the total protein in cowpea is nutritionally inaccessible (Goncalves *et al.,* 2016). According to Quamruzzaman *et al.,*(2022), the average protein content in asparagus beans ranged from 2.8-3.3%, whereas the protein content among six genotypes and the check variety is between 8.43-3.57%.Yardlong beans are rich in macro and micronutrients (Luthria *et al.,* 2014). Similar findings were recorded by Flyman and Afolayan (2008).Iron, zinc, copper and manganese deficiencies are most prevalent in pregnant women and children under the age of five. Mineral deficiencies can cause serious diseases and disorders that are either directly or indirectly connected to physiological difficulties such as inadequate oxygen transport to tissues, weakness, reduced cognitive function, poorer productivity, and increased susceptibility to infections (Jindal *et al*., 2023). Zinc is required for the normal operation of several

enzyme systems. Research findings reveal that zinc is essential for healthy bone development (Mastropasqua *et al.,* 2020).The synthesis of bones, connective tissue, sex hormones, and blood clotting components is aided by manganese. This bean also contributes significantly. Manganese deficiency may cause poor development in infants, bone demineralization, skin rashes, lower serum cholesterol, hair depigmentation, and increased alkaline phosphatase activity in males, as well as greater premenstrual difficulty in women. Now a days, food and nutritional insecurity become major problems in the world leading to malnutrition. Iron deficiency leads to anemia and poor child development (Franzo, 2012). Among the genotypes studied, micronutrients like zinc, iron, copper and manganese were found high in EC-769247.Gas chromatography and mass spectrometry (GC-MS) is an efficient method for biological analysis. Similar results were also reported by Senbagavalli *et al.,* (2024). The effect of various phytochemicals found in yardlong beans are listed in Table 4, and the chromatogram is displayed in Figure 5. Totally, 130 bioactive compounds were found in yardlong beans which are responsible for nutraceutical benefits. However, yardlong beans contain phytochemicals that can be used to make medicines because they have unique physiological effects on human beings (Goel *et al.,* 2022). The GC-MS chromatogram, shown in Figure 5, illustrates the diverse phytochemical compounds found in yardlong beans.Table 4 provides a comprehensive list of these bioactive compounds, detailing their molecular weights and pharmacological activities. Friedooleanan-3-ol and Friedelan-3-ene are rich in Euphorbiaceae (Tapioca) and Asteraceae family (lettuce, artichoke and endive) (Caneschi *et al.,* 2014 and Herrera *et al.,* 2018). Cyclohexane is rich in green leafy vegetables like amaranthus, moringa and spinach. Ergost -5-en-3-ol is found in essential oils. Campesterol and stigmasterol are present in green and yellow vegetables (corn, squash and bell pepper) and some legumes like soybean and fruits like berries and apricots. L-arbinitol is present in the form of arabinose in green and brown algae (Domozych *et al.,* 2009). All these biochemical compounds are prominently present in yardlong beans in different proportions which is cheaply available to humans. Since, the yardlong beans are rich in protein, fibre and essential micronutrients like iron, copper, zinc and manganese and health benefiting phytochemicals it is recognized as a “super food”.

Table 4: Yardlong bean pod components and their pharmaceutical activity with molecular formula identified by gas chromatography and mass spectrometry (GC-MS)

Compound name	Molecular formula	Pharmaceutical activity
Friedooleanan-3-ol	$C_{30}H_{52}O$	Antioxidant, antimicrobial, antipyretic, antiulcer, anticonvulsant, and antitumor activities
2-amino-3-hydroxy pyridine	$C_5H_6N_2O$	It possesses anti-inflammatory, analgesic, anticonvulsant, antidiabetic and antipyretic properties
Cyclohexanone	$C_6H_{10}O$	They have a camphor-likesmell and used in making soaps and germicides
Eicosane	$C_{20}H_{42}$	It has very potent anti-inflammatory, analgesic and antipyretic effects
Pyridine	C_5H_5N	It is renowned for its medicinal effects, such as antibacterial, antiviral, anticancer, analgesic, anticonvulsant and anti-inflammatory
Acetate	$C_2H_3O_2^-$	Acts as a buffering agent and used as a flavour enhancer in foods and pharmaceuticals
Friedelan-3-one	$C_{30}H_{50}O$	Non-carcinogenic, non-hepatotoxic,antimicrobial, anti-HIV, and anticancer potentials
9,12,15-octadecatrienoic acid	$C_{18}H_{30}O_2$	It possess anticancer, antiosteoarthritis, antifungal, antibacterial and antioxidant properties
Stigmasterol	$C_{29}H_{48}O$	It can cure and prevent a variety of cardiovascular ailments because of its anticancer and cholesterol-lowering properties.
1,2-epithio-3-hexanol	$C_6H_{12}OS$	It has been used for its antimicrobial, antioxidant, hepatoprotective, sedative, anticonvulsant, cytotoxic, antiparasitic, and antidiabetic activities.
n-hexadecanoic acid	$C_{16}H_{32}O_2$	Anti-inflammatory and useful in the treatment of rheumatism
Olean-12-ene	$C_{30}H_{50}$	It acts as hepatoprotective and gastroprotective, hypolipidemic and anti-atherosclerotic, it also hasantibacterial and antifungal properties
Cyclononanone	$C_9H_{16}O$	Used in the production of vitamins, hormones and certain medicines
1,4-benzenediol	$C_6H_6O_2$	Acne, seborrheic dermatitis, eczema, psoriasis, corns, calluses, and warts are treated
Campesterol	$C_{28}H_{48}O$	Anti-inflammatory effects, hypercholesterolemia management, steroid hormone precursor
Isopropyl linoleate	$C_{21}H_{38}O_2$	Acts as emollient, penetration enhancer, non-comedogenic
Androstan-4-one	$C_{19}H_{30}O$	Helps in muscle growth and strength, it increases the testosterone levels in the body

Nonanoic acid	$C_9H_{18}O_2$	Possess anti-microbial activity, helps in the treatment of epilepsy
Benzoic acid	$C_7H_6O_2$	Antimicrobial food preservative sodium benzoate is utilized as a therapy for urea cycle problems when in the form of salt
Ergost-5-en-3-ol	$C_{28}H_{48}O$	It has very potent anti-inflammatory, analgesic, and antipyretic effects.
Methoxyacetic acid	$C_3H_6O_3$	Reprotoxic potential, it produces reproductive toxicity
3-methoxyergost-8(14)-ene	$C_{29}H_{50}O$	It has anticancer and antiviral properties and is widely used as a solvent, particularly in paints and varnishes
Pentanedioic acid	$C_5H_8O_4$	Neuroprotective, cardioprotective, antimicrobial, and antitumor activities in preclinical studies
Octadecanoic acid	$C_{18}H_{36}O_2$	It has anti-inflammatory and antiatherogenic properties
L-arabinitol	$C_5H_{12}O_5$	Acts as a natural sweetener; it also possesses anticariogenic properties

5. Conclusion

The ultimate source of food and oxygen for all living things on our planet is plants and their byproducts, such as fruits, seeds, and leaves. For this purpose, it is important to research the phytonutrients present in the yardlong beans. The study concludes that the genotype EC -769247 is the best-performed genotype among six parents and one standard check (Arka Mangala) and it can be used as parent material for further breeding programmes. The GC-MS analysis further supports that yardlong beans have significant therapeutic and pharmacological benefits for humans.The ethanolic extract ofyardlong beans identified over 130 compounds, providing scientific evidence for their pharmacological potential. Many biological properties, such as hepatoprotective, antioxidant, anticarcinogenic, antibacterial, antifungal, anti-inflammatory, and anticancer effects, are displayed by the compounds identified by GC-MS in this study, making them extremely beneficial for the pharmaceutical sectors. This analysis highlights the diverse active compounds present in yardlong beans and underscores the crop significance. According to the obtained results, it is proved that yardlong bean has now become a cheap source for pharmaceutical development and production, according to pharmaceutical experts and enterprises.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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