Online ISSN 2456-6489

Research Article

Indian Journal of Agroforestry
Vol. 27, No. 2, April–June 2025

Melia Dubia Leaf Fodder Has Higher Volatile Phytochemicals during Winter: A Case Study Across Satpura and Northern Western Ghats Mountain Ranges, India

S S Malek[1], N S Thakur[1*], Susheel Singh[2], R P Gunaga[3] and V R Patel[4]

[1]*Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari- 396450, Gujarat*
[2]*Pesticide Residue Chemistry, N.M. College of Agriculture, Navsari Agricultural University, Navsari- 396450, Gujarat*
[3]*Department of Forest Products and Utilization, College of Forestry, Navsari Agricultural University, Navsari- 396450, Gujarat*
[4]*Department of Animal Nutrition, College of Veterinary Science & animal Husbandry (Kamdhenu University, Gandhinagar), Navsari Campus, Navsari-396450, Gujarat*

* Corresponding author. E-mail: drnsthakur74@gmail.com
https://doi.org/10.48165/ija.2025.27.02.06

ARTICLE INFO
Received: 07.04.2024
Accepted: 28.02.2025

Keywords:
Melia dubia
Leaf fodder
Volatile compounds
Phytochemicals
Antioxidant

ABSTRACT

Gas-chromatography mass-spectrometry (GC-MS) analysis of M. dubia leaf elucidated variation in volatile chemical compounds across provenances and seasons. In total, an array of 93 volatile phytochemical compounds was revealed. Winter season leaf samples contained maximum (55) compounds as compared to summer (35). Corroboration of detected chemical compounds with available literature divulged that similar compounds occur in other species of same and other families as well and have one or the other beneficial biological activities. The presence of volatile compounds in M. dubia leaf could be a rich source antioxidant, anti-inflammatory, and antibacterial activity etc. And leaf feeding to small ruminants and livestock may have many biological benefits in terms of favored growth performance, production quality, and enhanced endogenous antioxidant systems.

INTRODUCTION

Tree leaf fodder contains a variety of secondary metabolites, including antioxidant peptides, phenols, flavonoids, phytic acid, trypsin inhibitors, and lectins (Diaz-Sanchez *et al.*, 2015; Dey *et al.*, 2019; Wong et al., 2020; Sukhadiya *et al.*, 2021). These plant-derived secondary metabolites are rich in antioxidant, anti- inflammatory, and antibacterial activity (Diaz- Sanchez *et al.*, 2015, Kumar and Goel, 2019). Phytochemicals have been reported to have positive antioxidant benefits toward animals in terms of favored growth performance, production quality, and enhanced endogenous antioxidant systems, possibly by directly affecting specific molecular targets or/and indirectly as stabilized conjugates affecting the metabolic pathways (Hamaker *et al.*, 2009; Jorgensen *et al.*, 2010; Wong *et al.*, 2020). Accordingly, dissecting the antioxidant effects and the underlying mechanism of dietary phytochemicals is an important area.

Currently, cultivation of fodders is limited to only 4.00% of the total cultivable land in the country. The performance of livestock and the economics of milk production are profoundly dependent on the quantity and quality of fodder fed. There is a current shortfall of 35.60% green fodder, 10.50% dry fodder, and 44.00% concentrate feed across the country. The inadequacy of nutrients is a major limitation for livestock as a deficit of 728 mT (64%) of green fodder and 157 mT (25%) of dry fodder with 27% of crude protein (CP) and 24% of total digestible nutrients in India (Singh *et al.*, 2022). This can partly be overcome by feeding tree leaves and other organs, as huge quantity of biomass is available from fodder trees, which provide nitrogen, energy, minerals and vitamins and reduce cost of feeding (Wong et al., 2020; Sukhadiya *et al.*, 2022). Tree foliage and other

organs (drupes, pods) are important component of livestock diets and plays important role in the nutrition of herbivores in areas where few or no alternatives are available (Kamalak *et al.*, 2010; Sukhadiya *et al.*, 2019). Therefore, taking cue from the importance of these volatile and non- volatile chemical compounds, we intended to analyze these in *Melia dubia* Cav. leaf fodder. It shed leaves in December and new flush of leaves appear in February-March along with the flowers. The species is indigenous to the Western Ghats region in India and is common in moist deciduous forests of the Indian states from Kerala to Gujarat and also found in Bangladesh, Myanmar, Thailand, Mexico, Sri Lanka, Malaysia,Indonesia, China, Philippines, Australia and African countries (Thakur *et al.*, 2021; Sukhadiya *et al.*, 2021). It is a large deciduous tree of Meliaceae family, much advocated multipurpose industrially important (Parthiban *et al.*, 2019; Thakur *et al.*, 2023) and acceptable agroforestry species and gaining importance in wood-based industry (Mohanty *et al.*, 2019; Thakur *et al.*, 2018; Chavan *et al.*, 2022). Hence, looking in to need to explore new species as to feed source present study was undertaken to ascertain its leaf volatile compounds.

MATERIAL AND METHODS

Provenances and geo-climatic conditions

Eight provenances [two (P1 & P2) falling in Satpura mountain ranges and six (P3 & P8) in northern most tip of western Ghats or Sahyadri mountain ranges] were selected in Gujarat, India (Table 1). Sagai-1 and Sagai-2, provenances area characterized by black cotton soils, with average (30 years) annual normal rainfall of 924.8 mm and average annual maximum and minimum temperature of 34.7℃ and 20.7℃, respectively. Nanaponda and Kaprada provenances, a northern extension of Central Indian Deccan Plateau, belong to late Cretaceous-early Eocene age and followed by Quaternary sediments, have black cotton soils. The maximum daily temperature ranges from 32.2℃ to 41.2℃ while minimum temperature from 9.9℃ to 23.3℃. Average annual rainfall in these provenances is 2399 mm and 2842 mm, respectively. Waghai and Chichinagavtha, and Mahal and Ahwa provenances fall under south and north Dangs region, respectively. These areas have black rock-outcrops, shallow black, brown and alluvial soils of recent origin. The average annual rainfall ranges from 1500 to 3000 mm and average annual temperature is about 26℃ and maximum temperature may shoot up to 46°C and the winter temperatures 22℃.

Sample collection and processing

Five trees (each tree representing one replication) were selected randomly from each provenance for leaf fodder sample collection. Tree growth parameters *viz.* tree height and diameter at breast height (DBH) and average canopy area (m2) were recorded (Table 1). Leaf samples were collected from all directions (north-south and east-west) at lower, middle and upper tree canopy. The samples were washed with distilled water in laboratory and air-dried followed by drying in oven at 60℃±5℃ till constant weight was achieved. The dried samples were then finely grounded (particle size<1 mm) using grinder and laboratory grade pulverizer. Volatile and non-volatile compounds were estimated for winter and summer seasons of 2020 and 2021 and averaged to ascertain the provenance and seasonal variations.

Volatile phytochemical estimation through Gas- chromatography mass-spectrometry

M. dubia leaf sample phytochemicals were detected through Gas-chromatography mass-spectrometry (GC-MS) following Murugesan *et al.* (2013).

RESULTS AND DISCUSSION

M. dubia leaf volatile phytochemicals

Non targeted gas-chromatography mass-spectrometry (GC-MS) analysis of *M. dubia* leaf samples of different provenances and seasons *i.e.* winter (S1) and summer (S2) seasons, revealed an array of 93 volatile phytochemicals (Table 2). Chromatograms (randomly selected 4 out of 16 chromatograms of 8 provenances and two seasons) showing peak area and retention time of detected phytochemicals are depicted in figure 1 to 4 Total 76 and 60 compounds were detected in winter **1.** and summer, respectively (Table 3). Maximum of 55 and 35 compounds in winter and summer sample, respectively, were detected from Sagai-2 (P2) provenance. The lowest (23) compounds were detected in Chichinagavtha provenance (P6) in winter and summer. As many as, 43 common phytochemicals (Table 3) numbered 5, 7, 9, 13, 17, 19, 20, 23, 24, 26, 27, 30, 35, 36, 40, 45, 46, 47, 49, 52, 53, 55, 57, 60, 61, 62, 63, 64, 65, 69, 70, 73, 74, 76,77, 80, 81, 82, 85, 88, 89, 92 and 93 were identified in winter and summer season. Whereas, 33 phytochemicals numbered 4, 8,10, 11, 12, 14, 18, 22, 28, 29, 32, 33, 34, 38, 39, 41, 42,43, 44, 50, 54, 56, 59, 66, 67, 71, 75, 78, 83, 84, 86, 87 and 90 were only detected in winter. Similarly, 17 phytochemicals numbered 1, 2, 3, 6, 15, 16, 21, 25, 31,37, 48, 51, 58, 68, 72, 79 and 91 were unique in summer (Table 3).

Table 1: Geographical location of *M. dubia* provenances (P1-P2 in Satpura mountain ranges and P3 -P8 in The Northern most Western Ghats or Sahyadri mountain ranges) in Gujarat India, selected in the study

Provenance (P)	Geographical attributes			Average biometric attributes		
	Altitude (m)	Longitude (E)	Latitude (N)	Tree height (m)	DBH (cm)	Canopy area (m2)
Sagai-1 (P1)	373.68	73°47'33.13"	21°40'19.28"	25.80	155.73	246.00
Sagai-2 (P2)	320.04	73°44'21.30"	21°40'47.32"	35.90	172.00	256.16
Nana Pondha (P3)	63.09	73° 8'54.14"	20°26'5.45"	26.60	128.20	206.20
Kaprada (P4)	382.52	73°15'23.07"	20°20'15.71"	25.22	120.18	241.40
Waghai (P5)	127.41	73°29'4.63"	20°45'49.32"	33.76	156.99	221.20
Chichinagavtha (P6)	256.03	73°33'40.46"	20°47'19.06"	30.64	148.40	188.50
Mahal (P7)	262.13	73°36'6.52"	20°57'0.13"	42.52	149.00	157.40
Ahwa (P8)	319.13	73°39'24.02"	20°46'1.27"	36.60	117.20	126.60

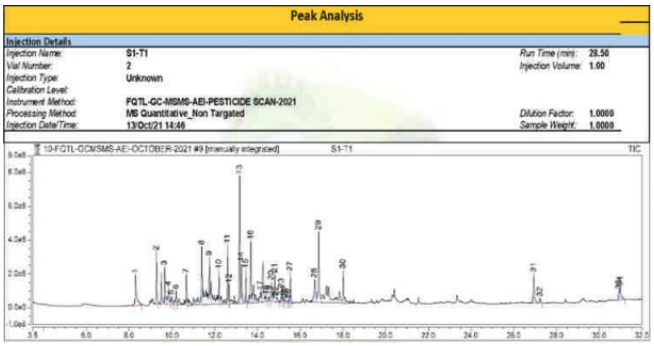


Figure 1: Chromatogram showing M. dubia leaf volatile phytochemical compounds detected in winter season sample of provenance 1 (Sagai-

Comparison of per cent peak area (Table 3) revealed that l-(+)-Ascorbic acid 2,6-dihexadecanoate; Phenol, 2,4-bis(1,1-dimethylethyl)-, phosphite (3:1); dl-a-Tocopherol; 2,4-Di-tert-butylphenol; 3,7,11,15- Tetramethyl-2-hexadecen-1-ol; Neophytadiene; 9,12,15-Octadecatrienoic acid, (Z,Z,Z)-; 2-Dimethyl(ethenyl)silyloxytetradecane; Sebacic acid, di(2-propylpentyl) ester; 2,3-Dimethyl-3-pyrazolin-5- one; 2- Propenoic acid, 2-(acetylamino)-; Nonadecane, 2-methyl-; 4-Heptanol, 2,6-dimethyl-4-(1-methylethyl)-; 1-Hexadecanol; 9-Nonadecene; Octadecanoic acid; Eicosane, 2-methyl-; 10- Heneicosene (c,t); 2-Pentadecanone, 6,10,14- trimethyl-; D-Mannitol, 1,2:3,4:5,6-tris-O-(1- methylethylidene)- were found in higher concentration (decreasing order) in winter and summer, respectively.

Paritala *et al.* (2015) reported that different members of Meliaceae family such as *A. indica* and *M. dubia* possess a vast array of biologically active compounds which are chemically diverse and structurally complex. Earlier, Parmar *et al.* (2019) reported 18 different types of phytochemicals in *M. dubia* leaf through GC–MS analysis. Murugesan *et al.* (2013) reported 42 phytochemicals from the *M. dubia* leaf. Jahirhussain *et al.* (2015) identified 33 phytochemicals as constituents with more than one peak area for 7 compounds from ethanolic leaf extract of *M. composita.* Mudhafar *et al.* (2020) reported 22 phytochemical compounds from *M. dubia* leaves using GCMS analysis. Our GC-MS analysis revealed greater number of phytochemicals as compared to previous reports on this species. The results deduced that there was variation in phytochemical compound occurrence among provenances and seasons. Synthesis of chemical compounds within plant system happens in response to external environmental stimuli caused by edapho-climatic stresses. It could be also be due to biotic stimuli (insect pest attack) to which plant develop defence and compounds synthesized could be beneficial for human beings and wild and domestic animals feeding on it (Tekli´c *et al.*, 2021; Sukhadiya *et al.*, 2022).

Corroboration of chemical compounds detected in our study with available literature revealed that they occur in other species of same family (Balasubramanian *et al.*, 2014; Kumar *et al.*, 2018) and have one or the other beneficial biological activities. The most common are anti-bacterial, anti-inflammatory agent, antioxidant, insecticidal, analgesic, antipyretic, antiarthritic, antic ancer, antihistaminic, antieczemic, antiandrogenic, hypo-cholesterolemic, antiviral anxiolytic activity *etc.* Many of them are used to cure gum disease and skin infections and other ailments (Wang and Huang, 2012; Hamid *et al.*, 2016; Ruthisha *et al.*, 2017; Gravel *et al.*, 2017; Swamy *et al.*, 2017; Amudha *et al.*, 2018; Elgorban *et al.*, 2019; Zhao *et al.*, 2020; Bratty *et al.*, 2020; Chikezie *et al.*, 2020; Subramanian *et al.*, 2020; Prodhan and Mridu, 2021; Huang *et al.*, 2021; Sethuraman and Ramachandran 2022; Moussaoui *et al.*, 2022). Thus, *M. dubia* leaf volatile phytochemicals are biologically active compounds and the leaf fodder could beneficial as top feed for livestock.

The presence of volatile compounds in *M. dubia* leaf could be source antioxidant, anti-inflammatory, and an-

tibacterial activity *etc.* (Diaz-Sanchez *et al.*, 2015; Kumar and Goel, 2019; Wong *et al.*, 2020). And its feeding to small ruminants and livestock may have positive effect toward animals in terms of favored growth performance, production quality, and enhanced endogenous antioxidant systems, possibly by directly affecting specific molecular targets or/and indirectly as stabilized conjugates affecting the metabolic pathways (Hamaker *et al.*, 2009; Jorgensen *et al.*, 2010; Wong *et al.*, 2020). Alkaloids have antibacterial activity which could be beneficial to livestock. Achi *et al.* (2017) reported that flavonoids (1.36%) present in *Ficus capensis* leaves possess medicinal benefits which includes antioxidant and

anti-inflammatory activity. Saponins of plant origins are important dietary supplements and exhibit antimicrobial activities and protect plants from microbial pathogens. Tree leaves show high digestibility values associated with low TTC levels (Forwood and Owensby, 1985). Total tannin content range of *M. dubia* leaf in present study fall within the values (0.89 to 30.43%) reported in other top feed species (Niranjan *et al.*, 2007; Datt *et al.*, 2008; Wankhede and Jain, 2011; Achi *et al.*, 2017). TTC values of *M. dubia* leaf also fall within the range advocated suitable in livestock feed (Devasena and Adilaxmamma, 2016).

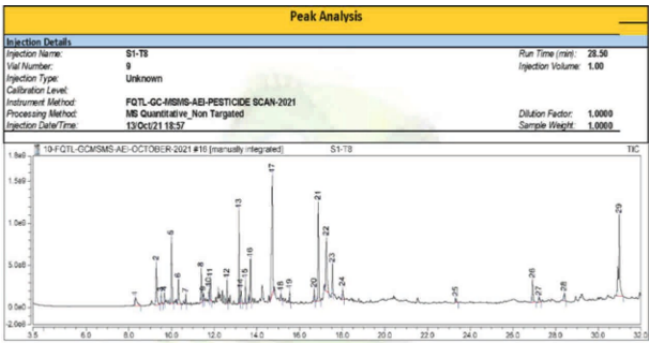


Figure 2: Chromatogram showing M. dubia leaf volatile phytochemical compounds detected in winter season sample of provenance 8 (Ahwa)

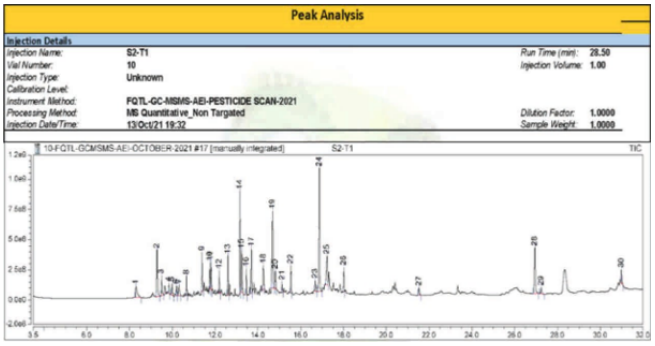


Figure 3: Chromatogram showing M. dubia leaf volatile phytochemical compounds detected in summer season sample of provenance 1 (Sagai-1)

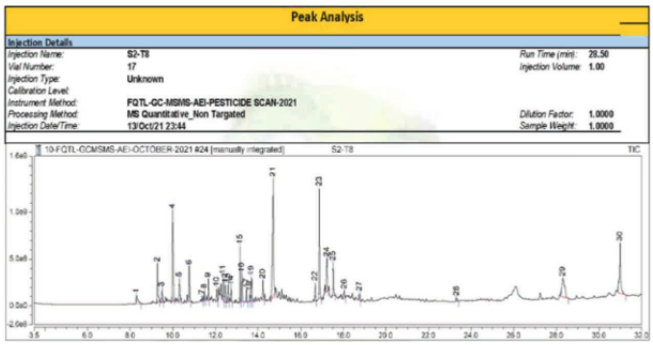


Figure 4: Chromatogram showing M. dubia leaf volatile phytochemical compounds detected in summer season sample of provenance 8 (Ahwa)

CONCLUSION

Gas-chromatography mass-spectrometry (GC-MS) analysis of *M. dubia* leaf revealed variation in volatile chemical compounds across provenances and seasons. Maximum 55 and 35 compounds were detected in winter and summer season, respectively. Study revealed significant variation in total alkaloid, flavonoids, phenolic, saponin, tannin and total terpenoids content across selected provenances and sampling seasons *i . e.* winter and summer. Corroboration of chemical compounds with available literature revealed that similar compounds occur in other species of same as well others families and have one or the other beneficial biological activities. The presence of volatile and non-volatile (secondary metabolites) compounds in *M. dubia* leaf could be source of antioxidant, anti-inflammatory, and antibacterial activity *etc.* and feeding leaves to small ruminants and livestock may have antioxidant and other health benefits to animals in terms of favored growth performance, production quality, and enhanced endogenous antioxidant systems.

ACKNOWLEDGEMENT

First author extends sincere thanks towards Education Department, Gujarat State Government for providing SHODH (Scheme of Developing High quality research) scheme financial assistance fellowship for his Doctoral study. All authors are thankful Deans, College of Forestry, Navsari Agricultural University, Navsari, and College of Veterinary Science & animal Husbandry (Kamdhenu University, Gandhinagar), Navsari Campus, Gujarat, India for providing necessary support to accomplish this study.

Table 2: *M. dubia* leaf volatile phytochemicals detected using non targeted gas chromatography mass spectrometry (GC-MS)

S.No.	Compound	Compound chemical formula & Molecular weight
1	(E)-Labda-8(17), 12-diene-15,16-dial	C20H30O2 (302.45)
2	1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester	C16H22O4 (278.34)
3	1,3-Dioxolane, 2-butyl-2-methyl-	C8H16O2 (144.21)
4	1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl-, (all-E)-(	C30H50O (426.7)
5	10-Heneicosene (c,t)	C21H42 (294.55)
6	1-Cyclohexyldimethyl silyloxy-3,5-dimethylbenzene	C16H26Osi (262.46)
7	1-Decanol, 2-hexyl-	C16H34O (242.44)
8	1-Decanol, 2-octyl-	C18H38O (270.5)
9	1-Dodecanol, 2-hexyl-	C18H38O (270.49)
10	1-Dodecanol, 2-octyl-	C20H42O (298.55)
11	1-Heneicosanol	C21H44O (312.57)
12	1-Heptacosanol	C27H56O (396.73)
13	1-Hexadecanol	C16H34O (242.44)
14	1-Hexadecyn-3-ol, 3,7,11,15-tetramethyl-	C20H40O (296.53)
15	1-Methyl-3-n-propyl-2-pyrazolin-5-one	C7H12N2O (140.18)
16	1-Undecanol	C11H24O (172.31)
17	2,3-Dimethyl-3-pyrazolin-5-one	C5H8N2O (112.13)
18	2,4,6-Decatrienoic acid, 1a,2,5,5a,6,9,10, 10a-octahydro-5, 5a-dihydroxy-4-(hy	C30H46O6 (594.31)
19	2,4-Di-tert-butylphenol	C14H22O (206.32)
20	2-Dimethyl(ethenyl) silyloxytetradecane	C19H40OSi (344.7)
21	2-Dimethyl(ethenyl) silyloxytridecane	C13H27Osi (312.6)
22	2-Oxazolamine, 4,5-dimethyl-	C5H8N2O (274.37)
23	2-Pentadecanone, 6,10,14-trimethyl-	C18H36O (268.47)
24	2-Propenoic acid, 2-(acetylamino)-	C5H7NO3 (129.11)
25	2-tert-Butyl-6-(5-chloro-2H-benzotriazol-2-yl)-4-methylphenol mesylate	C17H18-ClN3O (315.79)
26	3,7,11,15-Tetramethyl-2-hexadecen-1-ol (Phytol)	C20H40O (296.53)
27	3-Octenoic acid, 4-methyl-2-pentyl ester	C14H26O2 (226.35)
28	4a,7a-Epoxy-5H-cyclopenta[a]cyclopropa [f]cycloundecen-4(1H)-one, 1a,6,7,1	C28H40O12 (568.6)
29	4aa,4bß-Gibbane-1a, 10ß-dicarboxylic acid, 4a-formyl-2ß,7-dihydroxy-1-meth	C22H30O7 (406.5)
30	4-Heptanol, 2, 6-dimethyl-4-(1-methylethyl)-	C12H26O (186.33)
31	5,5,6-Trimethylhept-3-en-2-one	C10H18O (156.26)
32	6-Octadecenoic acid, methyl ester, (Z)-	C19H36O2 (296.48)
33	7,9-Di-tert-butyl-1-oxaspiro (4,5)deca-6,9-diene-2,8-dione	C17H24O3 (276.37)
34	7-Methyl-Z-tetradecen-1-ol acetate	C17H32O2 (254.40)
35	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	C19H32O2 (278.42)
36	9-Nonadecene	C19H38 (266.50)
37	9-Octadecenoic acid (Z)-, methyl ester	C19H36O2 (396.48)
38	Acetic acid, 3,7,11,15- tetramethyl-hexadecyl ester	C22H44O2 (340.58)
39	Antiquorin	C20H28O3 (316.43)
40	Bis(2-ethylhexyl) phthalate	C24H38O4 (390.55)
41	Carbonic acid, eicosyl vinyl ester	C23H44O3 (368.59)
42	Cholesta-8,24-dien-3-ol, (3ß,5a)-	C27H44O (284.63)
43	cis-13-Octadecenoic acid, methyl ester	C19H36O2 (296.48)
44	Decanedioic acid, bis(2-ethylhexyl) ester	C26H50O4 (426.68)

S.No.	Compound	Compound chemical formula & Molecular weight
45	dl-a-Tocopherol (Vitamin E)	C29H50O2 (416.68)
46	D-Mannitol, 1,2:3,4:5, 6-tris-O-(1-methylethylidene)-	C12H22O6 (302.36)
47	Docosanal	C22H44O (326.61)
48	Dodecane, 2,6,11-trimethyl-	C15H32 (212.41)
49	Dodecanoic acid (Lauric acid)	C12H24O2 (201.31)
50	E-8-Methyl-9-tetradecen-1-ol acetate	C17H32O2 (268.43)
51	Eicosanal-	C20H40O (296.53)
52	Eicosane	C20H42 (282.54)
53	Eicosane, 2-methyl-	C21H44 (296.57)
54	Eicosyl octyl ether	C28H58O (410.75)
55	Ethanol, 2-(dodecyloxy)-	C14H30O2 (230.39)
56	Fumaric acid, cis-hex-3-enyl tetradecyl ester	C24H42O4 (280.36)
57	Heptacos-1-ene	C27H54 (378.71)
58	Heptadecane	C17H36 (240.47)
59	Heptadecane, 2,6,10, 15-tetramethyl-	C21H44 (296.57)
60	Hexadecanal	C16H32O (256.42)
61	Hexadecane (Cetane)	C16H34 (226.41)
62	Hexadecane, 2,6,11, 15-tetramethyl-	C20H42 (282.5)
63	Hexadecanoic acid, methyl ester	C17H34O2 (270.45)
64	l-(+)-Ascorbic acid 2, 6-dihexadecanoate (vitamin C)	C38H68O8 (652.9)
65	Neophytadiene	C20H38 (278.5)
66	N-Heptanoyl-L-homoserine lactone	C11H19NO3 (213.3)
67	n-Hexadecanoic acid (Palmitic acid)	C16H32O2 (256.42)
68	n-Nonadecanol-1	C19H40O (284.5)
69	Nonacos-1-ene	C29H52 (406.8)
70	Nonadecane, 2-methyl-	C20H42 (282.5)
71	Nonadecyl Pentafluoropropionate	C22H39F5O2 (430.5)
72	Nonadecyl trifluoroacetate	C21H39F3O2 (380.52)
73	Nonyl tetradecyl ether	C23H48O (340.6)
74	n-Tetracosanol-1	C24H50O (354.65)
75	Octacosane, 2-methyl-	C29H60 (408.8)
76	Octadecanal (Stearaldehyde)	C18H36O (268.5)
77	Octadecanoic acid (Stearic acid)	C18H36O2 (284.48)
78	Octatriacontyl Pentafluoropropionate	C41H77F5O2 (697.0)
79	Octyl tetracosyl ether	C32H66O (466.9)
80	Pentadecane	C15H32 (212.42)
81	Phenol, 2,4-bis(1, 1-dimethylethyl)-, phosphite (3:1)	C42H63O3P (646.92)
82	Phenol, 2,4-di-t-butyl-6-nitro-	C14H21NO3 (251.32)
83	Phthalic acid, 5-methylhex-2-yl butyl ester	C19H28O4 (320.4)
84	Phthalic acid, hept-3-yl isobutyl ester	C19H28O4 (320.4)
85	Phthalic acid, hept-4-yl isobutyl ester (	C19H28O4 (320.4)
86	Phytol	C20H40O (296.53)
87	Pregnan-20-one, 5,6-epoxy-3,17-dihydroxy-16-methyl-, (3ß,5a,6a,16a)	C22H34O4 (362.5)
88	Sebacic acid, di(2-propylpentyl) ester	C26H50O4 (426.7)
89	Squalene	C30H50 (422.8)
90	tert-Hexadecanethiol (gold(3+) salt)	C48H99AuS3 (969.5)
91	Tetradecane	C14H30 (198.39)
92	trans-13-Octadecenoic acid, methyl ester (Oleic acid)	C18H34O2 (282.5)
93	Trichloroacetic acid, hexadecyl ester	C18H33Cl3O2 (387.8)

Table 4: Seasonal variation in peak area (%) of common volatile phytochemicals of *M. dubia* leaf fodder

Table 3: Provenance and seasonal variation in peak area (%) of *M. dubia* leaf fodder volatile phytochemicals (Please refer table 2 corresponding s.no. for phytochemical name)

~~Phytochemical*~~	Peak area (%)															
	S1 (Winter)								S2 (Summer)							
	Provenances								Provenances							
	P1	P2	P3	P4	P5	P6	P7	P8	P1	P2	P3	P4	P5	P6	P7	P8
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.20	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.66
3	-	-	-	-	-	-	-	-	-	-	-	-	1.76	-	-	-
4	-	0.74	-	-	-	-	0.89	-	-	-	-	-	-	-	-	-
5	-	-	-	-	3.92	3.60	-	2.31	3.35	2.54	3.85	-	-	2.79	-	-
6	-	-	-	-	-	-	-	-	-	-	-	0.39	-	-	-	-
7	-	2.37	-	-	-	-	0.97	-	-	0.56	-	-	-	-	-	1.37
8	-	1.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	1.36	-	-	-	-	-	-	-	-	-	-	-	-	-	0.90
10	-	0.44	-	-	-	-	1.42	-	-	-	-	-	-	-	-	-
11	1.11	-	1.13	-	-	0.93	-	-	-	-	-	-	-	-	-	-
12	3.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	4.96	-	3.61	3.79	3.94	3.87	-	2.60	3.44	2.06	4.20	4.88	-	3.19	3.04	-
14	-	0.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	2.02	-	-
16	-	-	-	-	-	-	-	-	-	1.47	-	3.67	-	1.77	2.60	-
17	-	3.52	4.16	5.49	4.29	4.04	3.63	2.00	2.90	2.73	-	-	3.10	-	3.61	2.01
18	-	-	1.30	-	-	-	-	1.02	-	-	-	-	-	-	-	-
19	1.05	10.60	2.63	1.85	-	0.88	12.79	7.49	1.64	6.57	1.92	-	-	0.82	-	10.11
20	-	-	-	8.42	7.28	6.07	7.65	0.84	2.05	5.95	1.20	-	6.88	1.12	-	4.07
21	-	-	-	-	-	-	-	-	-	-	3.48	6.79	-	-	-	-
22	6.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	3.62	0.88	-	-	1.81	1.93	1.22	1.14	3.96	2.86	2.29	2.48	1.24	1.22	-	2.02
24	4.23	1.56	5.21	-	2.33	-	-	4.50	-	-	-	2.68	-	3.96	6.41	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-
26	8.61	6.60	11.02	9.88	9.47	10.95	7.02	9.89	15.18	13.07	15.58	14.58	6.68	10.36	8.89	11.09
27	-	-	-	-	-	-	0.96	-	-	0.74	-	-	-	-	-	0.82
28	-	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-

DOI: https://doi.org/10.48165/ija.2025.27.02.06

DOI: https://doi.org/10.48165/ija.2025.27.02.06

Table 3: Provenance and seasonal variation in peak area (%) of *M. dubia* leaf fodder volatile phytochemicals (Please refer table 2 corresponding s.no. for phytochemical name) (continued)

	Peak area (%)															
Phytochemical*																
30	-	5.00	-	-	-	2.35	-	-	5.24	-	-	-	-	-	-	1.21
31	-	-	-	-	-	-	-	-	-	-	2.32	3.33	-	-	-	-
32	3.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	-	0.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	-	-	-	4.03	-	3.27	-	-	-	-	-	-	-	-	-	-
35	-	4.38	-	-	-	-	5.25	8.92	4.46	-	-	-	8.26	3.59	5.43	4.67
36	4.84	-	4.49	4.34	-	-	-	-	-	-	-	4.30	4.51	-	4.30	-
37	-	-	-	-	-	-	-	-	-	-	-	-	-	1.13	-	-
38	-	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	0.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	-	0.54	-	-	-	-	0.69	0.58	-	1.05	-	-	0.69	-	3.09	0.48
41	0.26	1.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	1.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	2.01	-	-	-	-	-	-	-	-	-
44	4.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	2.20	3.33	7.74	4.50	3.52	1.53	6.51	13.45	1.47	6.51	9.68	5.25	10.21	6.74	8.08	8.33
46	-	3.16	-	-	-	-	2.35	-	-	1.59	-	-	-	-	-	2.86
47	-	-	-	-	0.92	-	-	-	-	0.57	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	1.09	-	-	-	-	-	-	-
49	-	1.77	2.18	2.48	1.89	1.03	3.10	2.62	1.42	1.81	1.24	2.57	3.54	1.29	2.26	1.98
50	-	-	2.94	-	-	-	-	-	-	-	-	-	-	-	-	-
51	-	-	-	-	-	-	-	-	-	-	-	1.34	0.98	1.04	-	-
52	2.69	-	0.89	1.60	-	-	-	-	-	-	0.87	0.97	-	0.67	-	-
53	4.11	-	2.73	2.21	2.08	1.79	-	0.66	1.78	1.08	1.85	2.61	2.46	1.41	2.49	-
54	-	1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	-	-	-	-	2.50	2.36	0.44	1.58	2.28	0.96	2.42	1.93	-	-	-	-
56	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57	-	2.24	-	-	-	-	2.19	-	-	-	-	-	-	-	-	1.85
58	-	-	-	-	-	-	-	-	1.97	0.76	-	-	-	-	-	-
59	2.30	0.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	0.50	-	-	-	-	0.53	-	-	0.47	-	-
61	-	0.25	1.76	-	2.42	1.90	-	0.65	1.50	0.78	1.41	1.85	1.77	1.19	1.50	-

DOI: https://doi.org/10.48165/ija.2025.27.02.06

Table 3: Provenance and seasonal variation in peak area (%) of *M. dubia* leaf fodder volatile phytochemicals (Please refer table 2 corresponding s.no. for phytochemical name) (continued)

	Peak area (%)															
Phytochemical*																
62	2.72	0.61	1.59	2.13	1.94	-	-	-	3.71	-	-	-	-	1.40	1.78	-
63	-	1.89	-	-	-	-	1.99	-	-	3.20	-	-	-	-	-	1.76
64	-	7.34	8.22	8.93	11.35	7.46	18.14	16.57	9.42	14.12	10.95	13.05	17.45	10.14	11.91	16.71
65	9.87	4.41	7.85	-	7.89	5.85	4.61	6.77	8.44	-	8.14	6.04	4.82	5.40	5.81	-
66	-	-	-	-	-	-	-	0.55	-	-	-	-	-	-	-	-
67	1.74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.08	-
69	-	-	2.68	2.97	-	2.60	-	1.31	2.48	1.83	2.71	2.98	-	2.32	3.12	-
70	5.17	0.52	5.21	4.96	-	-	-	-	0.91	-	4.94	-	3.88	3.68	-	-
71	-	1.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.38
73	-	-	-	-	-	-	0.61	-	-	-	-	-	-	-	-	0.47
74	-	1.26	-	-	-	-	-	-	-	-	-	-	2.87	-	-	-
75	-	-	-	5.32	-	4.61	-	-	-	-	-	-	-	-	-	-
76	2.82	-	2.72	3.02	2.69	2.54	-	0.98	2.44	1.44	2.62	2.96	2.73	2.26	3.25	-
77	-	2.92	-	-	-	-	4.23	2.64	-	2.49	-	-	-	1.02	1.29	3.47
78	-	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.19
80	-	-	-	-	-	0.73	-	-	-	-	0.96	-	-	-	-	-
81	-	-	-	-	13.83	10.59	-	-	-	-	-	-	-	14.43	-	7.26
82	-	1.90	-	-	-	-	2.15	-	-	1.20	-	-	-	-	-	1.76
83	-	-	-	-	-	2.68	-	-	-	-	-	-	-	-	-	-
84	-	0.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85	-	-	-	-	-	-	0.72	-	-	0.69	-	-	1.41	-	0.81	-
86	0.36	0.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-
87	-	0.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-
88	-	-	5.28	6.07	7.83	5.52	-	2.77	6.56	4.46	6.06	7.16	8.89	5.09	7.99	-
89	0.59	-	1.04	1.02	0.68	0.74	-	0.68	0.84	-	-	1.08	-	-	-	-
90	0.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
91	-	-	-	-	-	-	-	-	-	-	2.22	-	-	-	-	-
92	-	1.71	1.88	1.86	-	-	-	1.22	1.53	2.04	-	-	-	-	2.22	1.68
93	-	2.36	-	-	-	-	-	-	-	0.66	-	-	-	-	-	-

P1-Sagai-1, P2-Sagai-2, P3-Nana Pondha, P4-Kaprada, P5-Waghai, P6-Chichinagawtha, P7-Mahal, P8-Ahwa

S.No.	Phytochemical	Max. peak area (%)	
		S1 (Winter)	S2 (Summer)
1.	l-(+)-Ascorbic acid 2,6-dihexadecanoate	18.14	17.45
2.	Phenol, 2,4-bis(1,1-dimethylethyl)-, phosphite (3:1)	13.83	14.43
3.	dl-a-Tocopherol	13.45	10.21
4.	2,4-Di-tert-butylphenol	12.79	10.11
5.	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	11.02	15.58
6.	Neophytadiene	9.87	8.44
7.	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	8.92	8.26
8.	2-Dimethyl(ethenyl)silyloxytetradecane	8.42	6.88
9.	Sebacic acid, di(2-propylpentyl) ester	7.83	8.89
10.	2,3-Dimethyl-3-pyrazolin-5-one	5.49	3.61
11.	2-Propenoic acid, 2-(acetylamino)-	5.21	6.41
12.	Nonadecane, 2-methyl-	5.21	4.94
13.	4-Heptanol, 2,6-dimethyl-4-(1-methylethyl)-	5.00	5.24
14.	1-Hexadecanol	4.96	4.88
15.	9-Nonadecene	4.84	4.51
16.	Octadecanoic acid	4.23	3.47
17.	Eicosane, 2-methyl-	4.11	2.61
18.	10-Heneicosene (c,t)	3.92	3.85
19.	2-Pentadecanone, 6,10,14-trimethyl-	3.62	3.96
20.	D-Mannitol, 1,2:3,4:5,6-tris-O-(1-methylethylidene)-	3.16	2.86
21.	Dodecanoic acid	3.10	3.54
22.	Octadecanal	3.02	3.25
23.	Nonacos-1-ene	2.97	3.12
24.	Hexadecane, 2,6,11,15-tetramethyl-	2.72	3.71
25.	Eicosane	2.69	0.97
26.	Ethanol, 2-(dodecyloxy)-	2.50	2.42
27.	Hexadecane	2.42	1.85
28.	1-Decanol, 2-hexyl-	2.37	1.37
29.	Trichloroacetic acid, hexadecyl ester	2.36	0.66
30.	Heptacos-1-ene	2.24	1.85
31.	Phenol, 2,4-di-t-butyl-6-nitro-	2.15	1.76
32.	Hexadecanoic acid, methyl ester	1.99	3.20
33.	trans-13-Octadecenoic acid, methyl ester	1.88	2.22
34.	1-Dodecanol, 2-hexyl-	1.36	0.90
35.	n-Tetracosanol-1	1.26	2.87
36.	Squalene	1.04	1.08
37.	3-Octenoic acid, 4-methyl-2-pentyl ester	0.96	0.82
38.	Docosanal	0.92	0.57
39.	Pentadecane	0.73	0.96
40.	Phthalic acid, hept-4-yl isobutyl ester	0.72	1.41
41.	Bis(2-ethylhexyl) phthalate	0.69	3.09
42.	Nonyl tetradecyl ether	0.61	0.47
43.	Hexadecanal	0.50	0.53

REFERENCES

Achi, N. K., Onyeabo, C., Ekeleme-Egedigwe, C. A., & Jennifer, C. O. (2017). Phytochemical, proximate analysis, vitamin and mineral composition of aqueous extract of Ficus capensis leaves in south eastern Nigeria. Journal of Applied Pharmaceutical Science, 7(3), 117–122.

Amudha, P., Jayalakshmi, M., Pushpabharathi, N., & Vanitha, V. (2018). Identification of bioactive components in Enhalus acoroides sea-grass extract by gas chromatography–mass spectrometry. Asian Journal of Pharmaceutical and Clinical Research, 11(10), 313–317.

Balasubramanian, S., Ganesh, D., & Suryanarayana, V. V. S. (2014). GC-MS analysis of phytocomponents in the methanolic extract of Azadirachta indica (neem). International Journal of Pharma and Bio Sciences, 5(4), 258–262.

Bratty, M. A., Makeen, H. A., Alhazmi, H. A., Syame, S. M., Abdalla, A. N., Homeida, H. E., Sultana, S., Waquar, A., & Asaad, K. (2020). Phytochemical, cytotoxic, and antimicrobial evaluation of the fruits of miswak plant, Salvadora persica L. Journal of Chemistry, 2020, Article 4521951. https://doi.org/10.1155/2020/4521951

Chavan, S. B., Uthappa, A. R., Sridhar, K. B., & Kakade, V. (2022). Scientific techniques for Melia dubia-based agroforestry systems: An emerging indigenous tree species for wood-based industries in India. Current Science, 122(21), 1451–1454.

Chikezie, P. C., Ekeanyanwu, R. C., & Chile-Agada, A. B. (2020). Phytocomponents from Anacardium occidentale, Psidium guajava, and Terminalia catappa altered membrane osmotic stability of sickle erythrocytes. Beni-Suef University Journal of Basic and Applied Sciences, 9, Article 1–22.

Datt, C., Datta, M., & Singh, N. P. (2008). Assessment of fodder quality of leaves of multipurpose trees in subtropical humid climate of India. Journal of Forestry Research, 19(3), 209–214.

Devasena, B., & Adilaxmamma, K. (2016). Chemical evaluation in vitro and in sacco of traditional fodder tree (Delonix elata Gamble) in buffalos. Buffalo Bulletin, 35(2), 159–164.

Dey, P., Sasaki, G. Y., Wei, P., Li, J., Wang, L., Zhu, J., McTigue, D., Yu, Z., & Bruno, R. S. (2019). Green tea extract prevents obesity in male mice by alleviating gut dysbiosis in association with improved intestinal barrier function that limits endotoxin translocation and adipose inflammation. Journal of Nutritional Biochemistry, 67, 78–89.

Diaz-Sanchez, S., D'Souza, D., Biswas, D., & Hanning, I. (2015). Botanical alternatives to antibiotics for use in organic poultry production. Poultry Science, 94, 1419–1430.

Elgorban, A. M., Bahkali, A. H., Dunia, A. A. F., & Wahab, M. A. A. (2019). Natural products of Alternaria sp., an endophytic fungus isolated from Salvadora persica from Saudi Arabia. Saudi Journal of Biological Sciences, 26(5), 1068–1077.

Forwood, J. R., & Owensby, C. E. (1985). Nutritive value of tree leaves in the Kansas Flint Hills. Journal of Range Management, 38(1), 61–64.

Gravel, I. V., Skibina, A. A., Kuz'menko, A. N., Demina, N. B., Krasnyuk, I. I., Zavadskiy, S. P., & Pirogov, A. V. (2017). Study of chemical composition of Asparagus racemosus roots. Moscow University Chemistry Bulletin, 72, 192–195.

Hamaker, B. R., & Tuncil, Y. E. (2009). A perspective on the complexity of dietary fiber structures and their potential effect on the gut microbiota. Journal of Molecular Biology, 23, 3838–3850.

Hamid, A. A., Oguntoye, S. O., Alli, S. O., Akomolafe, G. A., Aderinto, A., Otitigbe, A., Ogundare, A. M., Esinniobiwa, Q. M., & Aminu, R. O. (2016). Chemical composition, antimicrobial and free radical scavenging activities of Grewia pubescens. Chemistry International, 2(4), 254–261.

Huang, L., Zhu, X., Zhou, S., Cheng, Z., Shi, K., Zhang, C., & Shao, H. (2021). Phthalic acid esters: Natural sources and biological activities. Toxins, 13, Article 495. https://doi.org/10.3390/toxins13070495

Jahirhussain, G., Kala, K., Ayyappan, P., Muniappan, V., Tamilselvan, V., & Rajkumar, P. (2015). Profiling the secondary chemical class of in vivo Melia composita Willd. leaf using ethanolic fraction. World Journal of Pharmaceutical Research, 4(12), 1367–1376.

Jorgensen, H., Theil, P. K., & Knudsen, K. E. B. (2010). Satiating properties of diets rich in dietary fibre fed to sows as evaluated by physico-chemical properties, gastric emptying rate and physical activity. Livestock Science, 134, 37–40.

Kamalak, A., Canbolat, O., Atalay, A. I., & Kaplan, M. (2010). Determination of potential nutritive value of young, old and senescent leaves of Arbutus andrachne tree. Journal of Applied Animal Research, 37, 257–260.

Kumar, N., & Goel, N. (2019). Phenolic acids: Natural versatile molecules with promising therapeutic applications. Biotechnology Reports, 24, Article e00370.

Kumar, P. P., Nandhini, A. R., Subhapriya, P., & Gowri, S. B. A. (2018). Analysis of volatile compounds in the sap of Azadirachta indica (neem) using gas chromatography mass spectrometry. International Research Journal of Pharmacy, 9(3), 38–43.

Mohanty, S., Thakur, N. S., Gunaga, R. P., & Gajbhiye, N. (2019). Influence of Melia dubia Cav. spatial geometries on growth, herbage yield and essential oil constituents of Cymbopogon martinii (Roxb.) Wats. Journal of Essential Oil Bearing Plants, 22(3), 630–648.

Moussaoui, B., Rahali, A., Hamed, D., Guemou, L., & Riazi, A. (2022). Antioxidant and cytotoxic activities of alkaloids extracted from inermis nopals of Algerian Opuntia ficus-indica (L.). Asian Journal of Agriculture and Biology, 2022, Article 202105231.

Mudhafar, M., Zaino, I., Jaafar, C. N. A., Alsailawi, H. A., Majhool, A. A., & Alsaady, M. M. B. (2020). Phytochemical screening and characterization of Melia dubia leaves extract for antimicrobial activity against Escherichia coli and Staphylococcus aureus. Indian Journal of Ecology, 47(2), 493–496.

Murugesan, S., Senthilkumar, N., Rajeshkannan, C., & Vijayalakshmi, K. B. (2013). Phytochemical characterization of Melia dubia for their biological properties. Der Chemica Sinica, 4(1), 36–40.

Niranjan, P. S., Srivastava, V., Udeybir, & Verma, D. N. (2007). Nutritional evaluation of peepal leaves in Barbari kids. Indian Journal of Animal Nutrition, 24(2), 128–129.

Paritala, V., Chiruvella, K. K., Thamminenic, C., Ghantad, R. G., & Mohammed, A. (2015). Phytochemicals and antimicrobial potentials of mahogany family. Revista Brasileira de Farmacognosia, 25, 61–83.

Parmar, A. G., Thakur, N. S., & Gunaga, R. P. (2019). Melia dubia Cav. leaf litter allelochemicals have ephemeral allelopathic proclivity. Agroforestry Systems, 93, 1347–1360.

Parthiban, K. T., Chauhan, S. K., & Jude, S. R. (2019). Malabar neem:

Melia dubia. Agrobios India.

Prodhan, A. H. M. S. U., & Mridu, F. S. (2021). Baccaurea motleyana (Rambai): Nutritional, phytochemical, and medicinal overview. Advances in Traditional Medicine, 23, 11–35. https://doi.org/10.1007/s13596-021-00555-w

Ruthisha, P. K., Ratheesh, C. P., & Khaleel, K. M. (2017). Phytochemical evaluation and GC-MS analysis of whole plant extract of Seidenfia rheedii (Sw.) Szlach. (Orchidaceae). World Journal of Pharmaceutical Research, 6(2), 594–603.

Sethuraman, S. P., & Ramachandran, K. P. (2022). Chemical profiling of volatile bioactives in Luisia tenuifolia Blume successive extracts by GC–MS analysis. Applied Biochemistry and Biotechnology, 194, 84–98.

Singh, D. N., Bohra, J. S., Tyagi, V., Singh, T., Banjara, T. R., & Gupta, G. A. (2022). Review of India's fodder production status and opportunities. Grass and Forage Science, 77, 1–10.

Subramanian, S., Dowlath, M. J. H., Karuppannan, S. K., Saravanan, M., & Arunachalam, K. D. (2020). Effect of solvent on the phytochemical extraction and GC-MS analysis of Gymnema sylvestre. Pharmacognosy Journal, 12(4), 749–761.

Sukhadiya, M. L., Thakur, N. S., Patel, V. R., Gunaga, R. P., Kharadi, V. B., Tyagi, K. K., & Singh, S. (2021). Provenance variations in proximate principles, mineral matter, total phenols and phytochemicals of Melia dubia drupes: An unexplored alternate livestock feed stock. Journal of Forestry Research, 32(1), 119–131.

Sukhadiya, M. L., Thakur, N. S., Tyagi, K. K., Kharadi, V. B., Patel, V. R., & Gunaga, R. P. (2022). Economic analysis of Melia dubia Cav. drupe pulp as new alternate feed for small ruminants. Indian Journal of Ecology, 49(1), 46–51.

Sukhadiya, M. L., Thakur, N. S., Gunaga, R. P., Patel, V. R., Bhuva, D. C., & Singh, S. (2019). Melia dubia Cav. drupe pulp: A new alternate livestock feed resource. Range Management and Agroforestry, 40(2), 299–305.

Swamy, M. K., Arumugam, G., Kaur, R., Ghasemzadeh, A., Yusoff, M. M., & Sinniah, U. R. (2017). GC-MS based metabolite profiling, antioxidant and antimicrobial properties of different solvent extracts of Malaysian Plectranthus amboinicus leaves. Evidence-Based Complementary and Alternative Medicine, 2017, Article 1517683.

Teklić, T., Parađiković, N., Špoljarević, M., Zeljković, S., Lončarić, Z., & Lisjak, M. (2021). Linking abiotic stress, plant metabolites, biostimulants and functional food. Annals of Applied Biology, 178, 169–191.

Thakur, N. S., Chauhan, R. S., Hegde, H. T., Singh, N., Kumar, A., Gunaga, R. P., & Bhuva, D. C. (2023). Economic feasibility of five year old Melia dubia in different planting densities. Indian Forester, 149(8), 874–879.

Thakur, N. S., Hegde, H. T., Chauhan, R. S., Gunaga, R. P., & Bhuva, D. C. (2021). Root sucker technique for successful clonal multiplication of Melia dubia Cav. without sacrifice of mother tree. Current Science, 121(9), 1235–1237.

Thakur, N. S., Jilariya, D. J., Gunaga, R. P., & Singh, S. (2018). Positive allelospoly of Melia dubia Cav. spatial geometry improve quantitative and qualitative attributes of Aloe vera L. Industrial Crops and Products, 119, 162–171.

Wang, D. M., & Huang, L. F. (2012). Composition of volatile oil from the leaves of Uncaria sessilifructus Roxb. Journal of Applied Pharmaceutical Science, 2(11), 50–53.

Wankhede, A., & Jain, R. K. (2011). Nutritional evaluation of some tree leaves of Chhattisgarh plain. Indian Journal of Animal Nutrition, 28(3), 246–252.

Wong, F. C., Xiao, J., Wang, S., Ee, K. Y., & Chai, T. T. (2020). Advances on the antioxidant peptides from edible plant sources. Trends in Food Science and Technology, 99, 44–57.

Zhao, F., Wang, P., Lucardi, R., Su, Z., & Li, S. (2020). Natural sources and bioactivities of 2,4-di-tert-butylphenol and its analogs. Toxins, 12(1), Article 35.

How to Cite this Article: Malek S.S., Thakur N.S., Singh S., Gunaga R.P., Patel V.R.. (2025). Melia Dubia Leaf Fodder Has Higher Volatile Phytochemicals during Winter: A Case Study Across Satpura and Northern Western Ghats Mountain Ranges, India. *Indian Journal of Agroforestry*, ***27***(2), 44-55. https://doi.org/10.48165/ija.2025.27.02.06