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APPENDICES

Sources of CA	Sample codes	Collecting times
Prachin Buri	CA1	July
Ban Bo Lo (local growth) Nakhon Si Thammarat	CA2	September
Ubon Ratchathani	CA3	July
Trat	CA4	November
Ban Bo Lo (trade) Nakhon Si Thammarat	CA5	July
Rayong	CA6	July
Chon Buri	CA7	July
Pak Chong Nakhon Ratchasima	CA8	September
Sukhothai	CA9	September
Chiang Mai (green petioles)	CA10	November
Phitsanulok	CA11	November
Chiang Mai	CA12	July

Table 3.4 Various CA samples cultivated by Thailand Institute of Scientific and Technological Research

Sampling times (Month)	Sources of CA and codes		
	Ubon Ratchathani	Nakhon Si Thammarat	Nakhon Pathom
January	CA3-1	CA5-1	CA13-1
March	CA3-3	CA5-3	CA13-3
May	CA3-5	CA5-5	CA13-5
July	CA3-7	CA5-7	CA13-7
September	CA3-9	CA5-9	CA13-9
November	CA3-11	CA5-11	CA13-11

Table 3.5 Various CA samples collected from the commercial crops of Nakhon Pathom (CA13), Ubon Ratchathani and Nakhon Si Thammarat province

Sampling time (Month)	%Remained of MS	%Remained of AS	%Remained of MA	%Remained of AA
0	98.28	99.65	97.97	99.70
1	93.83	96.26	97.95	99.08
2	93.97	93.84	99.28	99.60
3	93.45	90.68	98.33	96.09
4	91.24	93.84	97.38	94.84

Table 4.1 Accelerated stability of MS, AS, MA and AA in solid form at 45°c, 75% RH by HPLC

Sampling time (hr.)	% Remained contents	
	Madecassoside (MS)	Asiaticoside (AS)
0	42.90	38.80
1	44.23	39.96
2	40.78	39.00
4	43.14	37.87
8	39.96	39.15
24	39.81	37.75

(a)

Sampling time (hr.)	% Remained contents	
	Madecassoside (MS)	Asiaticoside (AS)
0	42.90	38.80
1	44.95	41.85
2	44.18	41.57
4	42.91	38.79
8	44.95	40.94
24	41.47	37.80

(b)

Sampling time (hr.)	% Remained contents	
	Madecassoside (MS)	Asiaticoside (AS)
0	42.90	38.80
1	42.62	39.38
2	47.68	42.08
4	47.14	43.46
8	44.28	41.09

(c)

Table 4.2 Stability of MS and AS in sample solution under the room temperature **(a)**, cooling condition (at 4°C) **(b)** and the autosampler of HPLC instrument **(c)**

Extraction time (min.)	Extraction contents, %w/w			
	MS (mean±SD)	AS (mean±SD)	MA (mean±SD)	AA (mean±SD)
0	1.5269 ± 0.23	1.4581 ± 0.08	0.1408 ± 0.02	0.0560 ± 0.01
30	1.6792 ± 0.05	1.5781 ± 0.02	0.1776 ± 0.02	0.0589 ± 0.02
40	2.3891 ± 0.01	2.3058 ± 0.03	0.2342 ± 0.00	0.1047 ± 0.01
50	2.4672 ± 0.02	2.4099 ± 0.03	0.2581 ± 0.00	0.1277 ± 0.01
60	2.6047 ± 0.03	2.5191 ± 0.00	0.2818 ± 0.00	0.1467 ± 0.00
90	2.6105 ± 0.02	2.5433 ± 0.01	0.2803 ± 0.00	0.1355 ± 0.01

Table 4.3 Percentage contents of extraction of CA by reflux at various times

Extraction time (min.)	Extraction contents of MS, %w/w		
	10%of power (mean±SD)	50%of power (mean±SD)	100%of power (mean±SD)
0	1.5269 ± 0.23	0.8651 ± 0.02	1.2132 ± 0.00
1	1.7869 ± 0.02	1.6232 ± 0.08	1.6200 ± 0.08
2	2.5035 ± 0.01	2.7265 ± 0.05	2.2964 ± 0.07
3	2.5908 ± 0.02	3.3400 ± 0.30	2.5678 ± 0.04
5	2.6278 ± 0.09	3.0514 ± 0.07	2.5691 ± 0.00
10	2.6407 ± 0.04	2.9222 ± 0.29	2.6138 ± 0.04
20	2.6710 ± 0.00	2.7692 ± 0.14	2.4724 ± 0.03
30	2.4544 ± 0.00	2.7199 ± 0.05	2.3627 ± 0.02
60	2.3439 ± 0.00	2.5902 ± 0.05	2.2188 ± 0.01

(a)

Extraction time (min.)	Extraction contents of AS, %w/w		
	10%of power (mean±SD)	50%of power (mean±SD)	100%of power (mean±SD)
0	1.4581 ± 0.08	0.8038 ± 0.06	1.2276 ± 0.01
1	1.5010 ± 0.01	1.4600 ± 0.08	1.4700 ± 0.06
2	2.2440 ± 0.00	2.3724 ± 0.00	2.3553 ± 0.03
3	2.3952 ± 0.10	2.8298 ± 0.03	2.5003 ± 0.03
5	2.3864 ± 0.11	2.7558 ± 0.10	2.4989 ± 0.03
10	2.4009 ± 0.02	2.6500 ± 0.21	2.5920 ± 0.00
20	2.3981 ± 0.03	2.4643 ± 0.05	2.4883 ± 0.02
30	2.2154 ± 0.03	2.4357 ± 0.02	2.3235 ± 0.01
60	2.1295 ± 0.01	2.3512 ± 0.01	2.2317 ± 0.01

(b)

Extraction time (min.)	Extraction contents of MA, %w/w		
	10%of power (mean±SD)	50%of power (mean±SD)	100%of power (mean±SD)
0	0.1408 ± 0.02	0.1002 ± 0.01	0.0939 ± 0.01
1	0.1770 ± 0.00	0.1409 ± 0.02	0.1430 ± 0.02
2	0.3400 ± 0.00	0.3597 ± 0.01	0.2242 ± 0.00
3	0.3634 ± 0.01	0.4123 ± 0.01	0.2396 ± 0.00
5	0.3773 ± 0.00	0.4233 ± 0.01	0.2469 ± 0.00
10	0.3688 ± 0.00	0.3939 ± 0.03	0.2542 ± 0.00
20	0.3769 ± 0.00	0.3618 ± 0.01	0.2535 ± 0.00
30	0.3366 ± 0.00	0.3692 ± 0.02	0.2304 ± 0.00
60	0.3348 ± 0.01	0.3358 ± 0.01	0.2259 ± 0.00

(c)

Extraction time (min.)	Extraction contents of AA, %w/w		
	10%of power (mean±SD)	50%of power (mean±SD)	100%of power (mean±SD)
0	0.0560 ± 0.01	0.0184 ± 0.01	0.0550 ± 0.01
1	0.0566 ± 0.02	0.0560 ± 0.01	0.0694 ± 0.00
2	0.0569 ± 0.01	0.0923 ± 0.00	0.0920 ± 0.01
3	0.0936 ± 0.01	0.1276 ± 0.01	0.1051 ± 0.02
5	0.1294 ± 0.01	0.1380 ± 0.02	0.0938 ± 0.00
10	0.1266 ± 0.00	0.1288 ± 0.01	0.1124 ± 0.01
20	0.1144 ± 0.02	0.1349 ± 0.01	0.1002 ± 0.00
30	0.1039 ± 0.02	0.1225 ± 0.01	0.1125 ± 0.02
60	0.1154 ± 0.01	0.1449 ± 0.01	0.1073 ± 0.01

(d)

Table 4.4 The effect of ultrasonic extraction time and power on percentage contents of MS **(a)**, AS **(b)**, MA **(c)** and AA **(d)**

Extraction time (min.)	MS (%w/w)	AS (%w/w)	MS (%R)	AS (%R)
0	1.3115	1.3472	100.00	100.00
1	1.3159	1.3710	100.34	101.77
3	1.3402	1.3582	102.19	100.81
5	1.4066	1.4318	107.25	106.28
10	1.4191	1.4255	108.20	105.81
20	1.4094	1.4326	107.47	106.34
30	1.3357	1.3460	101.85	99.91
60	1.2871	1.3282	98.14	98.59

Table 4.5 The stability of MS and AS during UAE, values expressed as percentage contents and recovery

Extraction time (min.)	Extraction contents, %w/w			
	MS (mean±SD)	AS (mean±SD)	MA (mean±SD)	AA (mean±SD)
0.5	1.0671 ± 0.07	1.0256 ± 0.04	0.1606 ± 0.00	0.0407 ± 0.04
1	1.7717 ± 0.01	1.8172 ± 0.15	0.3064 ± 0.03	0.1054 ± 0.02
1.5	1.9007 ± 0.07	1.9386 ± 0.11	0.3765 ± 0.04	0.1206 ± 0.01
2	2.1985 ± 0.21	2.3030 ± 0.20	0.4298 ± 0.01	0.1252 ± 0.00
3	3.2107 ± 0.29	2.7907 ± 0.07	0.4142 ± 0.01	0.1409 ± 0.01
4	3.2935 ± 0.09	2.9323 ± 0.18	0.3645 ± 0.05	0.1316 ± 0.01
6	2.9730 ± 0.04	2.9507 ± 0.04	0.3975 ± 0.00	0.1112 ± 0.00
8	3.2184 ± 0.15	2.8472 ± 0.05	0.3377 ± 0.04	0.1299 ± 0.00

Table 4.6 The effect of microwave extraction time on percentage contents of MS, AS, MA and AA of CA sample

Extraction time (min.)	MS (%w/w)	AS (%w/w)	MS (%R)	AS (%R)
0	1.3822	1.2573	100.00	100.00
1	1.4239	1.3030	103.01	103.63
3	1.3508	1.2387	97.73	98.52
8	1.3625	1.2250	98.57	97.43

Table 4.7 The stability of MS and AS during MAE, values expressed as percentage contents and recovery

CA samples	Extraction contents, %w/w			
	MS	AS	MA	AA
CA1	4.3704	3.3503	0.0246	0.0315
CA2	1.9882	1.4711	0.0916	0.0322
CA3	3.3936	2.4666	0.1366	0.1179
CA4	4.7837	3.3201	0.2380	0.3906
CA5	3.2624	2.2324	0.1813	0.0716
CA6	5.4606	3.4743	0.0435	0.0372
CA7	5.4111	3.2861	0.0350	0.0516
CA8	4.1064	2.4864	0.0214	0.0259
CA9	3.8881	2.1378	0.0608	0.0491
CA10	3.3516	1.7289	0.9149	0.3769
CA11	5.4766	2.5832	0.2318	0.1200
CA12	5.1493	2.3871	0.1632	0.0705

Table 4.8 Contents of MS, AS, MA and AA in whole plant of various CA from Thailand Institute of Scientific and Technological Research

Month (sample codes)	Extraction contents, %w/w			
	MS	AS	MA	AA
January (CA13-1)	0.7174	0.6410	0.4953	0.6241
	0.7658	0.6963	0.5400	0.9093
	0.7929	0.7541	0.8494	0.9056
Average	**0.7587**	**0.6972**	**0.6282**	**0.8130**
SD	0.0382	0.0565	0.1928	0.1636
March (CA13-3)	0.8346	0.6980	0.9690	0.8423
	0.8026	0.7194	0.9451	0.8278
	0.8439	0.7632	1.3376	1.2061
Average	**0.8270**	**0.7269**	**1.0839**	**0.9587**
SD	0.0217	0.0332	0.2201	0.2144
May (CA13-5)	2.0638	1.6668	1.1612	0.8784
	1.8633	1.5563	1.1155	0.8279
	1.8372	1.4309	0.9945	0.8333
Average	**1.9214**	**1.5513**	**1.0904**	**0.8465**
SD	0.1240	0.1180	0.0861	0.0278
July (CA13-7)	1.3556	1.2320	0.6702	0.5867
	1.3790	1.2420	0.6521	0.5746
	1.5196	1.3101	0.7537	0.7721
Average	**1.4181**	**1.2614**	**0.6920**	**0.6445**
SD	0.0887	0.0425	0.0542	0.1107
September (CA13-9)	0.4868	0.3223	1.1721	0.9142
	0.4839	0.3746	0.6920	0.3969
	0.6157	0.4364	1.0016	0.7114
Average	**0.5288**	**0.3778**	**0.9552**	**0.6742**
SD	0.0753	0.0571	0.2434	0.2606
November (CA13-11)	1.4688	1.3637	0.7091	0.5267
	1.5112	1.4297	0.6966	0.6148
	1.5118	1.3936	0.8540	0.7937
Average	**1.4972**	**1.3957**	**0.7532**	**0.6451**
SD	0.0246	0.0330	0.0875	0.1361
Average of percentage content	**1.1585**	**1.0017**	**0.8672**	**0.7637**

Table 4.9 Contents of MS, AS, MA and AA in whole plant of CA from the commercial crop of Nakhon Pathom province in annual period

Month (sample codes)	Extraction contents, %w/w			
	MS	AS	MA	AA
January (CA3-1)	0.7657	0.6785	0.2375	0.2757
	0.7433	0.6508	0.2079	0.2152
	0.6851	0.6468	0.2407	0.2764
Average	**0.7314**	**0.6587**	**0.2287**	**0.2558**
SD	0.0416	0.0173	0.0181	0.0352
March (CA3-3)	1.7928	1.8174	0.6515	0.4177
	1.7708	1.7429	0.6562	0.4278
	1.7357	1.7211	0.6271	0.4245
Average	**1.7664**	**1.7605**	**0.6449**	**0.4233**
SD	0.0288	0.0505	0.0156	0.0052
May (CA3-5)	0.8894	0.7939	0.5402	0.4163
	0.8369	0.7696	0.5082	0.4005
	1.0810	0.7649	0.5906	0.5609
Average	**0.9358**	**0.7761**	**0.5463**	**0.4592**
SD	0.1285	0.0155	0.0416	0.0884
July (CA3-7)	0.6840	0.5891	0.6014	0.5183
	0.6164	0.5462	0.5534	0.4294
	0.5851	0.4070	0.4762	0.4757
Average	**0.6285**	**0.5141**	**0.5437**	**0.4745**
SD	0.0506	0.0952	0.0631	0.0444
September (CA3-9)	0.6670	0.5795	0.1433	0.1477
	0.8083	0.8272	0.1408	0.2014
	0.7583	0.6045	0.1701	0.1687
Average	**0.7446**	**0.6704**	**0.1514**	**0.1726**
SD	0.0716	0.1364	0.0163	0.0271
November (CA3-11)	0.3854	0.2426	0.4288	0.3038
	0.4627	0.3129	0.4565	0.3949
	0.4794	0.3628	0.5969	0.4917
Average	**0.4425**	**0.3061**	**0.4941**	**0.3968**
SD	0.0502	0.0604	0.0901	0.0940
Average of percentage content	**0.8749**	**0.7810**	**0.4349**	**0.3637**

Table 4.10 Contents of MS, AS, MA and AA in whole plant of CA from the commercial crop of Ubon Ratchathani province in annual period

Month (sample codes)	Extraction contents, %w/w			
	MS	AS	MA	AA
January (CA5-1)	0.5983	0.4307	1.4651	1.5734
	0.5820	0.4304	1.3287	1.5405
	0.4724	0.3882	1.2684	1.4875
Average	**0.5509**	**0.4164**	**1.3541**	**1.5338**
SD	0.0685	0.0244	0.1008	0.0434
March (CA5-3)	1.5210	1.3999	0.2693	0.2206
	1.3009	1.3096	0.2799	0.2015
	1.2218	1.3188	0.3016	0.2352
Average	**1.3479**	**1.3428**	**0.2836**	**0.2191**
SD	0.1550	0.0497	0.0165	0.0169
May (CA5-5)	2.2375	2.0238	0.8695	0.5163
	2.4496	2.1306	0.8614	0.5442
	2.2411	1.8377	0.7699	0.5405
Average	**2.3094**	**1.9974**	**0.8336**	**0.5337**
SD	0.1214	0.1482	0.0553	0.0151
July (CA5-7)	0.7730	0.7416	0.5676	0.4780
	0.7612	0.7404	0.5313	0.4637
	0.9780	0.7142	0.4262	0.4179
Average	**0.8374**	**0.7321**	**0.5084**	**0.4532**
SD	0.1219	0.0155	0.0735	0.0314
September (CA5-9)	1.1193	0.7873	0.4044	0.3782
	1.0808	0.7634	0.3964	0.3959
	1.0399	0.7934	0.4547	0.4432
Average	**1.0800**	**0.7814**	**0.4185**	**0.4058**
SD	0.0397	0.0159	0.0316	0.0336
November (CA5-11)	0.6433	0.4969	0.7911	0.7636
	0.6170	0.4278	0.6543	0.5653
	0.5629	0.4145	0.6670	0.5719
Average	**0.6077**	**0.4464**	**0.7041**	**0.6336**
SD	0.0410	0.0442	0.0756	0.1126
Average of percentage content	**1.1222**	**0.9534**	**0.6837**	**0.6298**

Table 4.11 Contents of MS, AS, MA and AA in whole plant of CA from the commercial crop of Nakhon Si Thammarat province in annual period

Collecting times (days)	Extraction contents, %w/w			
	MS (mean±SD)	AS (mean+SD)	MA (mean+SD)	AA (mean+SD)
7	2.1445 ± 0.11	2.7326 ± 0.26	0.3199 ± 0.00	0.2409 ± 0.02
14	3.0099 ± 0.04	4.0360 ± 0.03	0.1613 ± 0.01	0.1373 ± 0.01
20	3.8926 ± 0.10	4.6553 ± 0.19	0.3287 ± 0.01	0.2100 ± 0.03
28	3.5607 ± 0.08	4.3198 ± 0.04	0.3232 ± 0.01	0.1633 ± 0.01

(a)

Collecting times (days)	Extraction contents, %w/w			
	MS (mean±SD)	AS (mean+SD)	MA (mean+SD)	AA (mean+SD)
7	3.6355 ± 0.05	3.5067 ± 0.03	0.2114 ± 0.02	0.1434 ± 0.00
14	4.2949 ± 0.12	3.6557 ± 0.06	0.3838 ± 0.01	0.1886 ± 0.01
20	4.1360 ± 0.02	3.3998 ± 0.02	0.4440 ± 0.01	0.1791 ± 0.02
28	4.8266 ± 0.16	3.8487 ± 0.11	0.3968 ± 0.01	0.1948 ± 0.04

(b)

Collecting times (days)	Extraction contents, %w/w			
	MS (mean±SD)	AS (mean+SD)	MA (mean+SD)	AA (mean+SD)
7	3.2329 ± 0.25	3.2516 ± 0.12	0.1201 ± 0.01	0.1073± 0.01
14	2.9441 ± 0.10	3.0259 ± 0.06	0.2102 ± 0.02	0.1182 ± 0.04
20	3.0346 ± 0.22	3.2422 ± 0.19	0.2617 ± 0.05	0.1330 ± 0.03
28	3.1628 ± 0.08	3.5097 ± 0.08	0.2487 ± 0.03	0.1445 ± 0.07

(c)

Table 4.12 Contents of MS, AS, MA and AA in whole plant of CA from Ubon Ratchathani **(a)**, Nakhon Si Thammarat **(b)** and Rayong province **(c)** collected during the cultivation

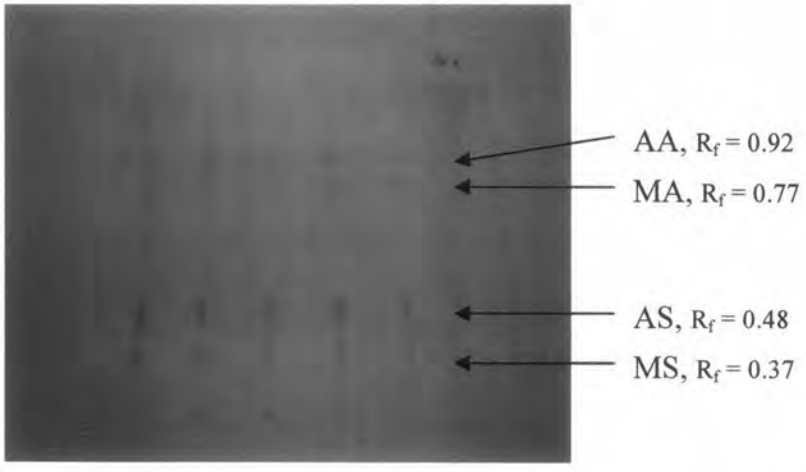
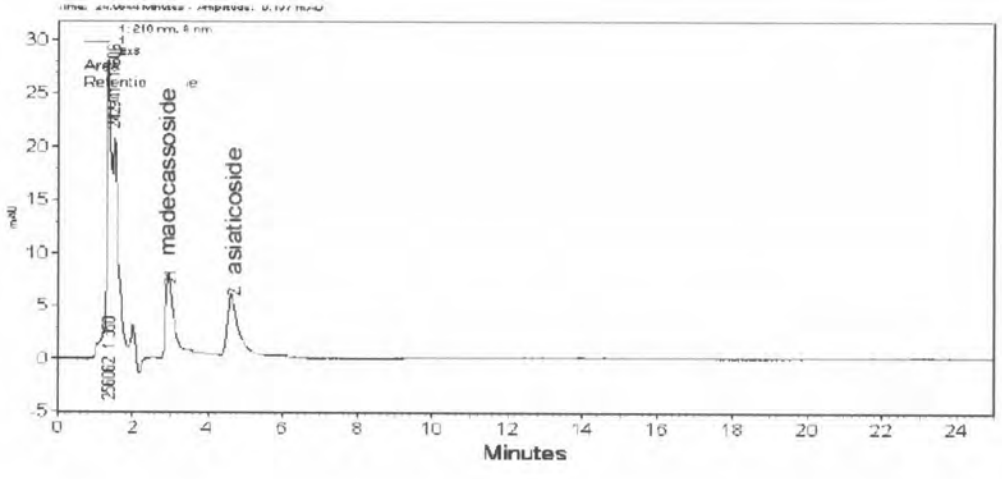
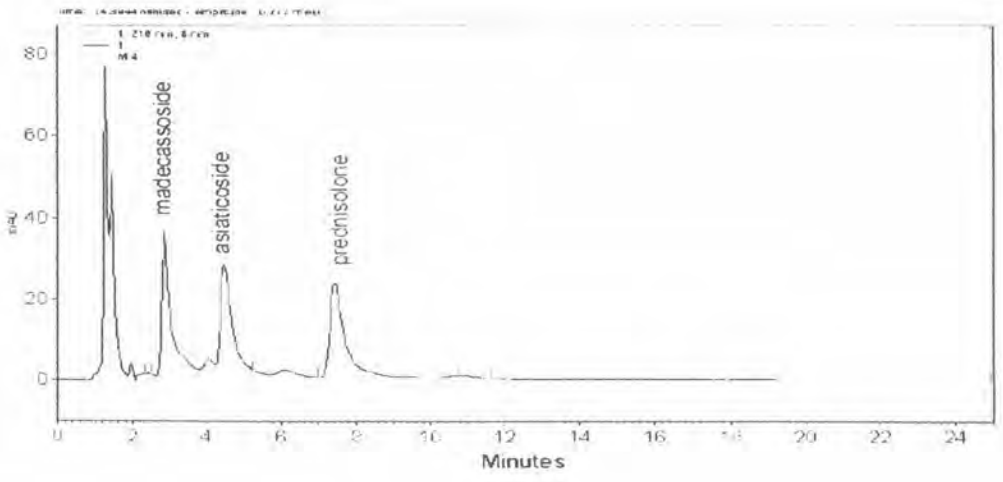


Figure 4.1 Spots on TLC-plate of madecassoside (MS), asiaticoside (AS), madecassic acid (MA) and asiatic acid (AA)

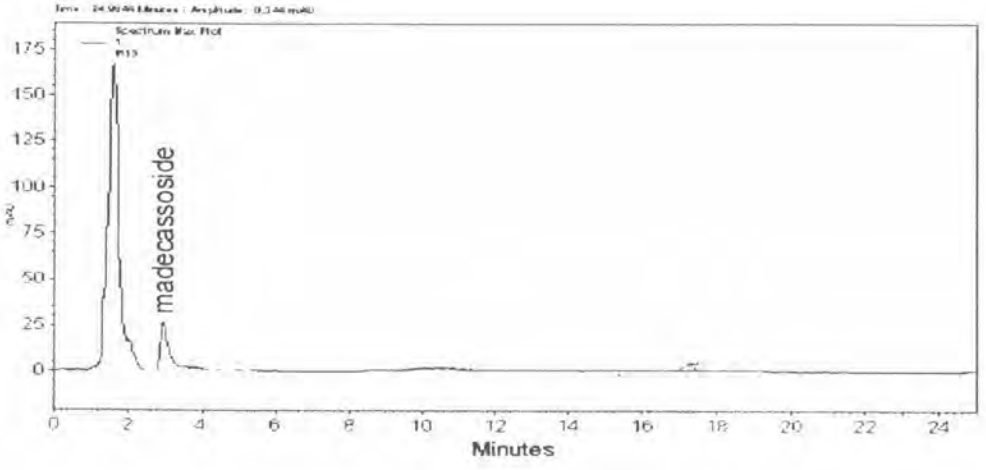


(a)

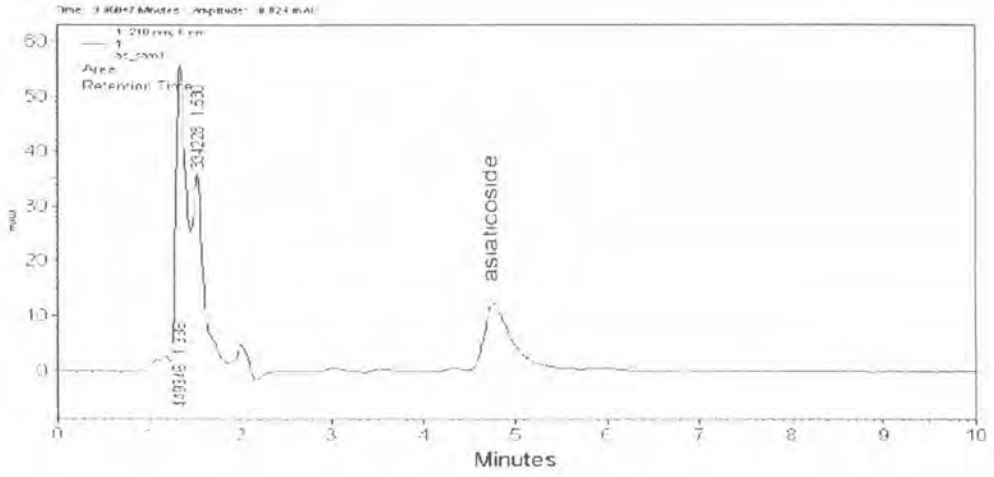


(b)

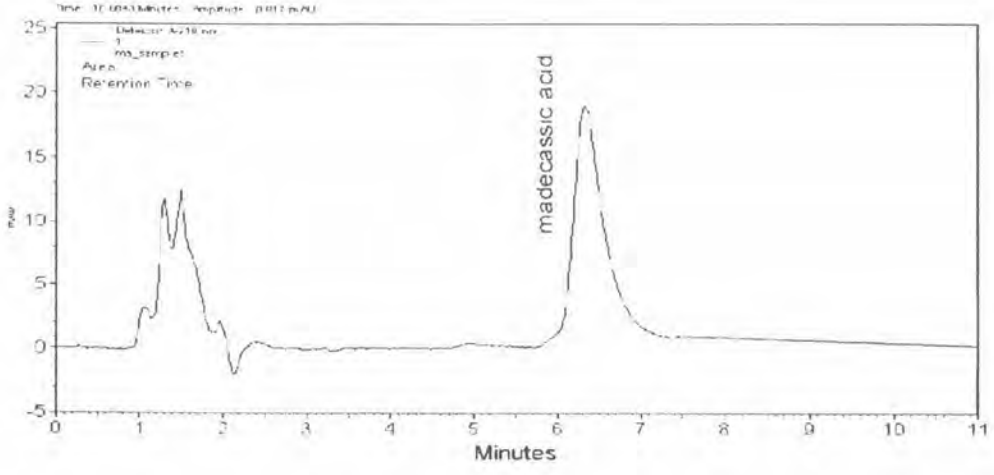
Figure 4.2 HPLC chromatogram of madecassoside and asiaticoside in standard solution **(a)** and CA extract with prednisolone as internal standard **(b)**



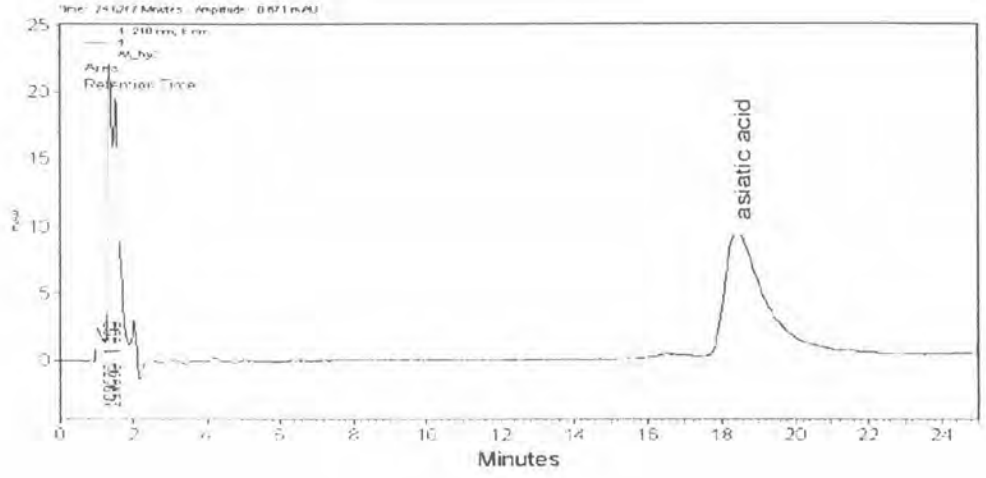
(a)



(b)

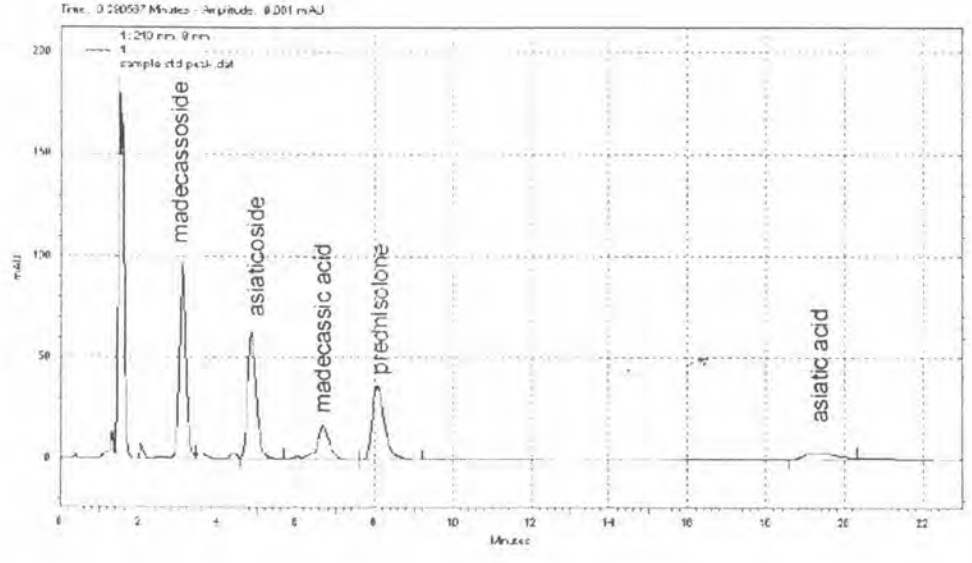


(c)

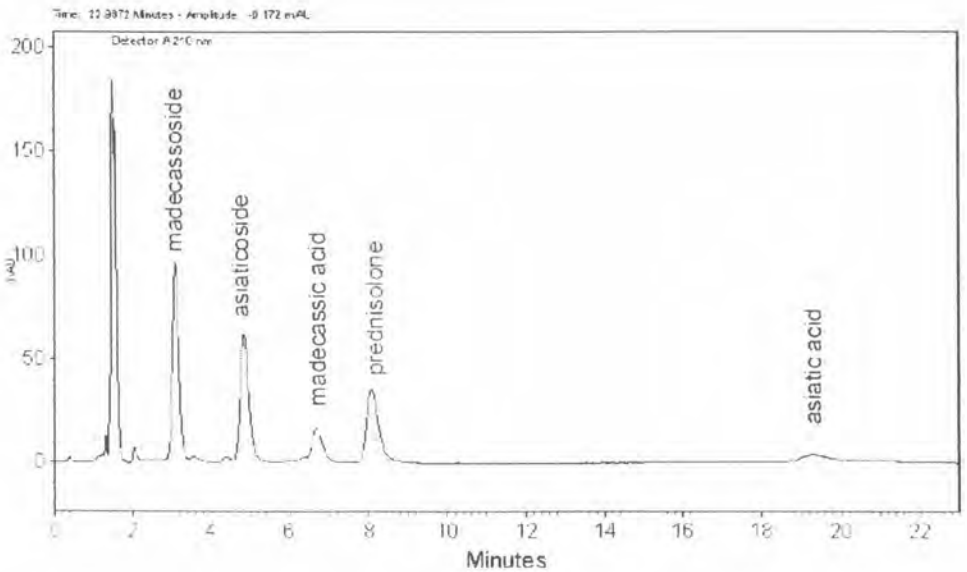


(d)

Figure 4.3 HPLC chromatogram of pure madecassoside **(a)**, asiaticoside **(b)**, madecassic acid **(c)** and asiatic acid **(d)**

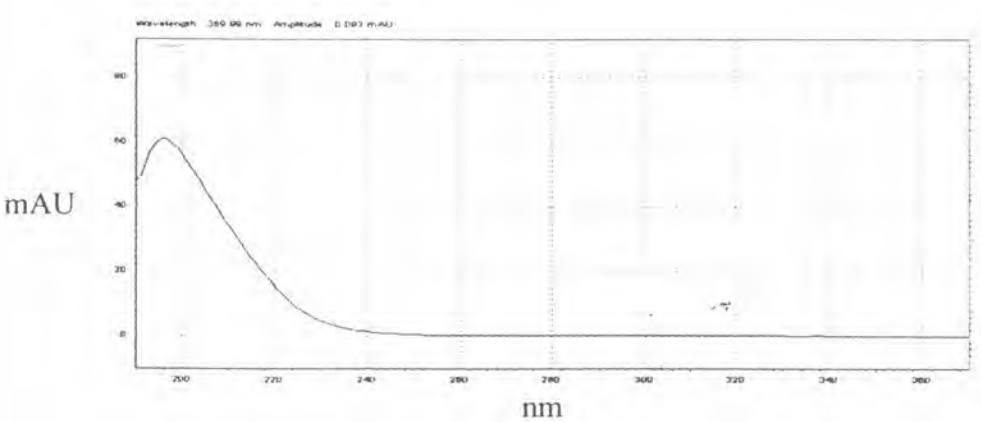


(a)

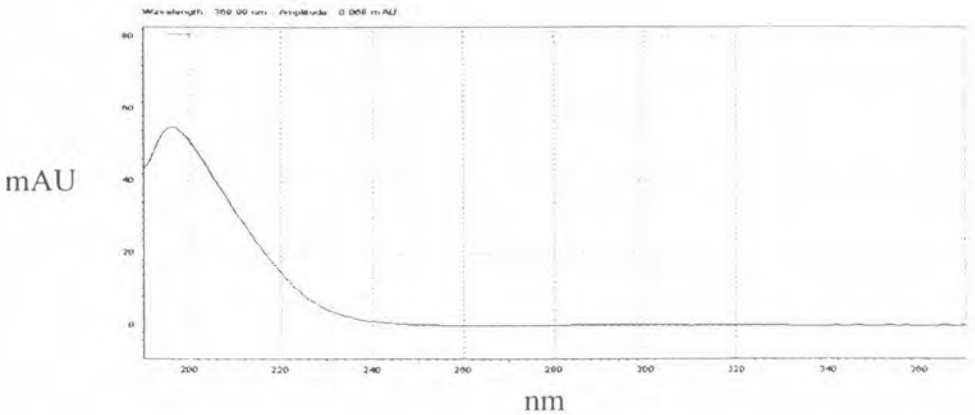


(b)

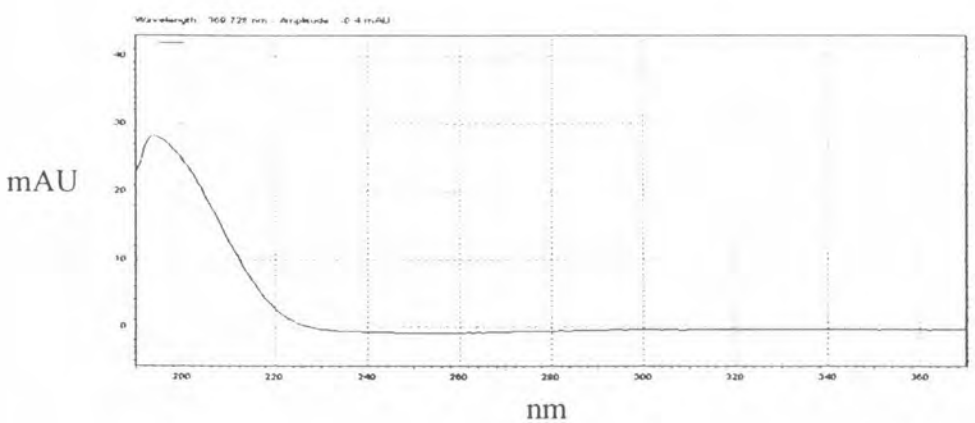
Figure 4.4 HPLC chromatogram of standard solution **(a)** and CA extract sample with prednisolone as internal standard **(b)**



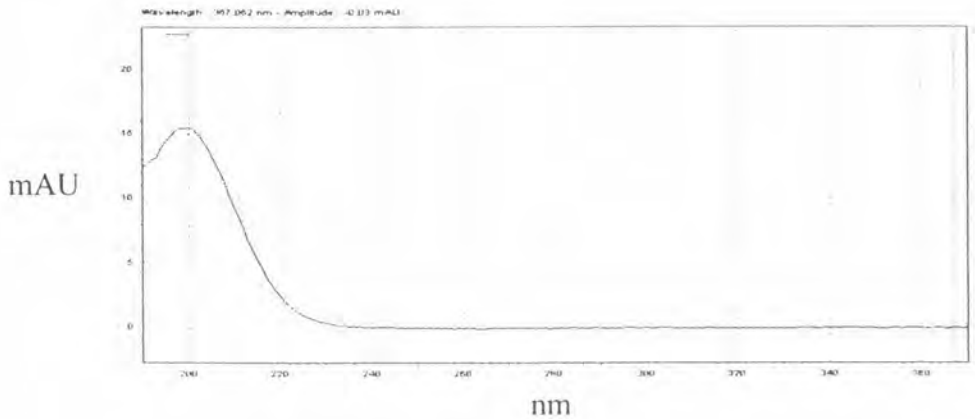
(a)



(b)

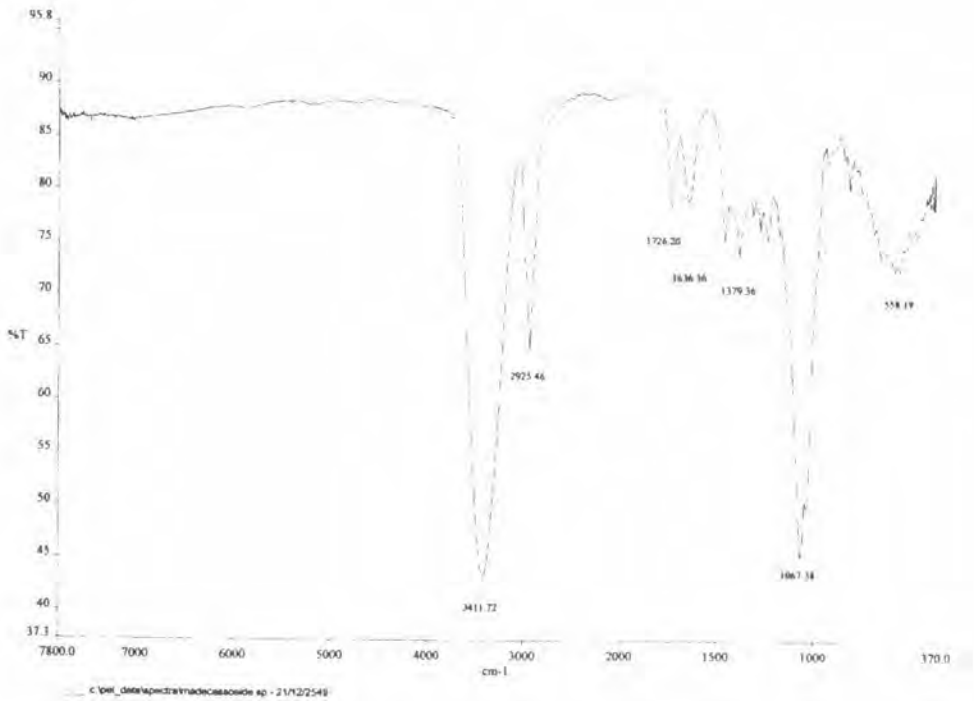


(c)



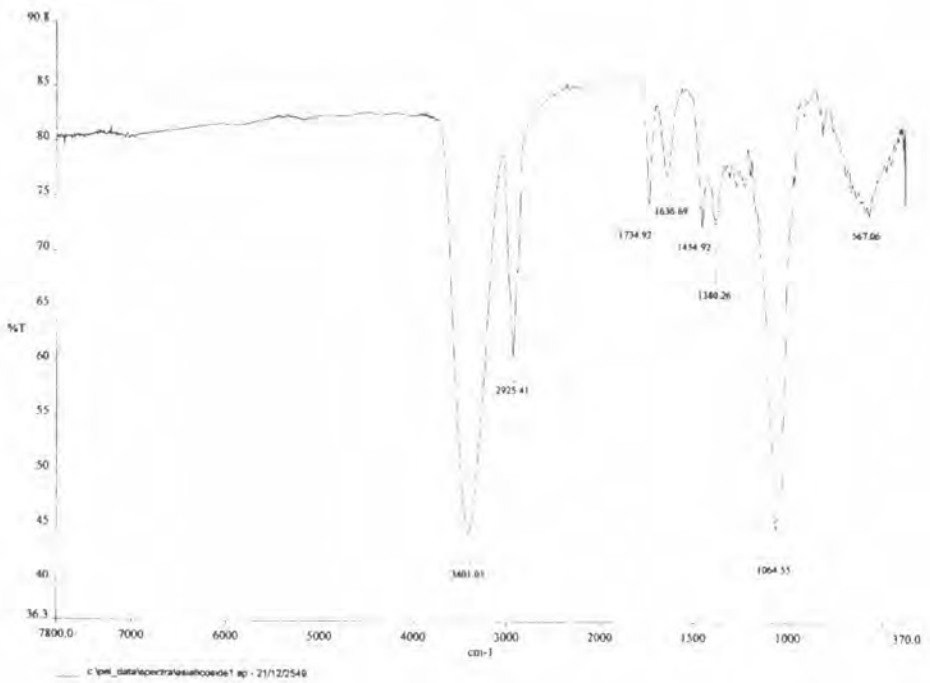
(d)

Figure 4.5 UV spectrums of pure MS **(a)**, AS **(b)**, MA **(c)** and AA **(d)**



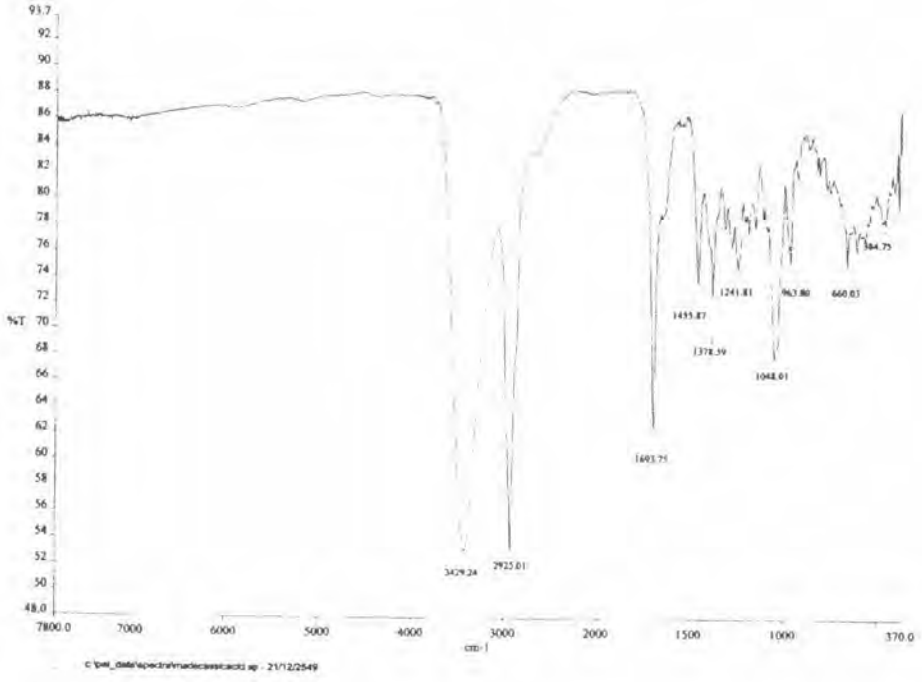
Wave number (cm^{-1})	Functional groups	Vibration
3411	-OH	OH-stretching
2925	$-CH_3$, $>CH_2$ and -CH- |	CH-stretching
1726	>C=O	C=O-stretching
1637	$-CH_3$ and $>CH_2$	CH-bending
1067	C-OH	CO-stretching

Figure 4.6 IR spectrum of pure madecassoside



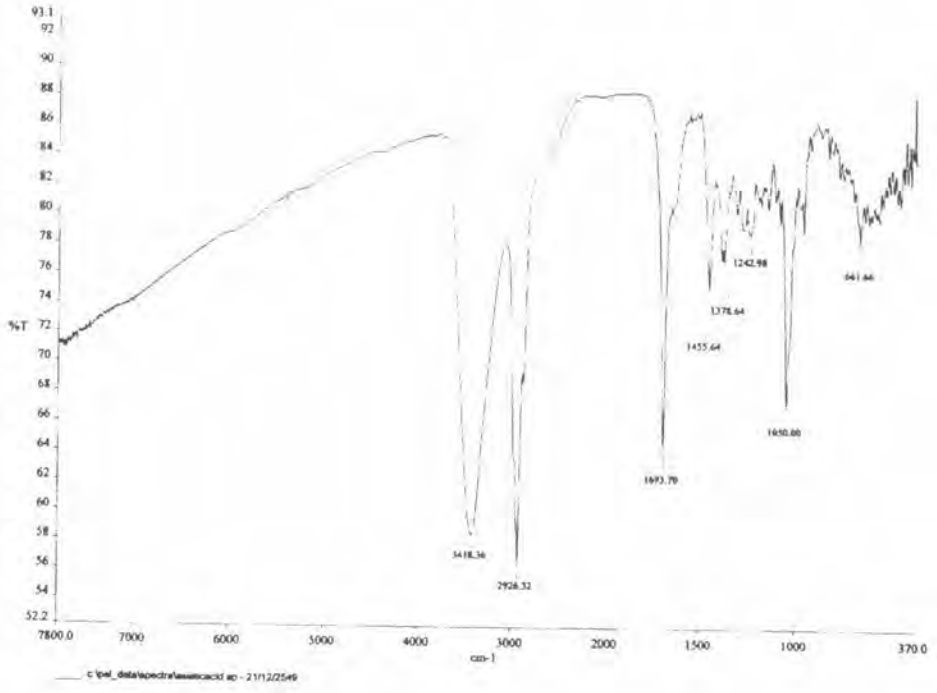
Wave number (cm^{-1})	Functional groups	Vibration
3401	-OH	OH-stretching
2925	$-CH_3$, $>CH_2$ and -CH-	CH-stretching
1735	>C=O	C=O-stretching
1637	$-CH_3$ and $>CH_2$	CH-bending
1065	C-OH	CO-stretching

Figure 4.7 IR spectrum of pure asiaticoside



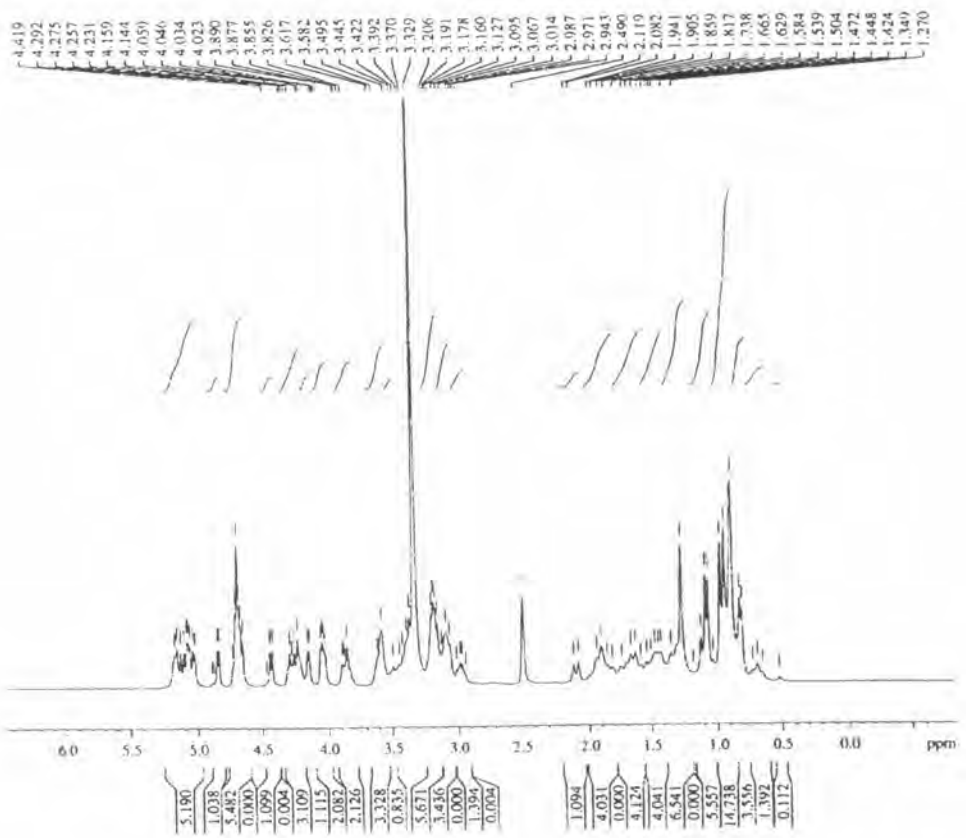
Wave number (cm^{-1})	Functional groups	Vibration
3429	-OH	OH-stretching
2925	$-CH_3$, $>CH_2$ and -CH-	CH-stretching
1694	>C=O	C=O-stretching
1048	C-OH	CO-stretching

Figure 4.8 IR spectrum of pure madecassic acid



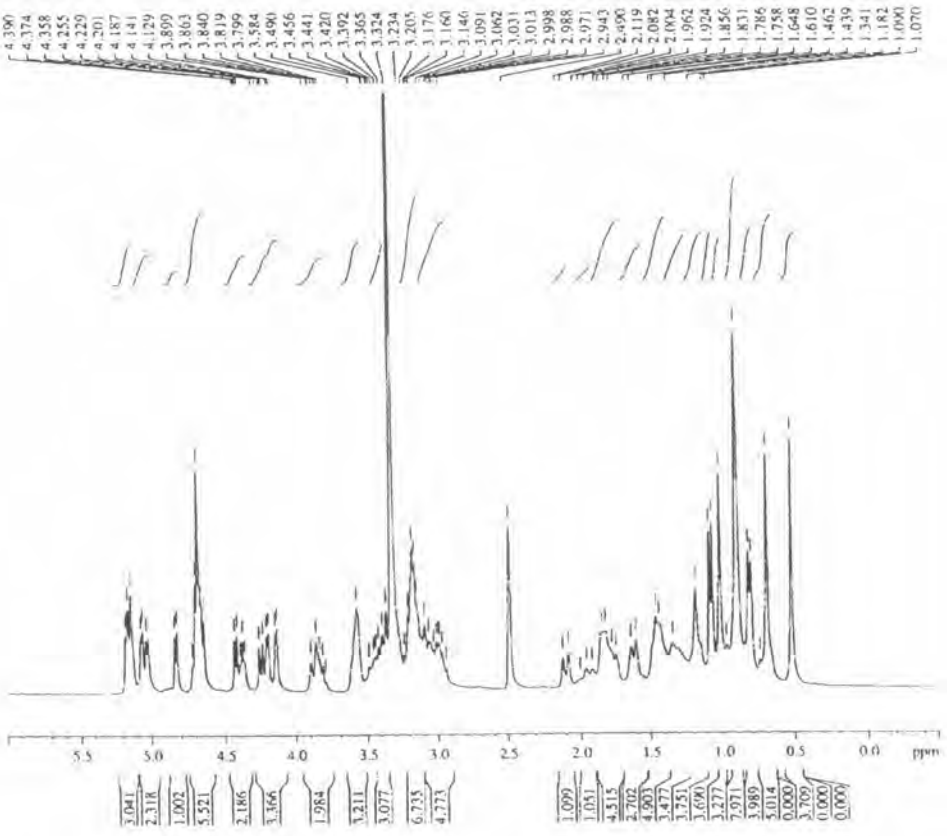
Wave number (cm^{-1})	Functional groups	Vibration
3418	-OH	OH-stretching
2926	$-CH_3$, $>CH_2$ and -CH-	CH-stretching
1694	>C=O	C=O-stretching
1050	C-OH	CO-stretching

Figure 4.9 IR spectrum of pure asiatic acid



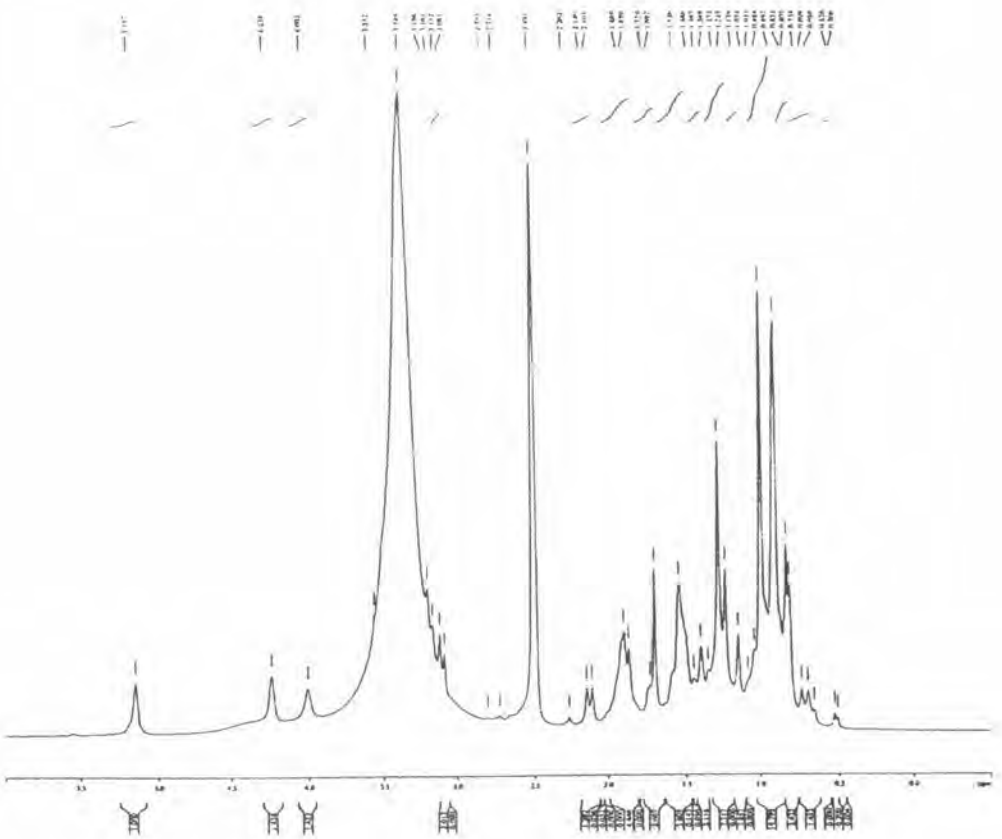
^{1}H chemical shifts δ: ppm	Assigned chemical structure
0.7-1.2	Six methyl group
5.14, 2.1(J =10.98)	Δ^{12}- ursene skeleton, H-18
5.15(J = 5.8), 4.25(J = 7.93), 4.85(J = 4.87)	Anomeric protons in Sugar part
4.04	-C<u>H</u>OH-

Figure 4.10 ^{1}H-NMR of pure madecassoside



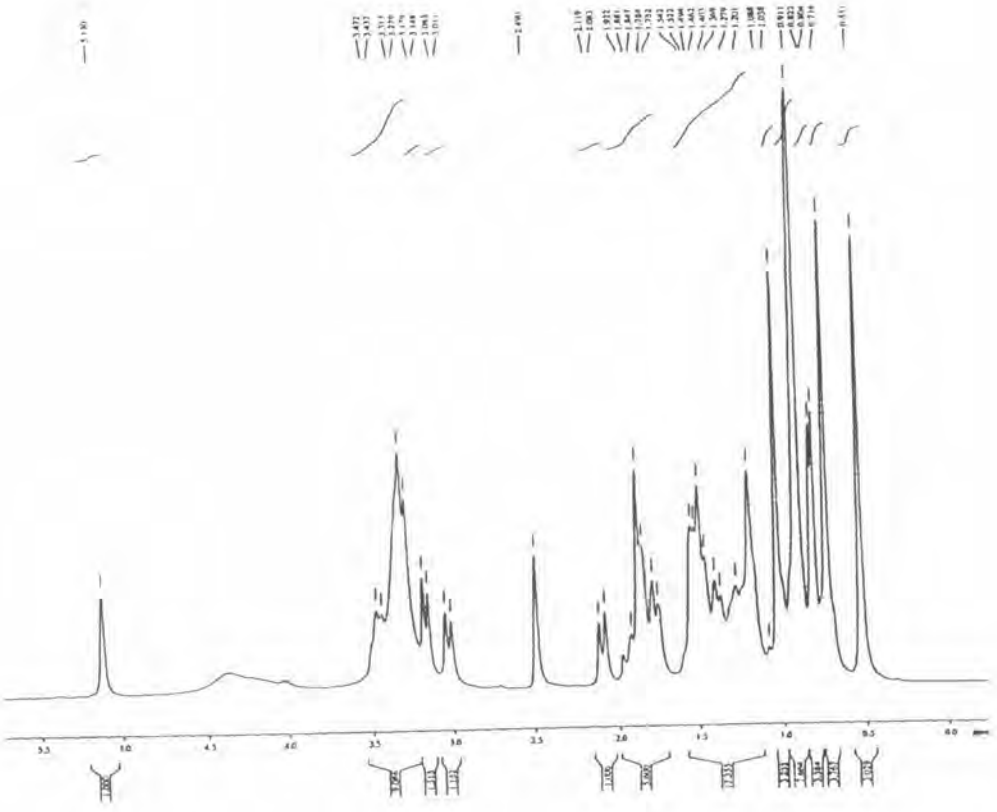
^{1}H chemical shifts δ: ppm	Assigned chemical structure
0.5-1.2	Six methyl group
5.14, 2.1(J=10.98)	Δ^{12}- ursene skeleton, H-18
5.18(J = 5.8), 5.16(J = 8.24), 4.84(J = 4.88)	Anomeric protons in Sugar part

Figure 4.11 ^{1}H-NMR of pure asiaticoside



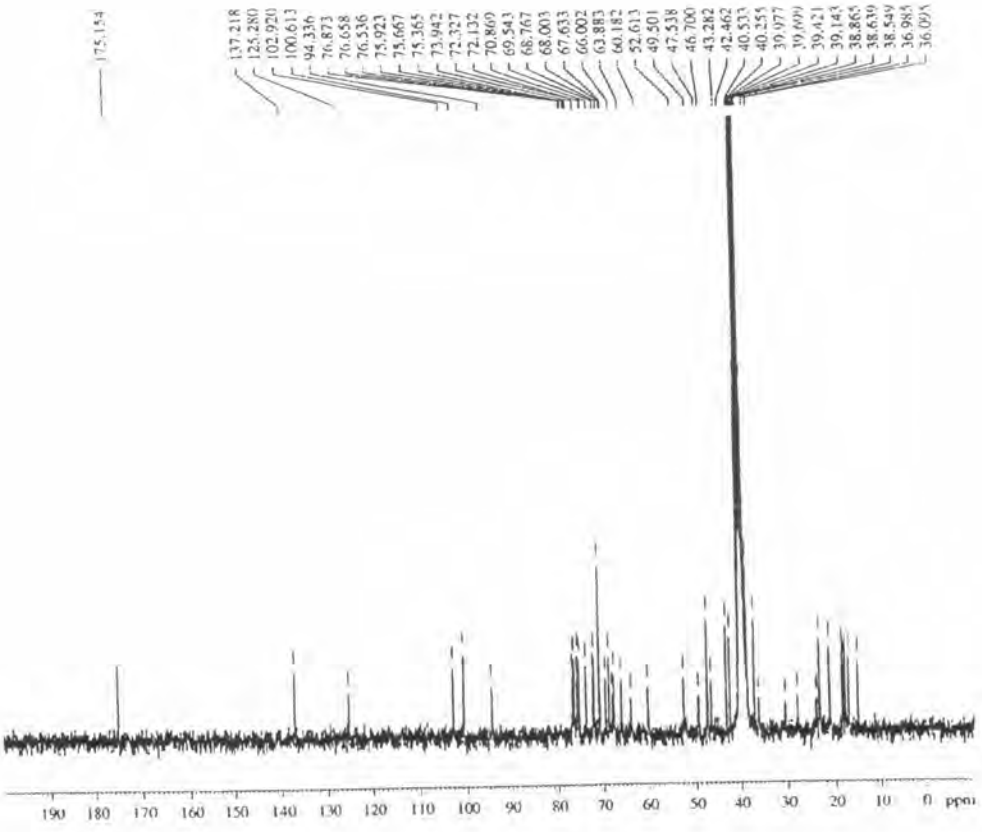
^{1}H chemical shifts δ: ppm	Assigned chemical structure
0.7-1.2	Six methyl group
5.14, 2.1(J =10.98)	Δ^{12}- ursene skeleton, H-18
4.04	-C<u>H</u>OH-

Figure 4.12 ^{1}H-NMR of pure madecassic acid



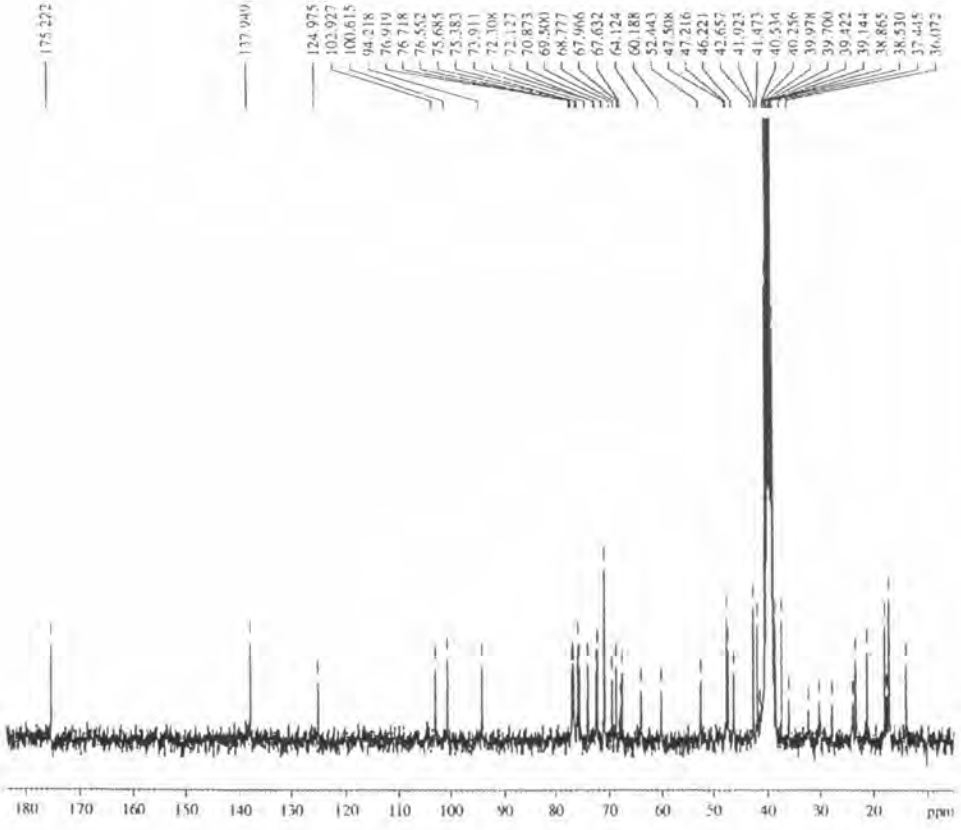
^{1}H chemical shifts δ: ppm	Assigned chemical structure
0.5-1.2	Six methyl group
5.13, 2.12(J=10.98)	Δ^{12}- ursene skeleton, H-18

Figure 4.13 ^{1}H-NMR of pure asiatic acid



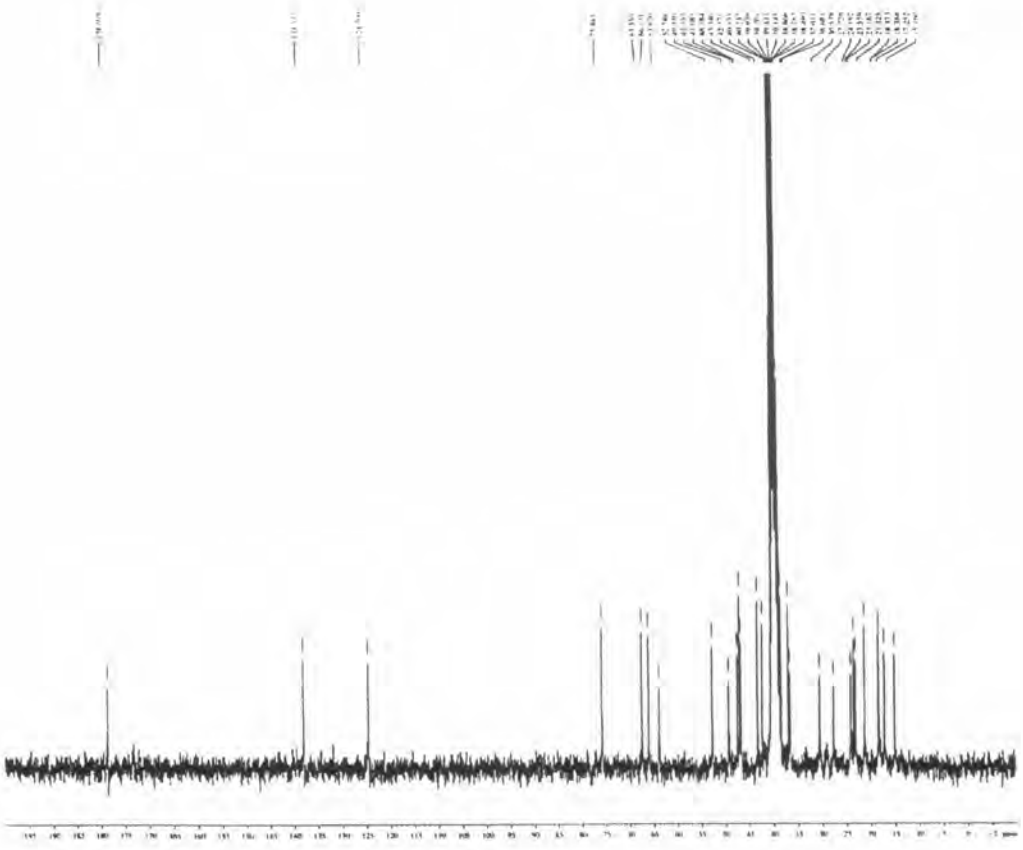
^{13}C chemical shifts δ: ppm	Assigned chemical structure
175	-COOR-
137, 125	-CH=CH-
60-100	17 C of sugar and C-2 and C-23 of Δ^{12}- ursene skeleton

Figure 4.14 ^{13}C-NMR of pure madecassoside



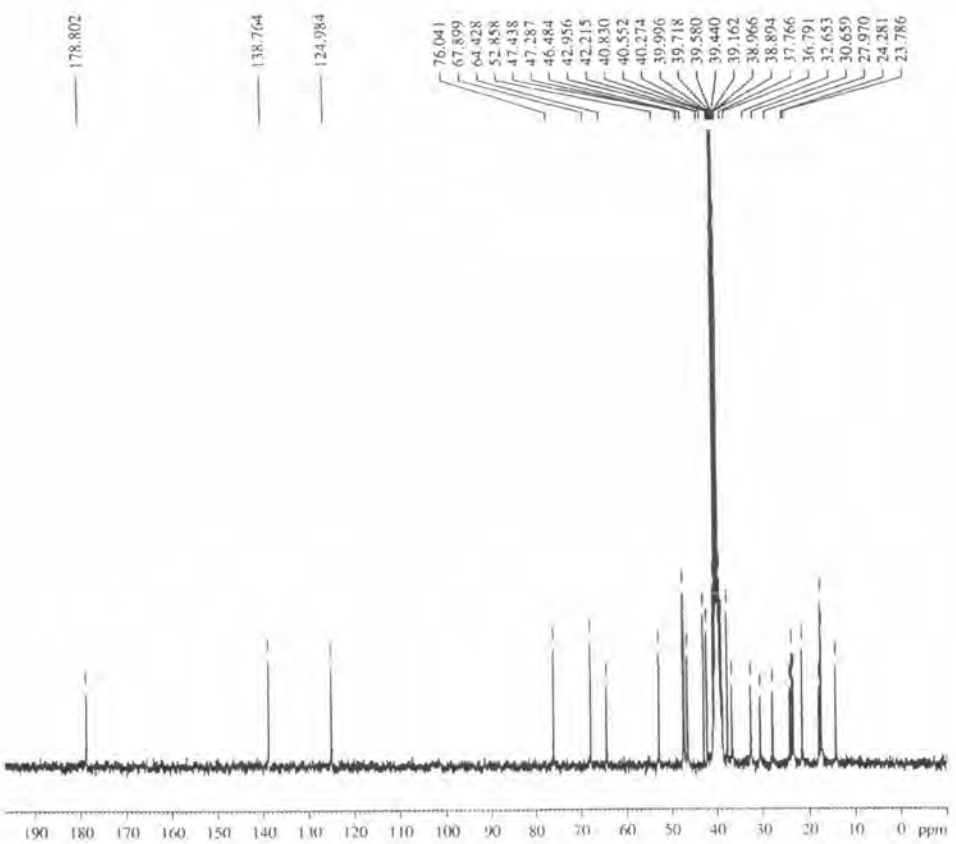
^{13}C chemical shifts δ: ppm	Assigned chemical structure
175	-COOR-
137, 124	-CH=CH-
60-100	17 C of sugar and C-2 and C-23 of Δ^{12}- ursene skeleton

Figure 4.15 ^{13}C-NMR of pure asiaticoside



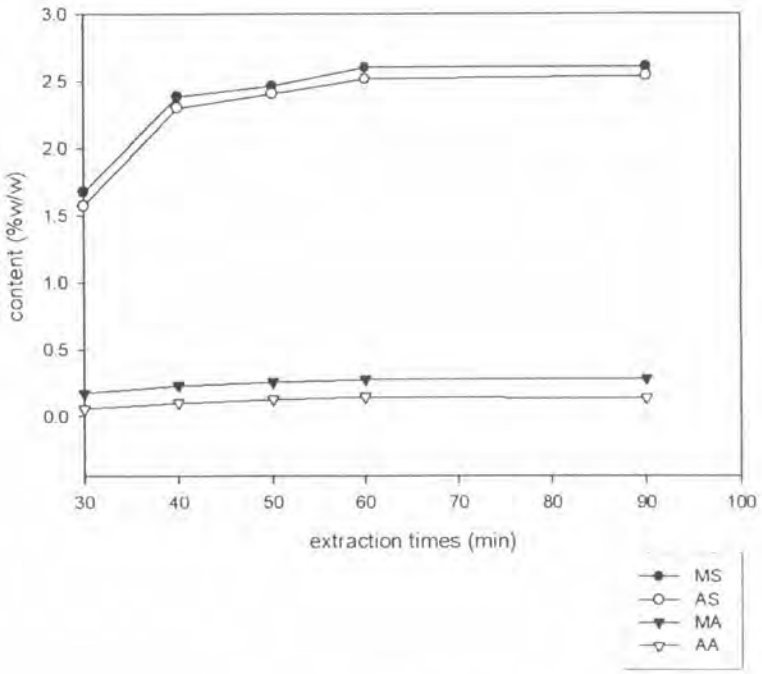
^{13}C chemical shifts δ: ppm	Assigned chemical structure
178	-COOR-
138, 124	-CH=CH-
76	C-3; (C-O)
60-70	C-2, C-6, C23; (C-O)
48	C-17; (C-C=O)

Figure 4.16 ^{13}C-NMR of pure madecassic acid

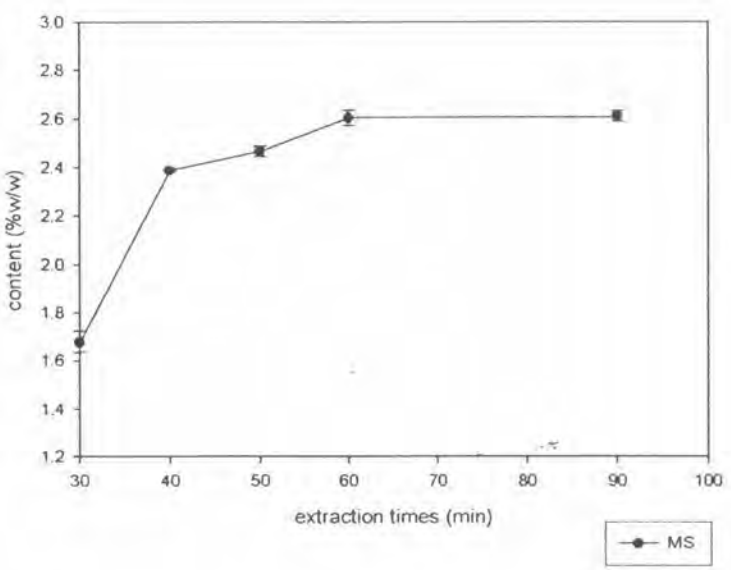


^{13}C chemical shifts δ: ppm	Assigned chemical structure
178	-COOR-
138, 124	-CH=CH-
76	C-3; (C-O)
60-70	C-2, C23; (C-O)
47	C-17; (C-C=O)

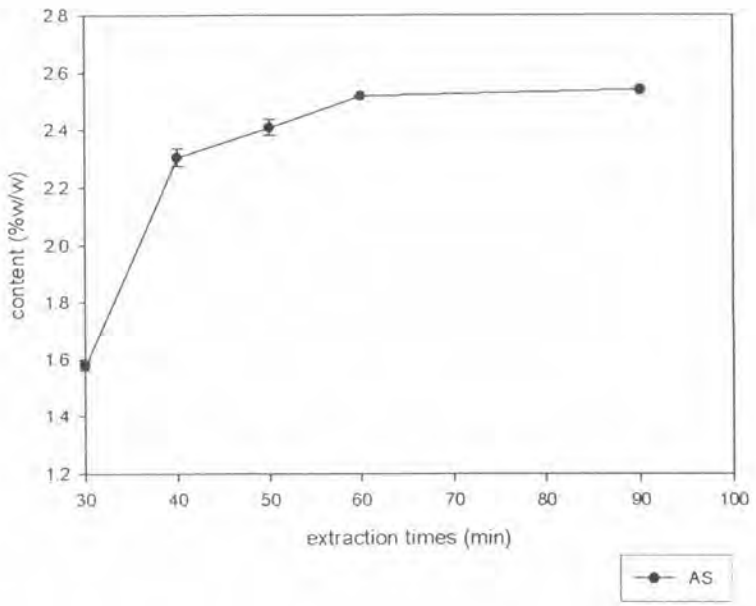
Figure 4.17 ^{13}C-NMR of pure asiatic acid


3.0
2.5
2.0
1.5
1.0
0.5
0.0
content (%w/w)
30
40
50
60
70
80
90
100
extraction times (min)
MS
AS
MA
AA

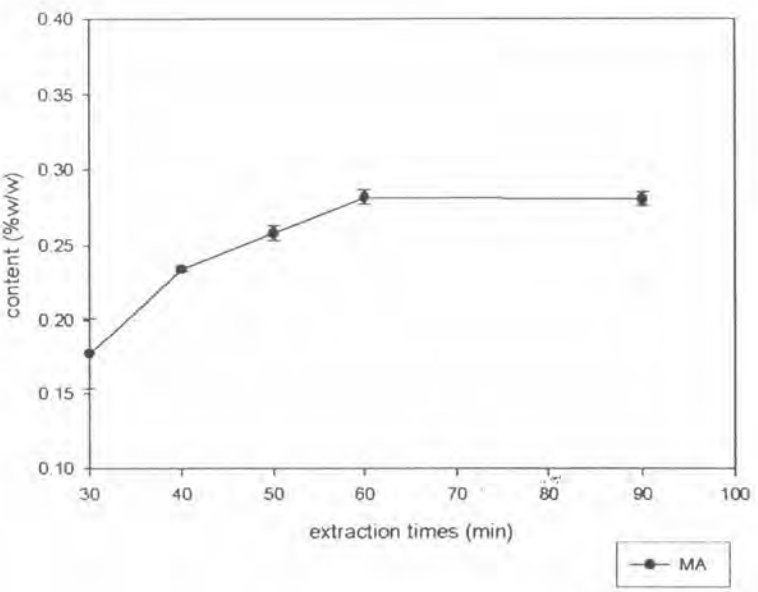
(a)


3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
content (%w/w)
30
40
50
60
70
80
90
100
extraction times (min)
MS

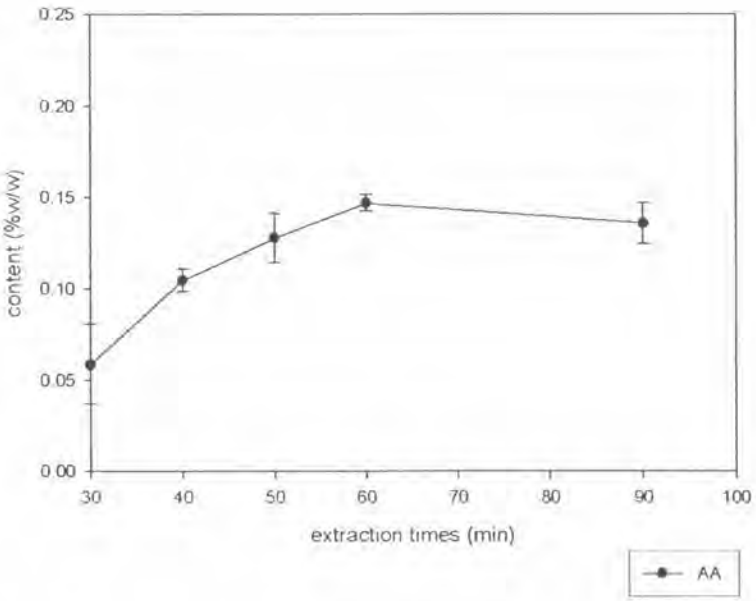
(b)


2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
content (%w/w)
30
40
50
60
70
80
90
100
extraction times (min)
AS

(c)


0.40
0.35
0.30
0.25
0.20
0.15
0.10
content (%w/w)
30
40
50
60
70
80
90
100
extraction times (min)
MA

(d)



(e)

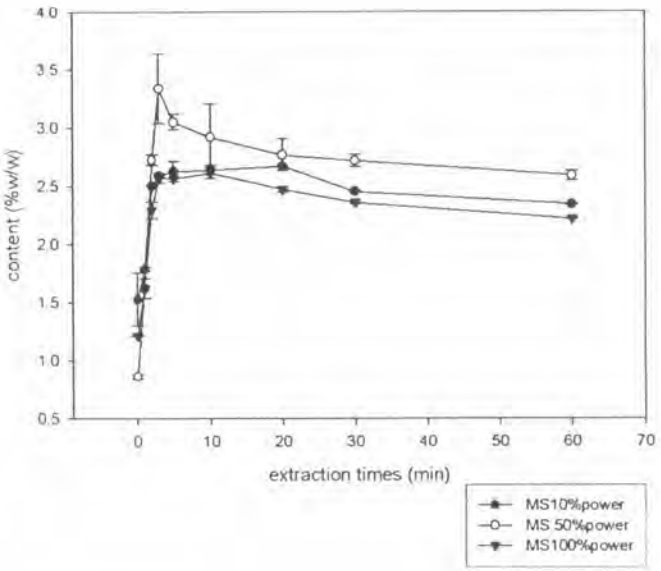
Figure 4.18 Percentage contents of MS, AS, MA and AA in whole plant of CA by reflux extraction at various times **(a)**

(b) Percentage contents of MS

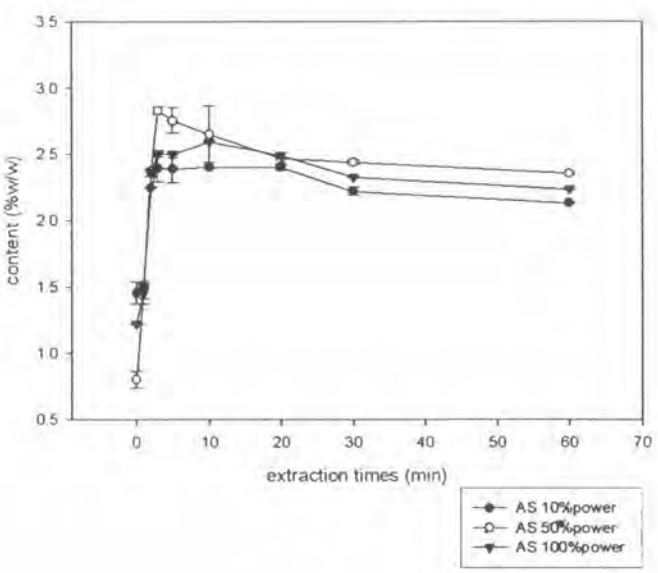
(c) Percentage contents of AS

(d) Percentage contents of MA

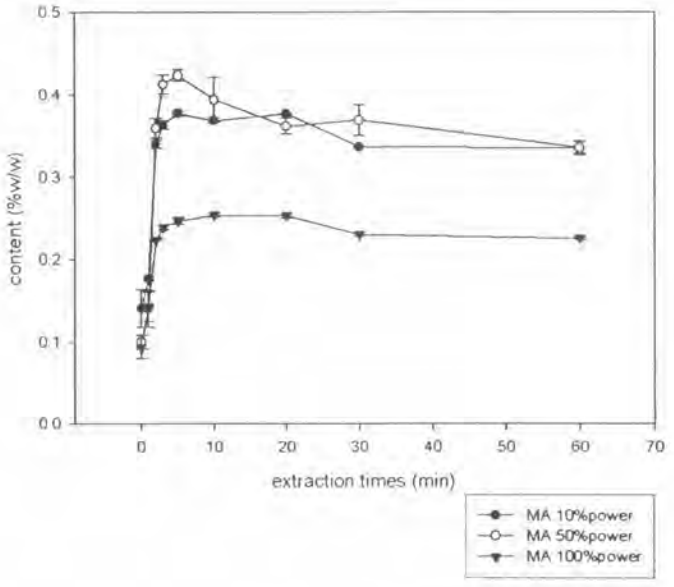
(e) Percentage contents of AA


content (%w/w)
extraction times (min)
MS10%power
MS 50%power
MS100%power

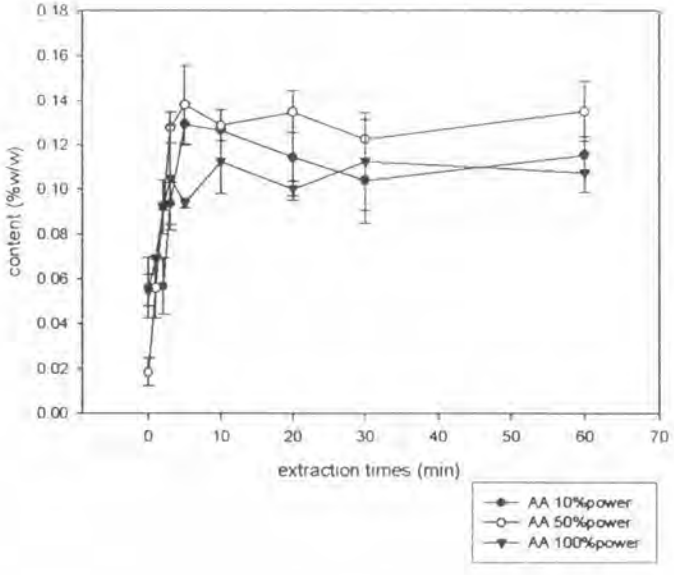
(a)


content (%w/w)
extraction times (min)
AS 10%power
AS 50%power
AS 100%power

(b)



(c)



(d)

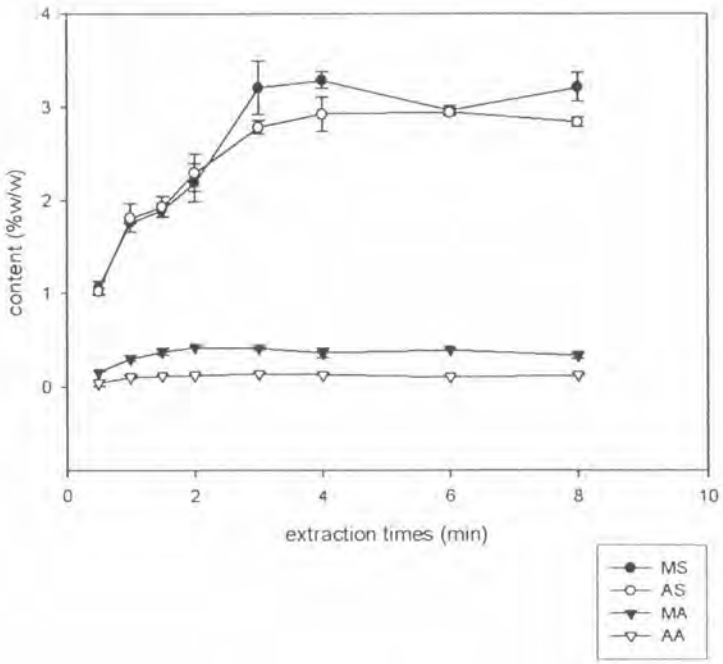
Figure 4.19 The effect of ultrasonic extraction time and power on percentage contents of MS, AS, MA and AA

(a) Percentage contents of MS

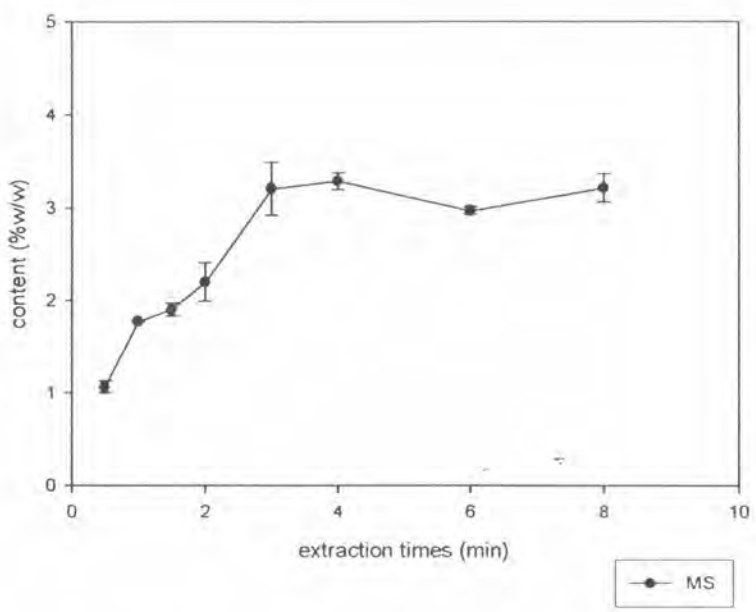
(b) Percentage contents of AS

(c) Percentage contents of MA

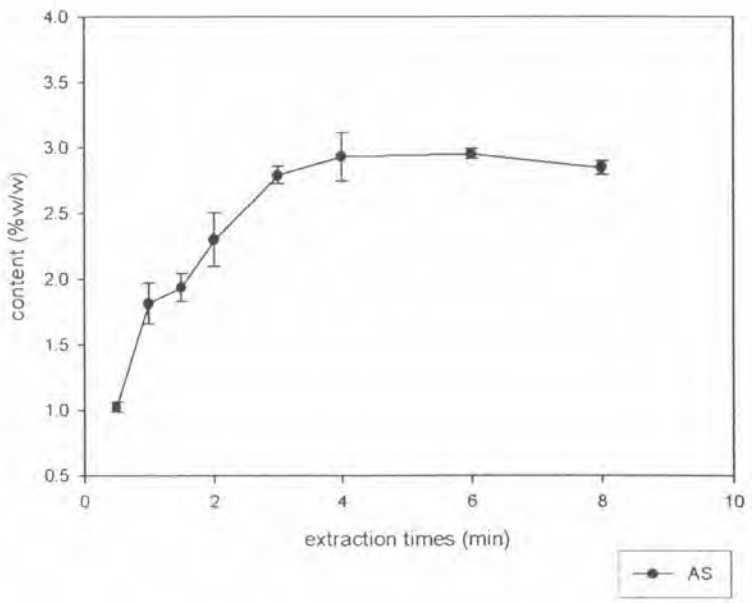
(d) Percentage contents of AA


content (%w/w)
extraction times (min)
MS
AS
MA
AA

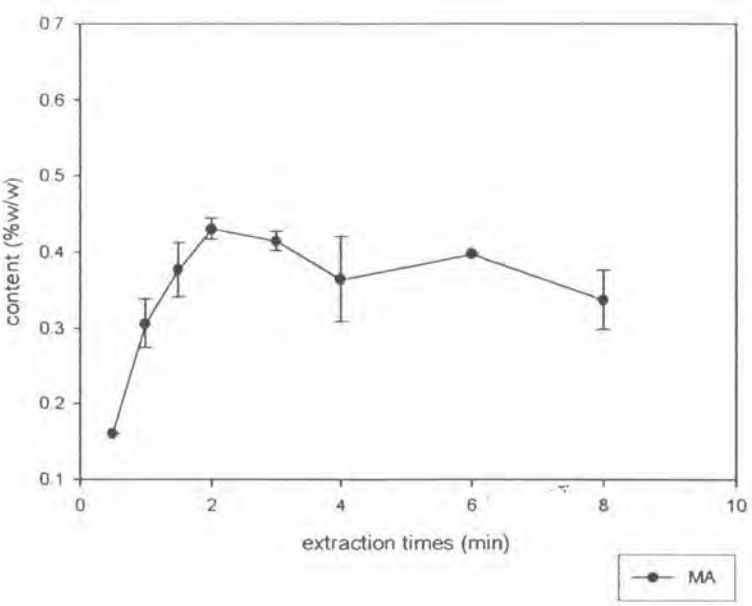
(a)


content (%w/w)
extraction times (min)
MS

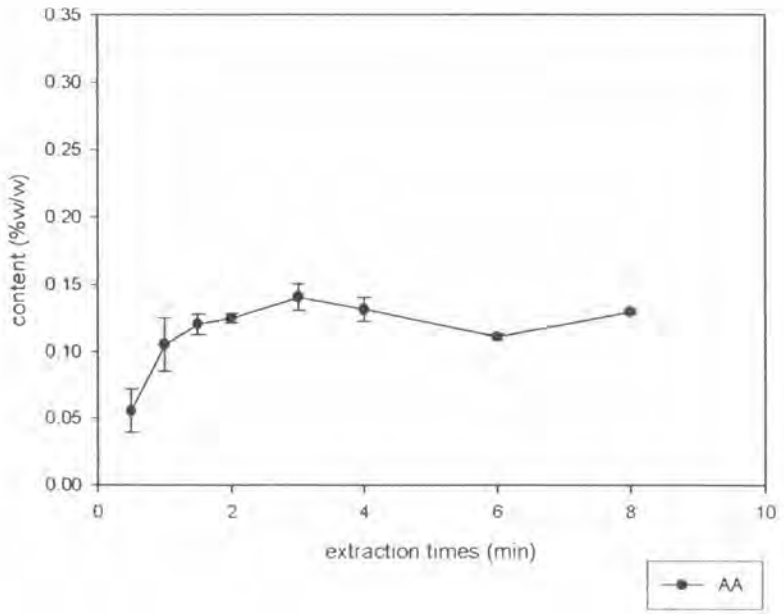
(b)


4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
content (%w/w)
0
2
4
6
8
10
extraction times (min)
AS

(c)


0.7
0.6
0.5
0.4
0.3
0.2
0.1
content (%w/w)
0
2
4
6
8
10
extraction times (min)
MA

(d)



(c)

Figure 4.20 The effect of microwave extraction time on percentage contents of MS, AS, MA and AA **(a)**

(b) Percentage contents of MS

(c) Percentage contents of AS

(d) Percentage contents of MA

(e) Percentage contents of AA

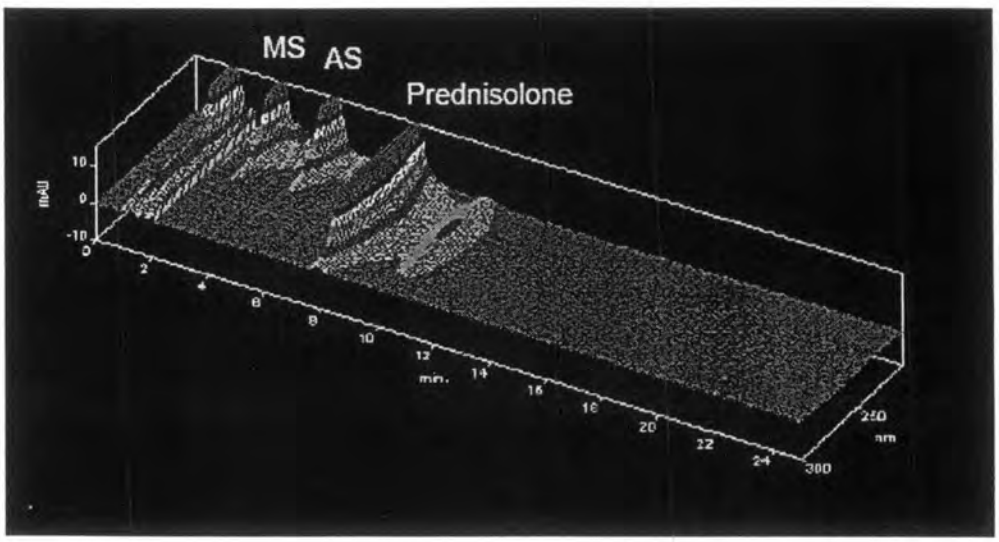


Figure 4.21 3D-HPLC chromatogram of MS and AS standard during UAE by using the photodiode array detector

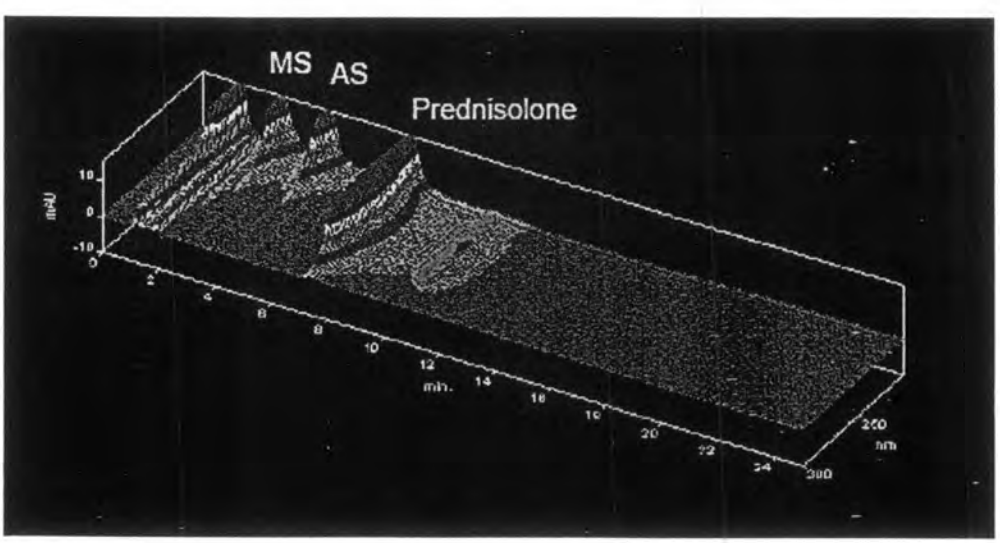
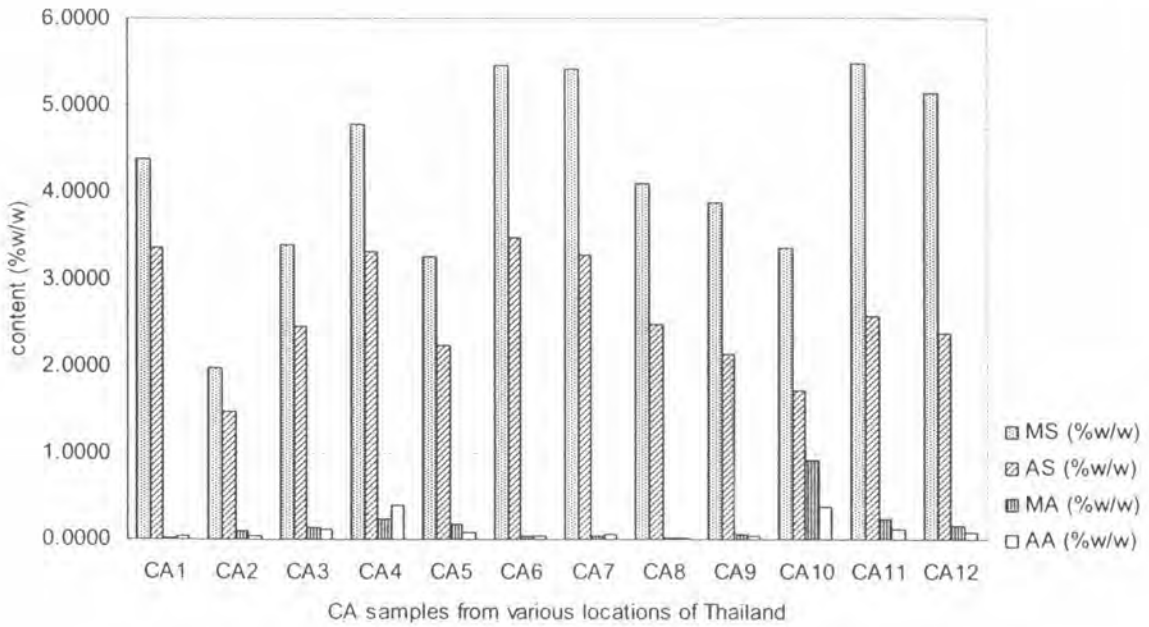
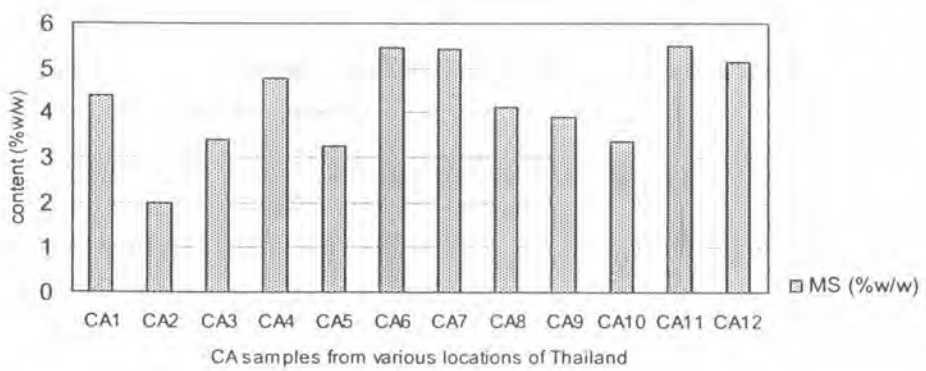


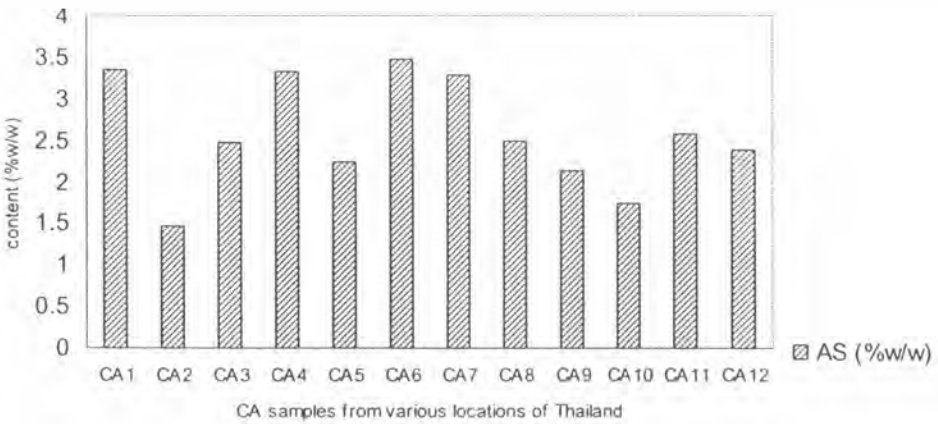
Figure 4.22 3D-HPLC chromatogram of MS and AS standard during MAE by using the photodiode array detector


6.0000
5.0000
4.0000
3.0000
2.0000
1.0000
0.0000
content (%w/w)
CA1 CA2 CA3 CA4 CA5 CA6 CA7 CA8 CA9 CA10 CA11 CA12
CA samples from various locations of Thailand
MS (%w/w)
AS (%w/w)
MA (%w/w)
AA (%w/w)

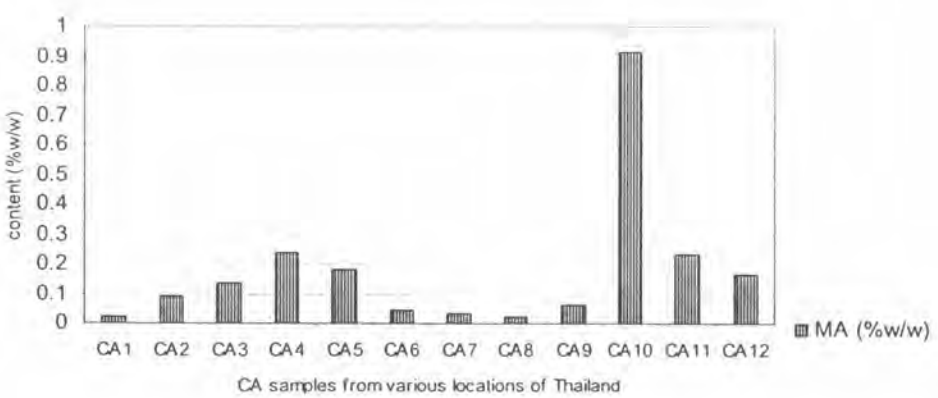
(a)


6
5
4
3
2
1
0
content (%w/w)
CA1 CA2 CA3 CA4 CA5 CA6 CA7 CA8 CA9 CA10 CA11 CA12
CA samples from various locations of Thailand
MS (%w/w)

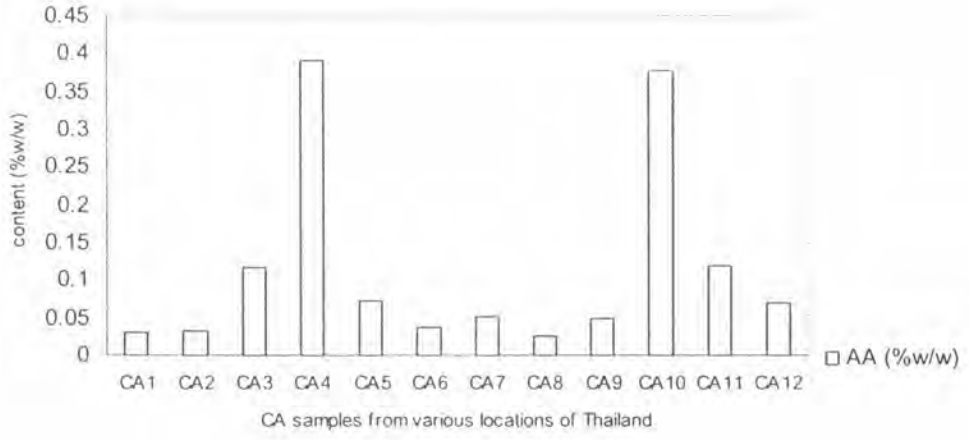
(b)


4
3.5
3
2.5
2
1.5
1
0.5
0
content (%w/w)
CA1 CA2 CA3 CA4 CA5 CA6 CA7 CA8 CA9 CA10 CA11 CA12
CA samples from various locations of Thailand
AS (%w/w)

(c)


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
content (%w/w)
CA1 CA2 CA3 CA4 CA5 CA6 CA7 CA8 CA9 CA10 CA11 CA12
CA samples from various locations of Thailand
MA (%w/w)

(d)



(c)

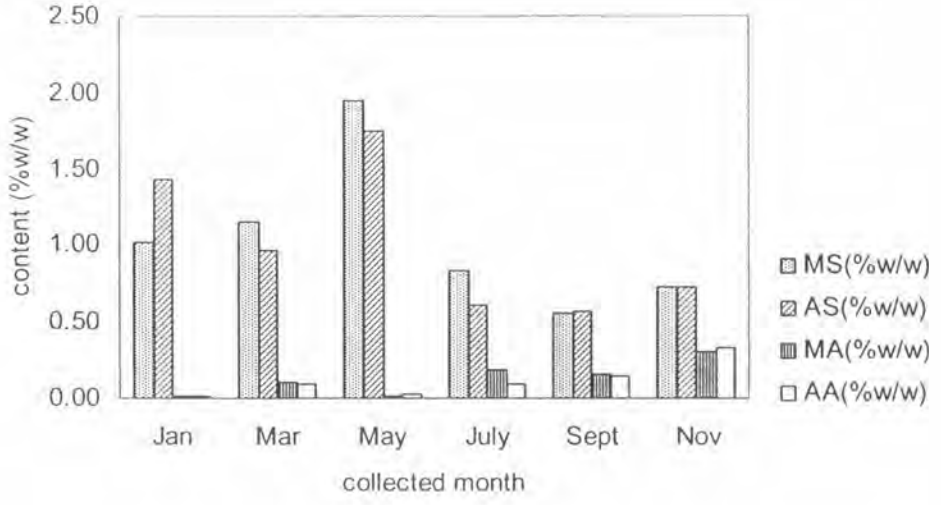
Figure 4.23 Contents of MS, AS, MA and AA in whole plant of various CA from Thailand Institute of Scientific and Technological Research **(a)**

(b) Contents of MS compared in various CA samples

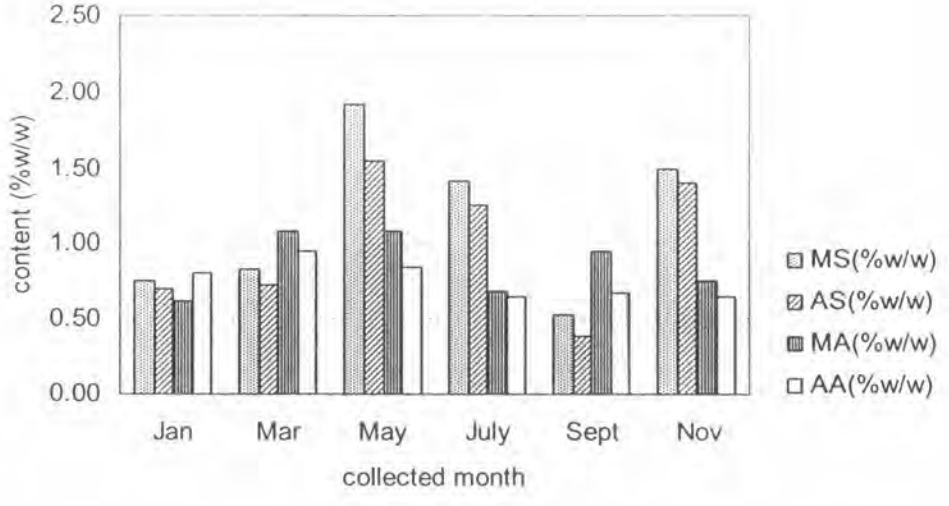
(c) Contents of AS compared in various CA samples

(d) Contents of MA compared in various CA samples

(e) Contents of AA compared in various CA samples



(a)



(b)

Figure 4.24 Comparison of percent contents of MS, AS, MA and AA in CA sample collected during the year 2003 **(a)** and 2006 **(b)** from Nakhon Pathom province

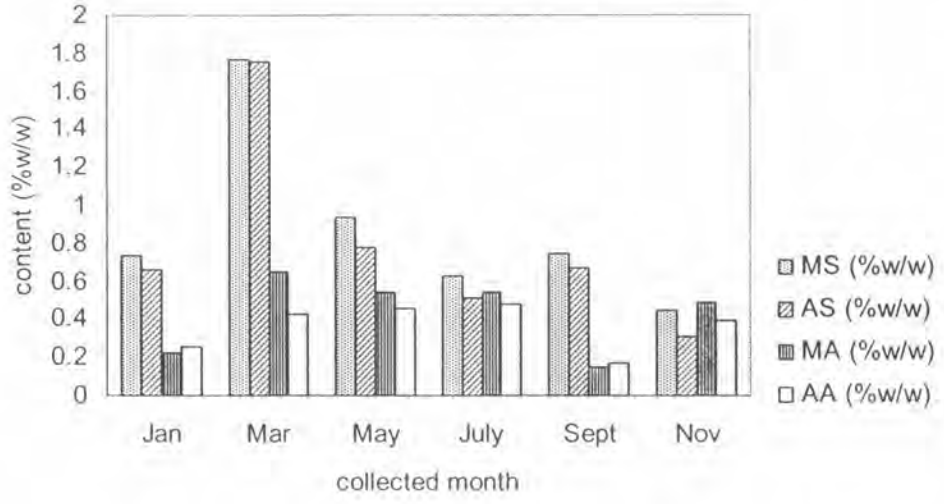


Figure 4.25 Contents of MS, AS, MA and AA in whole plant of CA from the commercial crop of Ubon Ratchathani province in annual period

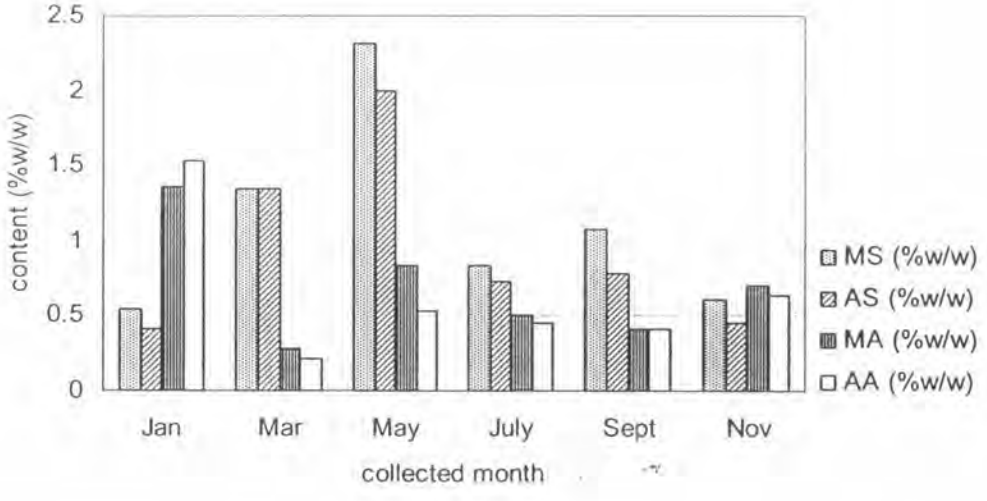
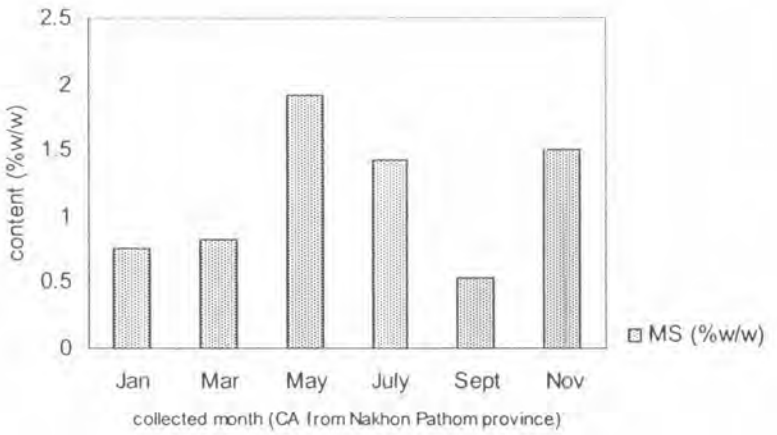
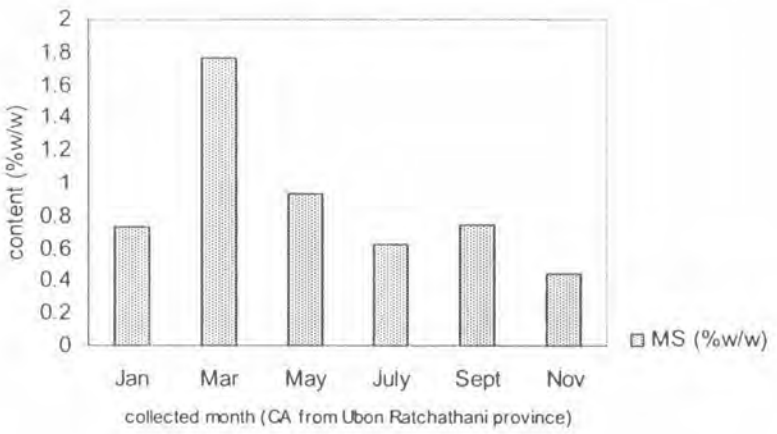


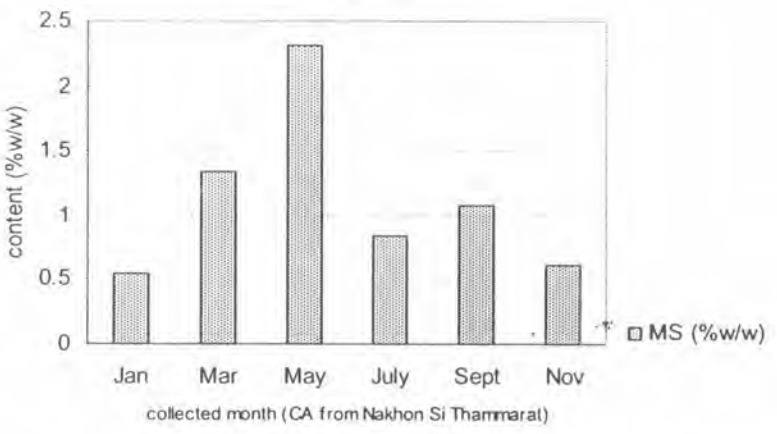
Figure 4.26 Contents of MS, AS, MA and AA in whole plant of CA from the commercial crop of Nakhon Si Thammarat province in annual period



(a)

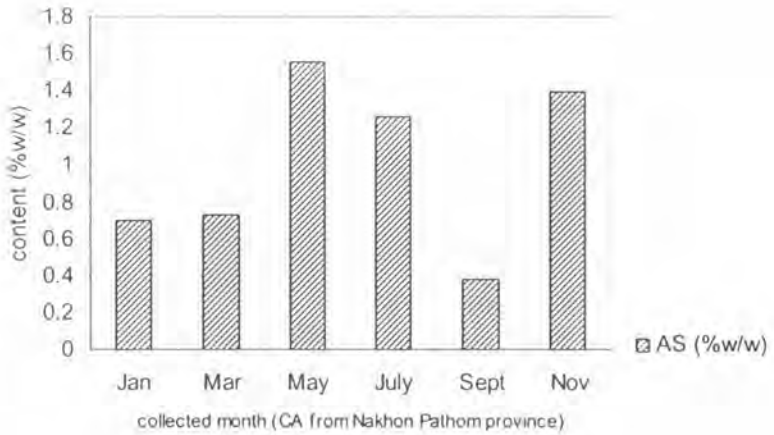


(b)

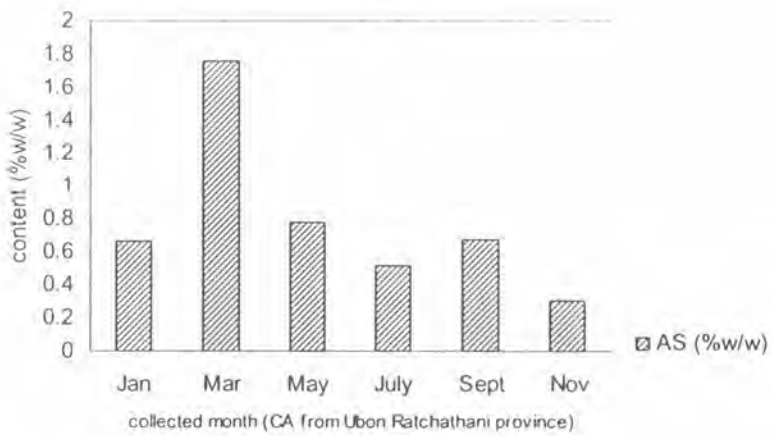


(c)

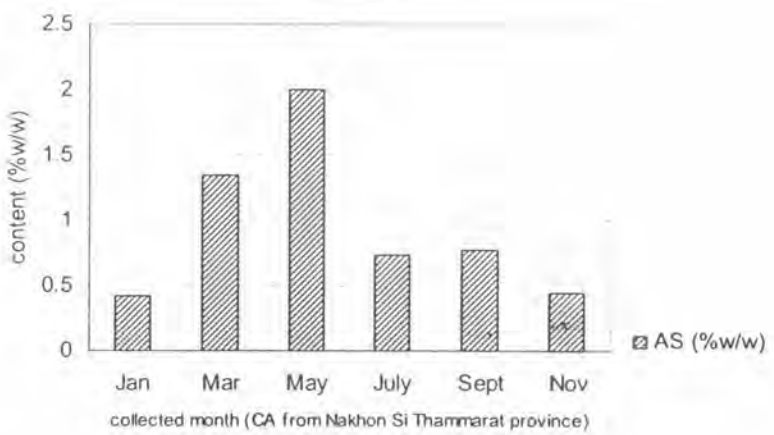
Figure 4.27 Annually content profiles of MS in whole plant of CA from the commercial crop of Nakhon Pathom **(a)**, Ubon Ratchathani **(b)** and Nakhon Si Thammarat province **(c)**



(a)

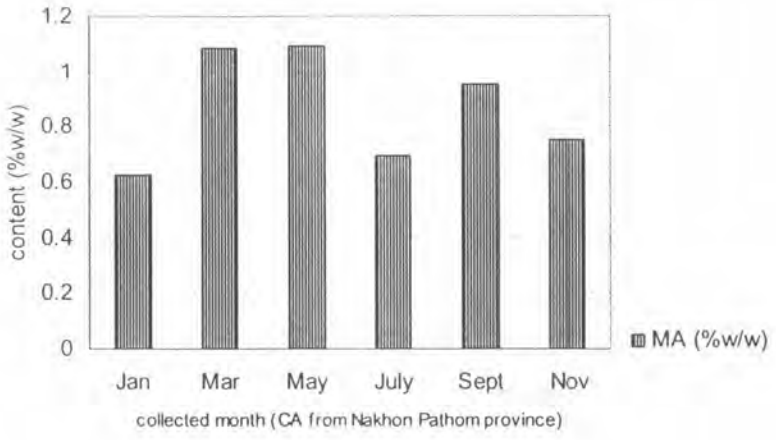


(b)

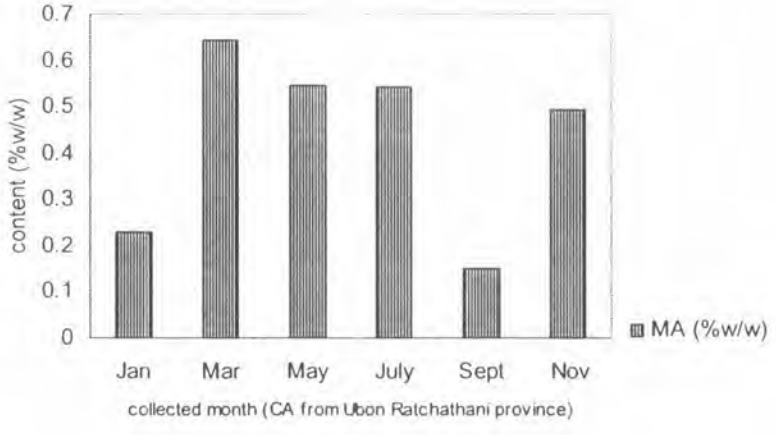


(c)

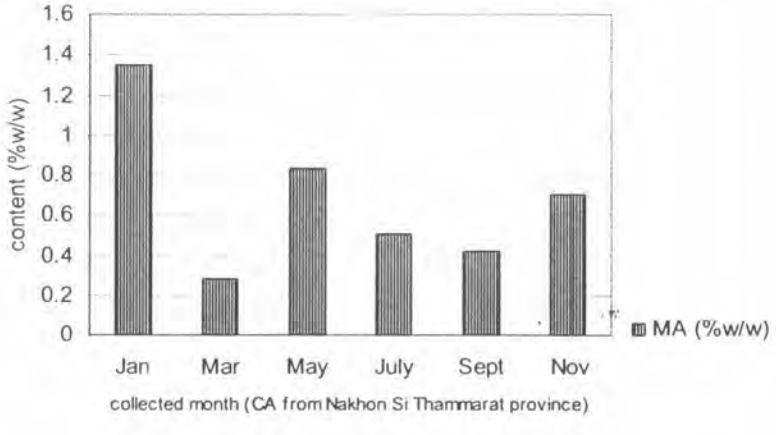
Figure 4.28 Annually content profiles of AS in whole plant of CA from the commercial crop of Nakhon Pathom **(a)**, Ubon Ratchathani **(b)** and Nakhon Si Thammarat province **(c)**



(a)

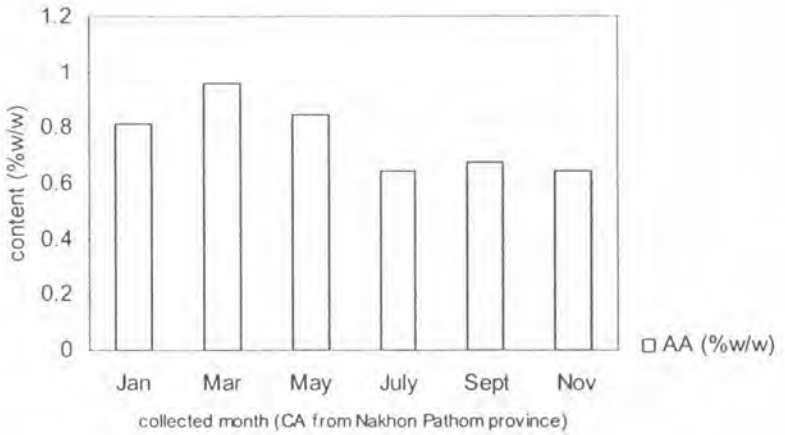


(b)

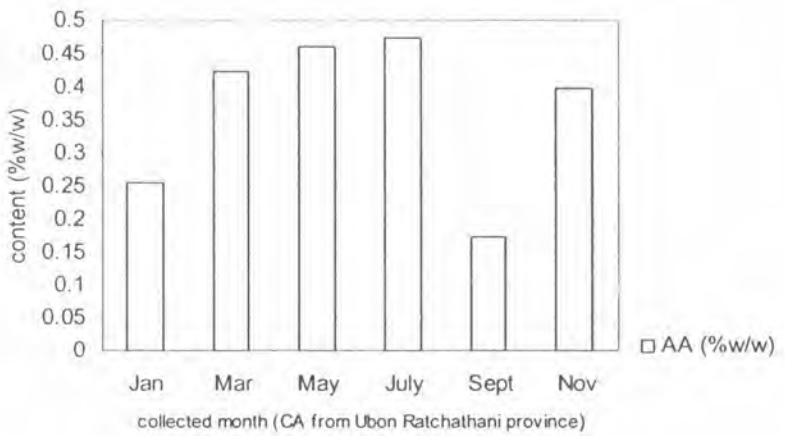


(c)

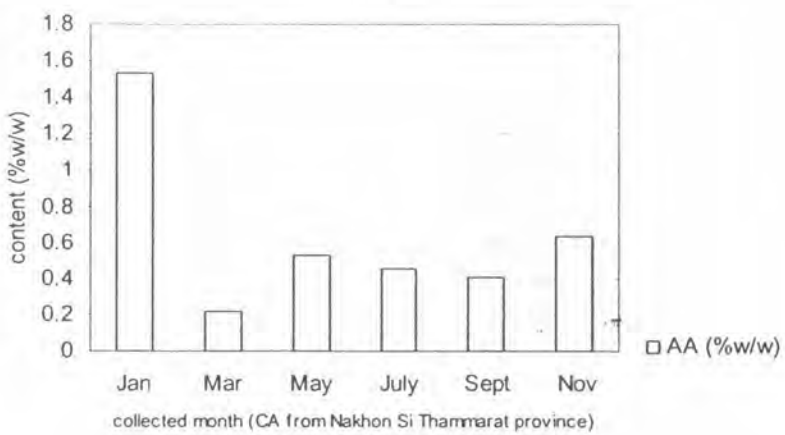
Figure 4.29 Annually content profiles of MA in whole plant of CA from the commercial crop of Nakhon Pathom **(a)**, Ubon Ratchathani **(b)** and Nakhon Si Thammarat province **(c)**



(a)

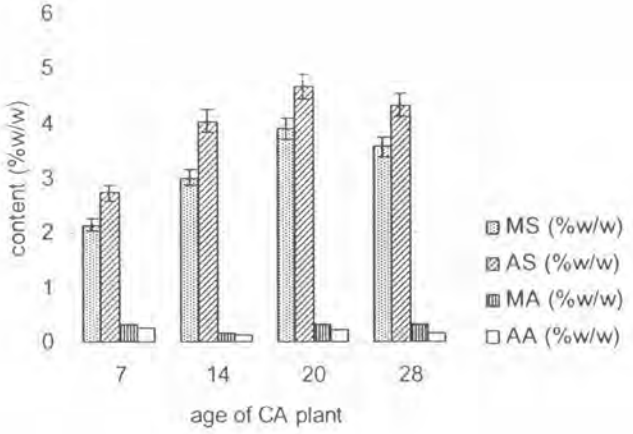


(b)

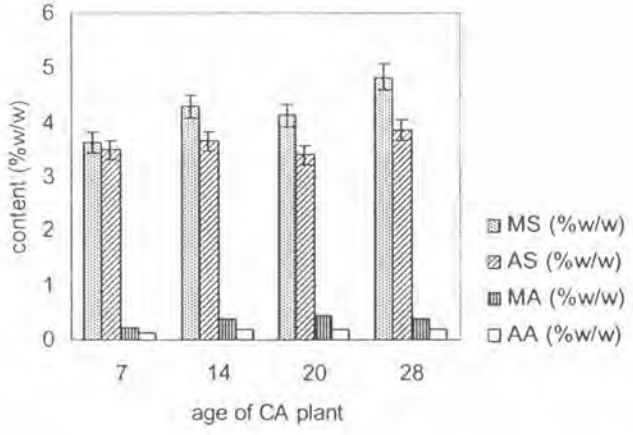


(c)

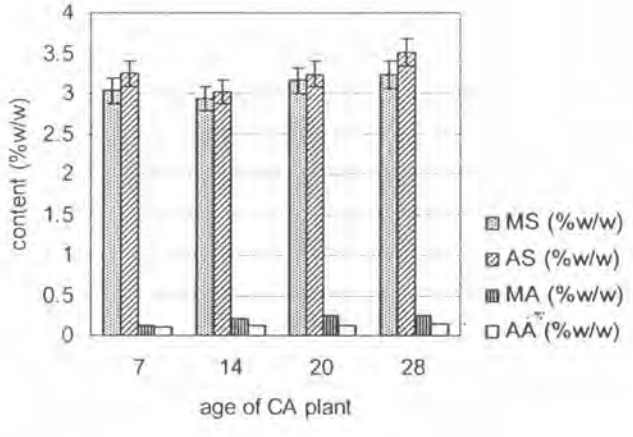
Figure 4.30 Annually content profiles of AA in whole plant of CA from the commercial crop of Nakhon Pathom **(a)**, Ubon Ratchathani **(b)** and Nakhon Si Thammarat province **(c)**



(a)



(b)



(c)

Figure 4.31 Contents of MS, AS, MA and AA in whole plant of CA from Ubon Ratchathani **(a)**, Nakhon Si Thammarat **(b)** and Rayong province **(c)** collected during the cultivation

VITAE

Mr. Pathom Somwong was born on September 20, 1978 in Nakhonratchasima, Thailand. He has been granted the degree of Bachelor of Science in Pharmacy, Field of Study Pharmaceutical Science from the Faculty of Pharmaceutical Sciences, Khon Kaen University, Thailand. The degree was conferred on March 23, 2001.