

Supplementary material

Friedelin and 3 β -Friedelinol: Pharmacological Activities

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Euphorbia grantii Oliv.



Jatropha maheshwarii
Subram. & Nayar



Artemisia annua L.

Fig. S1. Examples of some plants containing friedelin.

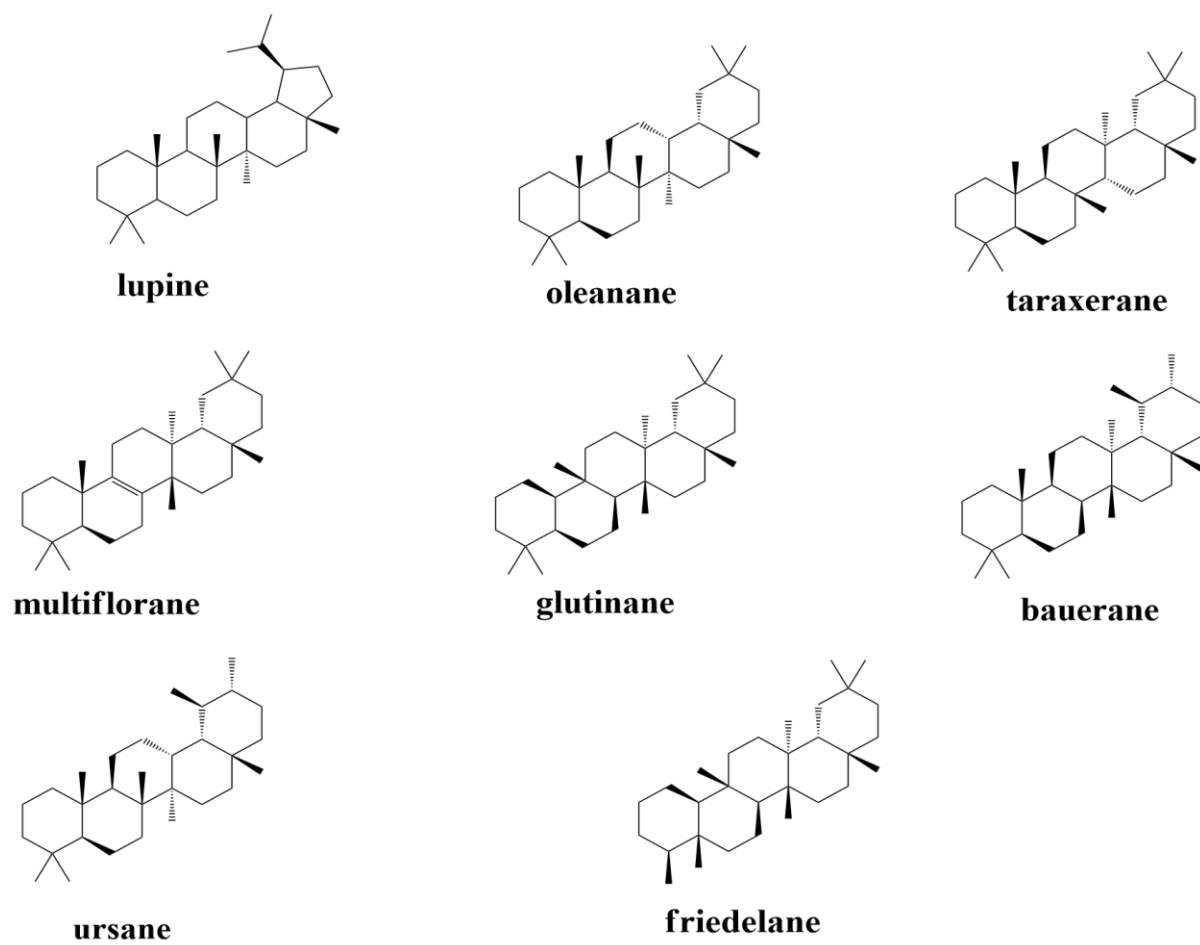


Fig. S2. Major types of pentacyclic triterpenes.

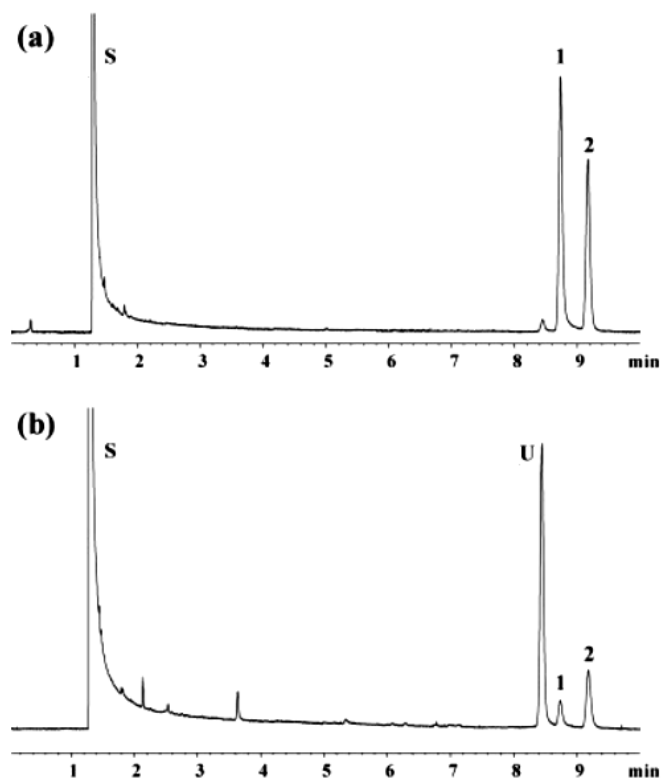


Fig. S3 Chromatogram of a standard solution (50 mg/l) of friedelan-3-ol and friedelin, and (b) chromatogram of an extract of *M. ilicifolia*. Peak assignments: 1, friedelan-3-ol ($t_r = 8.76$ min); 2, friedelin ($t_r = 9.19$ min); U, unknown ($t_r = 8.47$ min). Reproduced from Vistuba et al. 2013.

Table S1. Natural sources of some plants containing friedelin and its derivatives.

Family	Genus	Species	Friedelin or 3 β -friedelinol	Reference
Fabaceae	<i>Peltophorum</i>	<i>Peltophorum dubium</i>	Friedelin	(Parveen et al. 2010a)
Calophyllaceae	<i>Haplocalthra</i>	<i>Haplocalthra paniculata</i>	Friedelin	(Nagem and Da Silveira 1986)
	<i>Calophyllum</i>	<i>Calophyllum soulattri</i>	Friedelin	(Mah et al. 2011)
	<i>Kielmeyera</i>	<i>Kielmeyera elata</i>	Friedelin	(da S Gramacho et al. 1999)
	<i>Mammea</i>	<i>Mammea africana</i>	Friedelin	(Crichton and Waterman 1978)
	<i>Mesua</i>	<i>Mesua ferrea</i>	Friedelin	(Teh et al. 2011)
Asteraceae	<i>Artemisia</i>	<i>Artemisia gmelinii</i>	Friedelin, 3 β -friedelinol	(Zheng 1994)
	<i>Cichorium</i>	<i>Cichorium intybus</i>	Friedelin	(Zareen et al. 2008)
	<i>Dittrichia</i>	<i>Dittrichia viscosa</i>	Friedelin, 3 β -friedelinol	(Grande et al. 1992)
	<i>Gynura</i>	<i>Gynura japonica</i>	Friedelin, 3 β -friedelinol	(Lin et al. 2004)
	<i>Kleinia</i>	<i>Kleinia fulgens</i>	Friedelin	(Bohlmann et al. 1981)
	<i>Ligularia</i>	<i>Ligularia dolichobotrys</i>	Friedelin	(Li et al. 2004)
	<i>Mikania</i>	<i>Mikania triangularis</i>	Friedelin	(Knudsen et al. 1986)
	<i>Olearia</i>	<i>Olearia paniculata</i>	Friedelin, 3 β -friedelinol	(Corbett et al. 1964)
	<i>Stevia</i>	<i>Stevia porphyrea</i>	Friedelin	(Sánchez-Arreola et al. 1999)
	<i>Vernonia</i>	<i>Vernonia discolor</i>	Friedelin, 3 β -friedelinol	(Bazon et al. 1997)
	<i>-Sphagneticola</i>	<i>Sphagneticola trilobata</i>	Friedelin, 3 β -friedelinol	(Qiang et al. 2011)
Phyllanthaceae	<i>Gutierrezia</i>	<i>Gutierrezia alamanii</i>	Friedelin	(Bohlmann et al. 1979)
	<i>Phyllanthus</i>	<i>Phyllanthus flexuosus</i>	Friedelin	(Tanaka and Matsunaga 1988)
	<i>Phyllanthus</i>	<i>Phyllanthus reticulatus</i>	Friedelin, 3 β -friedelinol	(Hui et al. 1976)
	<i>Bridelia</i>	<i>Bridelia micrantha</i>	Friedelin, 3 β -friedelinol	(Pegel and Rogers 1968)
Apocynaceae	<i>Thecacoris</i>	<i>Thecacoris trichogyne</i>	Friedelin	(Kuete et al. 2010)
Anastrophyllaceae	<i>Vincetoxicum</i>	<i>Vincetoxicum hirundinaria</i>	Friedelin	(Nowak and Kisiel 2000)
Myricaceae	<i>Plicanthus</i>	<i>Plicanthus hirtellus</i>	Friedelin	(Wang et al. 2009)
	<i>Myrica</i>	<i>Myrica rubra</i>	Friedelin	(Li et al. 2011)
Euphorbiaceae	<i>Mallotus</i>	<i>Mallotus pallidus</i>	Friedelin	(Likhitwitayawuid and Supudompol 2005)
	<i>Euphorbia</i>	<i>Euphorbia tortilis</i>	Friedelin, 3 β -friedelinol	(Anju et al. 2018)
	<i>Euphorbia</i>	<i>Euphorbia segetalis</i>	Friedelin	(Ferreira et al. 1998)
	<i>Euphorbia</i>	<i>Euphorbia grantii</i>	Friedelin, 3 β -friedelinol	(Munhoz et al. 2014)
	<i>Jatropha</i>	<i>Jatropha maheshwarii</i>	Friedelin, 3 β -friedelinol	(Venkatesan et al. 2005)
	<i>Macaranga</i>	<i>Macaranga tanarius</i>	Friedelin, 3 β -friedelinol	(Hui et al. 1975 b)

Lamiaceae	<i>Hymenocardia</i>	<i>Hymenocardia acida</i>	Friedelin	3β-	(Igoli and Gray 2008)
	<i>Clerodendrum</i>	<i>Clerodendrum formicarum</i>	Friedelin, friedelinol		(Ali et al. 2010)
	<i>Volkameria</i>	<i>Volkameria inermis</i>	Friedelin		(Parveen et al. 2010 b)
	<i>Clerodendrum</i>	<i>Clerodendrum mandarinorum</i>	Friedelin		(Zhu et al. 1996)
	<i>Salvia</i>	<i>Salvia fruticosa</i>	Friedelin		(El-Sayed et al. 2001)
	<i>Vitex</i>	<i>Vitex negundo</i>	Friedelin		(Nallusamy et al. 2021)
	<i>Pogostemon</i>	<i>Pogostemon cablin</i>	Friedelin, 3β-friedelinol	3β-	(Chen et al. 2013)
Sapotaceae	<i>Diploknema</i>	<i>Diploknema butyracea</i>	Friedelin		(Awasthi and Mitra 1968)
Vitaceae	<i>Cissus</i>	<i>Cissus quadrangularis</i>	Friedelin		(Gupta and Verma 1991)
Rutaceae	<i>Luvunga</i>	<i>Luvunga sarmentosa</i>	Friedelin		(Lien et al. 2002)
	<i>Orixa</i>	<i>Orixa japonica</i>	Friedelin		(Abe et al. 1971)
	<i>Citrus</i>	<i>Citrus ×aurantium</i>	Friedelin		(Ribeiro et al. 2008)
	<i>Murraya</i>	<i>Murraya euchrestifolia</i>	Friedelin		(Wu et al. 1998)
	<i>Harrisonia</i>	<i>Harrisonia abyssinica</i>	Friedelin		(Baldé et al. 2001)
	<i>Citrus</i>	<i>Citrus medica</i>	Friedelin		(Iwase et al. 2000)
	<i>Zanthoxylum</i>	<i>Zanthoxylum ailanthoides</i>	Friedelin		(Cheng et al. 2003)
Hypericaceae	<i>Harungana</i>	<i>Harungana madagascariensis</i>	Friedelin		(Happi et al. 2020)
	<i>Cratoxylum</i>	<i>Cratoxylum arborescens</i>	Friedelin		(Sim et al. 2011)
	<i>Psorospermum</i>	<i>Psorospermum laurentii</i>	Friedelin		(Wabo et al. 2007)
	<i>Vismia</i>	<i>Vismia japurensis</i>	Friedelin, 3β-friedelinol	3β-	(Nguemeving et al. 2006)
Vochysiaceae	<i>Callisthene</i>	<i>Callisthene major</i>	Friedelin		(do Carmo et al. 1981)
Clusiaceae	<i>Clusia</i>	<i>Clusia hilariana</i>	Friedelin		(Corrêa et al. 1985)
	<i>Garcinia</i>	<i>Garcinia cymosa</i>	Friedelin		(Klaiklay et al. 2011)
	<i>Tripetalum</i>	<i>Tripetalum cymosum</i>	Friedelin		(Mathur 1972)
	<i>Clusia</i>	<i>Clusia nemorosa</i>	Friedelin, 3β-friedelinol	3β-	(Leong and Harrison 1999)
	<i>Tovomita</i>	<i>Tovomita brasiliensis</i>	Friedelin		(De Andrade et al. 1998)
Ericaceae	<i>Erica</i>	<i>Erica arborea</i>	Friedelin		(Marques et al. 2000)
	<i>Rhododendron</i>	<i>Rhododendron formosanum</i>	Friedelin, 3β-friedelinol	3β-	(Carrión-Prieto et al. 2017)
	<i>Vaccinium</i>	<i>Vaccinium myrtillus</i>	Friedelin		(Krishna. 2006)
Celastraceae	<i>Salacia</i>	<i>Salacia impressifolias</i>	Friedelin		(Vrancheva et al. 2021)
	<i>Pleurostylia</i>	<i>Pleurostylia opposita</i>	Friedelin, 3β-friedelinol	3β-	(Rodrigues et al. 2019)
	<i>Euonymus</i>	<i>Euonymus fortunei</i>	Friedelin, 3β-friedelinol	3β-	(Dantanarayana et al. 1983)
	<i>Monteverdia</i>	<i>Monteverdia macrocarpa</i>	Friedelin, 3β-friedelinol	3β-	(真崎辰次 and Zasshi 1959)
Bignoniaceae	<i>Maytenus</i>	<i>Maytenus truncata</i>	Friedelin		(Chavez et al. 1999)
	<i>Fernandoa</i>	<i>Fernandoa adenophylla</i>	Friedelin		(Alves et al. 2018)
	<i>Tanaecium</i>	<i>Tanaecium jaroba</i>	Friedelin, 3β-friedelinol	3β-	(Rizvi and Sultana 1973)
Malvaceae	<i>Triumfetta</i>	<i>Triumfetta rhomboidea</i>	Friedelin, 3β-		(Mitaine-Offer et al. 2002 b)
					(Ho et al. 1995)

Ganodermataceae	<i>Ganoderma</i>	<i>Ganoderma applanatum</i>	friedelinol		(Protiva et al. 1980)
Anacardiaceae	<i>Mangifera</i>	<i>Mangifera indica</i>	Friedelin, 3β-friedelinol		(Anjaneyulu et al. 1994)
Putranjivaceae	<i>Drypetes</i>	<i>Drypetes laciniata</i>	Friedelin		(Fannang et al. 2011)
	<i>Putranjiva</i>	<i>Putranjiva roxburghii</i>	Friedelin		(Sengupta, et al. 1968)
Urticaceae	<i>Oreocnide</i>	<i>Oreocnide frutescens</i>	Friedelin, 3β-friedelinol		(Zhang et al. 2010)
	<i>Myrianthus</i>	<i>Myrianthus serratus</i>	Friedelin		(Lontsi, Ngounou et al. 1998)
	<i>Leucosyke</i>	<i>Leucosyke quadrinervia</i>	Friedelin, 3β-friedelinol		(Ian-Lih et al. 1993)
Myrtaceae	<i>Syzygium</i>	<i>Syzygium formosanum</i>	Friedelin		(Chang et al. 1999)
	<i>Rhodomyrtus</i>	<i>Rhodomyrtus tomentosa</i>	Friedelin		(Hui et al. 1975 a)
Ebenaceae	<i>Diospyros</i>	<i>Diospyros ferrea</i>	Friedelin, 3β-friedelinol		(Bhakuni et al. 1971)
Fabaceae	<i>Erythrophleum</i>	<i>Erythrophleum fordii</i>	Friedelin		(Tsao et al. 2008)
	<i>Caesalpinia</i>	<i>Caesalpinia minax</i>	Friedelin, 3β-friedelinol		(Jiang et al. 2002)
	<i>Dalbergia</i>	<i>Dalbergia ovalis</i>	FRIEDELIN		(Nunes et al. 1989)
	<i>Pentaclethra</i>	<i>Pentaclethra eetveldeana</i>	Friedelin, 3β-friedelinol		(Herz 1996)
Burseraceae	<i>Senna</i>	<i>Senna obtusifolia</i>	Friedelin		(Sob et al. 2008)
	<i>Protium</i>	<i>Protium heptaphyllum</i>	Friedelin		(Susunaga et al. 2001)
Ulmaceae	<i>Ulmus</i>	<i>Ulmus pumila</i>	Friedelin		(Wang et al. 2006)
	<i>Holoptelea</i>	<i>Holoptelea integrifolia</i>	Friedelin, 3β-friedelinol		(Misra et al. 1974)
Rosaceae	<i>Photinia</i>	<i>Photinia lucida</i>	Friedelin		(Chen et al. 2010)
	<i>Sorbus</i>	<i>Sorbus tianschanica</i>	Friedelin		(Li et al. 2010)
Poaceae	<i>Arundo</i>	<i>Phragmites australis</i>	Friedelin		(Chaudhuri and Ghosal 1970)
Crassulaceae	<i>Kalanchoe</i>	<i>Kalanchoe integra</i>	Friedelin		(Gaind et al. 1976)
Balanopaceae	<i>Balanops</i>	<i>Balanops australiana</i>	Friedelin		(Setzer et al. 2000)
Lauraceae	<i>Machilus</i>	<i>Machilus zuihoensis</i>	Friedelin		(Cheng et al. 2005)
Pinaceae	<i>Larix</i>	<i>Larix kaempferi</i>	Friedelin		(Ohtsu et al. 1998)
Piperaceae	<i>Piper</i>	<i>Piper umbellatum</i>	Friedelin		(Tabopda et al. 2008)
Primulaceae	<i>Ardisia</i>	<i>Ardisia japonica</i>	Friedelin, 3β-friedelinol		(Dat et al. 2007)
Bromeliaceae	<i>Tillandsia</i>	<i>Tillandsia usneoides</i>	Friedelin		(Djerassi and McCrindle 1962)
Alariaceae	<i>Andaria</i>	<i>Andryala pinnatifida</i>	Friedelin		(Takemoto and Takeshita 1970)
Sapindaceae	<i>Dimocarpus</i>	<i>Dimocarpus longan</i>	Friedelin, 3β-friedelinol		(Riederer et al. 2015)
	<i>Paullinia</i>	<i>Paullinia pinnata</i>	Friedelin		(Annan et al. 2009)
Goodeniaceae	<i>Scaevola</i>	<i>Scaevola taccada</i>	Friedelin, 3β-friedelinol		(Kikuchi 1974)
Polypodiaceae	<i>Drynaria</i>	<i>Drynaria aglaomorpha</i>	Friedelin, 3β-friedelinol		(Ramesh et al. 2001)
Fagaceae	<i>Quercus</i>	<i>Quercus salicina</i>	Friedelin, 3β-friedelinol		(Yoshikawa et al. 1986)
	<i>Castanopsis</i>	<i>Castanopsis eyrei</i>	Friedelin, 3β-friedelinol		(Arthur and Ko 1968)

Buxaceae	<i>Pachysandra</i>	<i>Pachysandra terminalis</i>	friedelinol	
Gentianaceae	<i>Swertia</i>	<i>Swertia corymbosa</i>	Friedelin	(Kikuchi et al. 1971)
			Friedelin, 3β-friedelinol	(Ramesh et al. 2002)
Rubiaceae	<i>Ophiorrhiza</i>	<i>Ophiorrhiza japonica</i>	Friedelin	(Fujita and Sumi 1967)
	<i>Damnacanthus</i>	<i>Damnacanthus indicus</i>	Friedelin	(Koyama et al. 1992)
Moraceae	<i>Antiaris</i>	<i>Antiaris toxicaria</i>	Friedelin	(Vouffo et al. 2010)
	<i>Ficus</i>	<i>Ficus cordata</i>	Friedelin, 3β-friedelinol	(Poumale et al. 2008)
Annonaceae	<i>Goniothalamus</i>	<i>Goniothalamus thwaitesii</i>	Friedelin, 3β-friedelinol	(Seidel et al. 2000)
Cannabaceae	<i>Cannabis</i>	<i>Cannabis sativa</i>	Friedelin, 3β-friedelinol	(Sethi et al. 1977)
Polygonaceae	<i>Bistorta</i>	<i>Bistorta officinalis</i>	Friedelin, 3β-friedelinol	(Manoharan et al. 2005)
Picrodendraceae	<i>Piranhea</i>	<i>Piranhea mexicana</i>	Friedelin, 3β-friedelinol	(del Rayo Camacho et al. 2000)
Asparagaceae	<i>Ruscus</i>	<i>Ruscus aculeatus</i>	Friedelin	(Dunouau et al. 1996)
Plantaginaceae	<i>Linaria</i>	<i>Linaria saxatilis</i>	Friedelin, 3β-friedelinol	(Gordaliza et al. 1995)
	<i>Scoparia</i>	<i>Scoparia dulcis</i>	Friedelin	(Mahato et al. 1981)
Loganiaceae	<i>Strychnos</i>	<i>Strychnos dolichothyrsa</i>	Friedelin	(Verpoorte 1978)
Heliotropiaceae	<i>Heliotropium</i>	<i>Heliotropium ellipticum</i>	Friedelin, 3β-friedelinol	(Jain et al. 2001)
Campanulaceae	<i>Codonopsis</i>	<i>Codonopsis pilosula</i>	Friedelin	(Tsai et al. 2008)
Orchidaceae	<i>Bulbophyllum</i>	<i>Bulbophyllum vaginatum</i>	Friedelin	(Leong et al. 1997)
Achariaceae	<i>Ryparosa</i>	<i>Ryparosa acuminata</i>	Friedelin	(Shaari et al. 1993)
Asphodelaceae	<i>Hemerocallis</i>	<i>Hemerocallis fulva</i>	Friedelin	(Takemoto and Kusano 1966)
Salicaceae	<i>Xylosma</i>	<i>Xylosma longifolia</i>	Friedelin	(Truong et al. 2011)
Tachinidae	<i>Eugenia</i>	<i>Eugenia bergii</i>	Friedelin, 3β-friedelinol	(Rücker et al. 1977)
Compositae	<i>Artemisia</i>	<i>Artemisia roxburghiana</i>	Friedelin	(Kumar and Kumari 2018)
Araliaceae	<i>Dendropanax</i>	<i>Dendropanax trifidus</i>	Friedelin	(縣功 1961)
Salvadoraceae	<i>Azima</i>	<i>Azima tetracantha</i>	Friedelin	(Jose et al. 2014)
Calophyllaceae	<i>Calophyllum</i>	<i>Calophyllum sclerophyllum</i>	Friedelin, 3β-friedelinol	(Lim, et al. 2016)
Acoraceae	<i>Acorus</i>	<i>Acorus calamus</i>	Friedelin	(Nallusamy et al. 2020)
Combretaceae	<i>Terminalia</i>	<i>Terminalia avicennioides</i>	Friedelin	(Mann et al. 2011)
Irvingiaceae	<i>Irvingia</i>	<i>Irvingia malayana</i>	Friedelin, 3β-friedelinol	(Jaipetch et al. 2019)

Table S2. ¹H- and ¹³C-NMR spectral data of friedelin, epifriedelinol, and friedelinol.

No.	Friedelin*		Epifriedelinol**		3 β-Friedelinol***	
	¹³ C-NMR	¹ H-NMR	¹³ C-NMR	¹ H-NMR	¹³ C-NMR	¹ H-NMR
1	22.3	1.95,1.71 (2H, ddd)	15.8	1.69,1.45	19.6	1.58,1.35
2	41.5	2.37,2.27 (2H, ddd)	35.2	1.99,1.56	36.7	2.16
3	213.2	-	72.8	3.81	72.2	3.41
4	58.2	2.25(1H, q)	49.2	1.25	53.2	1.17
5	42.1	-	37.5	-	37.4	-
6	41.3	1.74,1.28 (2H, m)	42.8	1.76	41.4	1.75
7	18.2	1.49,1.36 (2H, m)	17.5	1.41,1.39	17.8	1.38,1.35
8	53.1	1.38 (1H, dd)	53.2	1.28	53.0	1.28
9	37.4	-	36.1	-	38.7	-
10	59.5	1.53(1H, m)	61.0	0.93	60.1	1.00
11	35.6	1.45,1.26 (2H, m)	35.7	1.42,1.24	35.3	1.38,1.18
12	30.5	1.33,1.32 (2H, m)	29.3	1.34,1.31	30.6	1.31,1.26
13	39.7	-	37.9	-	39.7	-
14	38.3	-	39.1	-	38.3	-
15	32.4	1.47,1.27 (2H, m)	30.0	1.53,1.28	32.8	1.52,1.28
16	36.0	1.58,1.35 (2H, m)	35.6	1.46,1.18	36.1	1.48,1.26
17	30.0	-	29.6	-	30.1	-
18	42.8	1.56(1H, m)	42.4	1.56	42.9	1.54
19	35.3	1.37,1.22 (2H, m)	35.3	1.37,1.21	36.1	1.41,1.24
20	28.2	-	27.8	-	28.1	-
21	32.8	1.50,1.31 (2H, m)	32.3	1.49,1.28	32.4	1.46,1.25
22	39.2	1.51,0.95 (2H, m)	38.9	0.93,1.49	39.3	1.45,0.89
23	7.0	0.88 (3H, d)	11.4	1.02	9.9	1.01
24	14.6	0.73 (3H, s)	16.4	0.88	14.6	0.78
25	17.9	0.87 (1H, s)	18.6	0.93	18.1	0.81
26	20.2	1.01(1H, s)	20.1	0.95	20.1	0.98
27	18.6	1.05(1H, s)	18.2	1.00	18.6	1.01
28	32.1	1.18(1H, s)	32.1	1.18	31.8	1.18
29	35.0	1.00 (1H, s)	35.0	0.94	32.1	0.97
30	31.8	0.94(1H, s)	31.8	0.98	35.1	1.012

*Data of friedelin(Mann, Ibrahim et al. 2011). ** Data of epifriedelinol (Salazar, Silva et al. 2000) (Kannathasan, Senthilkumar et al. 2019).***Data of friedelinol (Salazar, Silva et al. 2000, Kiem, Minh et al. 2004).

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