# SYSTEMATIC VARIATION IN LEAF AMINO ACID COMPOSITIONS OF LEGUMINOUS PLANTS

HOCK-HIN YEOH, YEOW CHIN WEE and LESLIE WATSON\*

Botany Department, National University of Singapore, Kent Ridge, Singapore 0511, \*Taxonomy Unit, Research School of Biological Sciences, The Australian National University, P.O. Box 475, Canberra, A.C.T., Australia

(Revised received 12 March 1984)

Key Word Index-Leguminosae, leaf amino acids, systematic variation

Abstract—The leaf protein content for 17 species of legumes ranges from 2 8 to 9 4 g % fr wt, with an average of 5 3 g % fr wt Taxonomic pattern is detectable in leaf amino acid patterns, those of the Mimosoideae being distinguishable from those of the Papilionoideae and Caesalpinioideae

### INTRODUCTION

Analyses of available data on seed amino acid compositions of legumes have shown variations consistent with grouping of the Leguminosae into the subfamilies, Mimosoideae, Caesalpinioideae and Papilionoideae [1, 2] There is also evidence of correlation between viral susceptibility and taxonomic groupings in the case of certain legume hosts [3] In dicotyledonous plants, amino acid compositions of leaves have yielded taxonomic distinctions between groupings, e g between caryophylloids, legumes and acanthoids [4] while in a monocotyledonous family, the Poaceae, the existence of taxonomic pattern in the amino acid compositions of leaves, caryopses and ribulose-1,5-bisphosphate carboxylase, has also been demonstrated [5-7] As part of our continuing effort to understand the taxonomic predictability of protein amino acid compositions of plants, it seemed worthwhile to examine the Leguminosae to discover whether taxonomic pattern can be detected in the leaf amino acid compositions of a dicotyledonous family, and whether the legume pattern is distinguishable from that of the grasses [7] This paper presents the amino acid analyses of leaves from 17 species of legumes, representing all three subfamilies [8]

## RESULTS AND DISCUSSION

Leaf protein content for the 17 species of legumes studied showed large variation, ranging from 28 g % fr wt in *Tamarındus indica* to 94 g % fr wt in *Bauhınıa purpurea* (Table 1) Comparisons at subfamily level do not show any taxonomic correlation in the distribution pattern of leaf protein content, the mean protein content in the Mimosoideae (52 g % fr wt), Caesalpinioideae (53 g % fr wt) and Papilionoideae (56 g % fr wt) being closely similar

Variations in the leaf amino acid compositions for the 17 species of legumes are given in Table 1 Of these, Mimosa pudica and Bauhinia purpurea are interesting in that they have yielded the highest level of Leu (13.8%) and Asp (16.0%) respectively Comparisons of the three subfamilies show that the Mimosoideae pattern is distinguishable from that of the Papilionoideae by its

significantly higher (at 5% probability level) Glu and His and lower Asp and Thr, and from the Caesalpinioideae by its significantly higher Glu and His and lower Thr and Phe content (Table 1) The amino acid profiles of the Caesalpinioideae and Papilionoideae do not show any significant differences at the 5% probability level although some amino acid values of the Caesalpinioideae (such as Asp, Glu, Met and His) occupy an intermediate position between the Mimosoideae and the Papilionoideae Although the sample of species is small, this result is consistent with taxonomic schemes which place the Papilionoideae closer to the Caesalpinioideae than to the Mimosoideae [3, 8].

Comparison of the legume leaf amino acid patterns with those of grasses [7] shows that they are clearly distinguishable, the legumes having yielded significantly higher levels of Asp, Pro, Tyr, Phe, His and Arg and lower levels of Ser and Ala These observations seem to support the suggestion that a systematic survey of a wide range of plant groups may reveal predictable leaf protein amino acid compositions [4, 7]

## **EXPERIMENTAL**

Plant materials Leaf samples were collected from plants grown in the garden of the Botany Department, National University of Singapore, the Singapore Botanic Gardens and elsewhere in Singapore Their identities were checked with reference to regional floras and voucher specimens have been deposited in the National University of Singapore Botany Department Herbarium

Preparation for amino acid analysis Leaf blades of mature and healthy leaves were finely cut and 100-200 mg material was hydrolysed in 0.5 ml 3 N mercaptoethanol sulphonic acid in a sealed tube at 110° for 22 hr [7] After hydrolysis, 0.5 ml 2 N NaOH was added to the sample which was then diluted with 2 ml distilled water. The sample (100  $\mu$ l) was then analysed on a Beckman amino acid analyser 119CL. Duplicate analyses representing collections from different plants of the same species carried out for some species showed some variations (see Table 1) Such variations among individuals of the same species have been observed in our earlier studies [7] but so far they have not affected significantly the taxonomic conclusions. For subsequent

Table 1 Total leaf amino acid compositions of legumes

Glu Pro Gly Ala Val Met Ile Leu Tyr Phe His Lys Trp Arg 150 68 54 58 46 20 30 89 45 54 30 80 01 43 150 68 54 58 46 21 33 88 49 58 31 73 00 45 130 61 59 63 52 19 37 92 56 63 29 66 00 48 134 57 71 58 47 21 33 138 48 54 55 65 00 48 139 70 66 57 49 18 37 92 54 63 28 62 00 46 140 66 60 59 48 20 35 100 51 58 28 65 00 46 131 59 56 62 48 21 37 90 53 61 23 69 01 49 132 68 54 62 43 17 33 96 61 68 24 67 01 40 131 59 56 62 43 17 33 96 51 61 24 80 02 45 133 66 54 62 47 19 35 96 51 61 24 80 02 45 134 58 57 61 51 18 36 92 50 59 28 60 03 47 135 59 58 68 48 21 34 109 52 60 26 60 03 47 137 90 50 50 50 60 140 138 57 61 51 18 36 92 50 59 28 60 03 47 139 58 58 64 47 19 35 96 51 61 25 62 01 44 131 59 55 59 54 18 37 91 52 62 27 71 00 45 131 59 55 59 49 15 38 93 56 68 01 26 69 01 40 131 59 55 59 49 15 38 93 56 68 25 69 01 47 131 59 55 59 54 18 37 91 55 62 27 71 00 45 139 74 53 59 49 15 38 93 56 68 25 69 01 40 140 55 61 47 17 34 19 55 62 27 71 00 45 141 54 54 57 47 17 34 91 52 62 27 71 00 45 141 54 54 57 47 17 34 91 52 65 62 01 44 141 54 54 57 47 17 34 91 52 62 57 60 01 39							mino a	cid coi	npositic	Amino acid compositions (g% total amino acids)	, total	amino	acıds)						Total amino acids
formus A Cunn ex Benth         121         51         63         51         58         46         20         30         89         45         54         30         89         45         54         30         61         43           formus A Cunn ex Benth         120         48         58         150         61         59         63         54         50         61         45           nonmus L         119         48         57         146         74         53         60         45         19         34         92         49         58         26         60         94         56         61         48         57         146         74         53         60         45         19         34         92         49         58         49         58         60         48           L         119         48         57         146         74         53         60         45         19         34         88         49         58         49         58         60         94         88         49         58         60         48         19         34         36         48         36         48         37	Species		Ihr	Ser	Gļn	Pro	Gly	Ala	Val	Met	Ile	Leu	Tyr	Phe	Hıs	Lys	Ттр	Arg	(g% fr wt)
Cormus A Cunn ex Benth         121         51         63         150         63         51         58         46         20         30         89         45         54         30         80         45         54         30         80         45         30         80         45         30         80         45         50         48         46         20         30         88         49         88         49         88         49         80         90         48         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         40         80         80         40         8	Mimosoideae																		
Cormus A Cunn ex Benth         120         48         58         150         68         54         58         46         21         33         88         49         58         173         00         45           voorman L         119         52         52         130         61         59         63         52         56         63         59         60         48           rad L) Fosberg         119         48         51         130         61         59         63         52         56         63         60         48           L         126         49         41         49         51         130         61         57         49         18         49         58         49         58         49         58         60         48           L         120         49         41         66         60         57         49         18         63         60         48         49         58         61         60         48           L         120         48         110         66         57         49         18         70         51         48         41         51         51	Acacia auriculiformis A Cunn ex Benth	121	5 1	63		63	51	58	46	20	30		45	54	30		0 1	43	3.59
trad () Fosberg         119         5.2         130         61         59         63         52         19         56         60         48           rad () Fosberg         119         48         57         146         74         53         60         45         19         49         58         66         60         60         48           L         L         121         49         57         146         74         53         60         45         19         48         54         60         60         48           L         L         121         49         51         146         74         51         60         48         51         60         48         60         48         60         48         60         48         60         48         60         48         60         48         70         60         50         48         70         60         48         70         60         60         50         48         60         48         60         48         60         48         60         48         60         48         60         48         60         48         60         60	Acacia auriculiformis A Cunn ex Benth	120		28	150		54			21					3.1		00	4 5	308
LL         48         57         146         74         53         60         45         19         34         92         49         58         26         75         19         34         92         49         58         26         75         14         74         57         71         58         47         21         33         138         48         54         25         44         00         48           (Lamk) Merr         121         49         51         134         57         74         18         48         25         54         60         44         60         57         49         18         48         25         54         60         48         70         51         60         48         48         21         37         90         53         48         48         21         37         90         53         60         48         48         21         36         68         48         21         36         61         48         48         21         36         61         48         48         21         36         61         48         48         21         36         61         48	Adenanthera pavonina L	119	52		130	61											00	8 4	7.45
The control of the co	Albizia falcataria (L.) Fosberg	119		57	146	74				19							0 1		4 46
an value	Mimosa pudica L	126		47	134	5.7	7.1			21		138					00		7 02
an value	Parkia javanica (Lamk ) Merr	121	49	51	139	7.0	99	57	49	1 8		92	54	63			00	44	3 52
Treal Label         160         53         48         119         60         65         51         48         16         35         105         53         61         23         63         24         67         11         49           Griseb         127         57         56         131         59         56         62         48         21         37         90         53         61         23         64         49         100         46         100         52         65         24         67         101         49           persist Cantley ex Prain         128         61         59         134         86         86         48         21         35         16         87         66         48         21         35         86         56         62         48         21         36         66         61         48         21         36         67         61         47         11         33         96         61         68         61         47         19         35         96         61         64         47         11         36         54         62         47         19         35         96	Taxonomic mean value	121	20	54	140				4 8	20	3.5	100	5.1			6.5	00	46	516
Tree L 160 53 48 119 60 65 51 48 16 35 105 55 63 24 53 03 44 5 3 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	Caesalpinioideae																		
1 Chrisch         127         57         56         131         59         56         48         21         37         90         53         61         23         69         100         52         65         24         67         10         49           1 Garisch         122         55         52         125         59         58         68         48         21         35         65         24         67         69         50         69 <th>Bauhinia purpurea L</th> <td>160</td> <td>53</td> <td>8 4</td> <td>119</td> <td>09</td> <td>6.5</td> <td>5 1</td> <td>8 4</td> <td>16</td> <td>3.5</td> <td>105</td> <td>5.5</td> <td>63</td> <td>24</td> <td>53</td> <td>03</td> <td>4 4</td> <td>943</td>	Bauhinia purpurea L	160	53	8 4	119	09	6.5	5 1	8 4	16	3.5	105	5.5	63	24	53	03	4 4	943
122         55         52         125         59         58         68         48         22         36         100         52         65         24         67         01         46           I Rafin         128         61         59         134         68         37         68         48         21         35         86         52         63         26         67         01         47           I Rafin         128         61         59         134         68         37         68         48         21         35         66         67         01         47           Indical L         118         51         56         127         68         56         47         20         36         51         61         68         48         49         51         69         51         61         68         49         51         62         47         19         35         96         61         61         64         49         61         40           Incart         48         12         47         19         35         96         51         64         45         71         70         45	Cassia biflora Griseb	12.7	57	99	13.1	59	_	62	8 4	21	3.7	06		61	23		0 1	49	5 4 2
1 Rafin         128         61         59         134         68         37         68         48         21         35         86         52         63         26         61         68         50         61         47           nqensis Cantiley ex Prain         125         49         52         108         76         56         62         43         17         33         96         61         68         24         90         01         40           ndatea L         118         51         56         127         68         56         62         47         20         36         96         51         61         40         90         91         40         40           nean value         131         54         54         62         47         19         35         96         54         47         71         90         54         45         45           nean value         122         53         59         124         76         53         61         47         17         34         38         36         50         54         47         17         34         38         39         50         54	Cassia biflora Gniseb	12.2	5.5		12.5			89				100		6.5		4	0 1	46	5 3 2
nagensis Cantley ex Prain         125         49         52         108         76         56         62         43         17         33         96         61         68         24         90         01         40           ndaca L         118         51         56         127         68         56         62         47         20         36         51         61         24         80         01         40           nean value         131         54         54         12         62         47         19         35         96         51         64         24         90         01         40           rAfzel         122         53         59         124         76         53         61         47         17         34         109         52         60         26         45         14         44           tusa L         140         55         49         134         58         57         61         81         36         50         52         60         52         62         57         71         00         45           tusa L         124         51         52         13         <	Delonix regia Rafin	128	6.1		134		3.7		4 8	2.1				63			0 1	47	5 65
ndaca L         118         51         56         127         68         56         62         47         20         36         51         61         24         80         02         45           nean value         131         54         54         62         47         19         35         96         51         64         24         71         02         45           tAfzel         122         53         59         124         76         53         61         47         17         34         109         52         60         26         62         01         44           tuss L         120         55         49         134         58         57         61         51         18         36         52         52         60         54         18         37         91         52         62         57         61         81         37         91         52         62         57         61         81         37         91         52         62         77         71         00         45           s retragonolobus (L) DC         124         58         54         66         49         18	Saraca thaipingensis Cantley ex Prain	12.5	49				9 9	62	43	17			61				0 1	40	3 32
Afzel         131         54         54         123         65         54         67         19         35         96         54         64         24         71         02         45           Afzel         122         53         59         124         76         53         61         47         17         34         109         52         60         26         62         01         44           tusal Lusal Rusal Lusal Lusal Lusal Rusal Rusal Lusal Rusal Rusal Lusal Rusal Rusal Lusal Rusal Ru	Tamarındus ındıca L	118	51	26	12.7		9 9				36		5.1	61			02	4 5	2.75
taked table to the first of the	Taxonomic mean value	131	54		123					19	3.5		54		-	7.1	0.2	45	5 30
122 53 59 124 76 53 61 47 17 34 109 52 60 26 62 01 44  140 55 49 134 58 57 61 51 18 36 92 50 59 28 60 03 47  rea Benth 124 51 59 130 77 57 60 50 18 38 89 50 59 22 75 00 41  gonolobus (L) DC 124 58 51 123 56 54 66 49 18 37 110 55 62 27 71 00 45  gonolobus (L) DC 121 57 51 125 58 54 67 47 20 35 114 54 61 25 65 02 46  will 2	Papilionoideae																		
n(L) DC         134         58         57         61         51         18         36         92         50         59         58         60         63         47           rea Benth         124         51         59         131         59         55         59         54         18         37         91         52         62         27         71         00         45           gonolobus (L) DC         124         58         51         123         56         54         66         49         18         37         110         55         62         23         66         01         47           gonolobus (L) DC         121         57         51         125         58         54         67         47         20         35         114         54         61         25         65         01         47           Willd         129         59         60         119         74         53         59         49         15         36         68         25         63         01         49           a pers         153         55         48         141         54         57         47         17	Baphia nitida Afzel	12.2	53	59	124	9 /	53	6 1	47	17	34		52	09	26	62	0 1	4 4	631
134 53 52 131 59 55 59 54 18 37 91 52 62 27 71 00 45 124 51 59 130 77 57 60 50 18 38 89 50 59 22 75 00 41 125 58 51 123 56 54 66 49 18 37 110 55 62 23 66 01 47 129 59 60 119 74 53 59 49 15 38 93 56 68 25 63 01 39 153 55 48 141 54 54 57 47 17 34 91 52 61 21 65 04 48 132 55 54 129 65 55 61 49 18 36 97 52 61 21 65 04 48	Crotalaria retusa L	140	5.5	49	134		5.7	61	5 1	18	-						03	47	3 09
(L) DC 124 58 51 123 56 54 66 49 18 37 110 55 62 23 66 01 47 (L) DC 121 57 51 125 58 54 67 47 20 35 114 54 61 25 68 02 46 129 59 60 119 74 53 59 49 15 38 93 56 68 25 63 01 39 153 55 48 141 54 54 57 47 17 34 91 52 61 21 65 04 48 132 55 54 129 65 55 65 65 65 65 65 65 65 65 65 65 65	Desmodium triftorum (L ) DC	134	53		13.1			59	54	18	37	91				7.1	00	4 5	280
(L) DC 124 58 51 123 56 54 66 49 18 37 110 55 62 23 66 01 47 (L) DC 121 57 51 125 58 54 67 47 20 35 114 54 61 25 65 02 46 129 59 60 119 74 53 59 49 15 38 93 56 68 25 63 01 39 153 55 48 141 54 54 57 47 17 34 91 52 61 21 65 04 48 132 55 54 129 65 55 61 49 18 36 97 52 61 25 65 02 43	Millettia atropurpurea Benth	124	51	59	130	11		09		18						7.5	00	41	4 24
bus (L) DC 121 57 51 125 58 54 67 47 20 35 114 54 61 25 65 02 46 129 59 60 119 74 53 59 49 15 38 93 56 68 25 63 01 39 153 55 48 141 54 54 57 47 17 34 91 52 61 21 65 04 48 132 55 54 129 65 55 61 49 18 36 97 52 61 25 66 02 43	Psophocarpus tetragonolobus (L) DC	124	58	51	123		54			18	3.7	110			23		0.1	47	099
129 59 60 119 74 53 59 49 15 38 93 56 68 25 63 01 39 153 55 48 141 54 54 57 47 17 34 91 52 61 21 65 04 48 132 55 54 129 65 55 61 49 18 36 97 52 61 25 66 02 43	Psophocarpus tetragonolobus (L.) DC	121		51	125		54				3.5	114		61		6.5	0.2	46	6.74
153 55 48 141 54 54 57 47 17 34 91 52 61 21 65 04 48 132 55 54 129 65 55 61 49 18 36 97 52 61 25 66 02 43	Pterocarpus indicus Willd	129		09	119	74	53	59		1.5					2.5	63	0 1	39	647
132 55 54 129 65 55 61 49 18 36 97 52 61 25 66 02 43 5	Sesbania grandiflora Pers	153		8 4	141	54	54	5.7		17		91		61	21		0 4		6 42
	Taxonomic mean value	13.2						6.1		18				6.1					5.57

taxonomic mean calculations mean values of duplicate analyses were used

Total leaf amino acids Total leaf amino acid contents were calculated from the amino acid analyses, and expressed as g % fr wt leaf samples

Acknowledgements—We thank Kath Britt for performing the amino acid analyses This work is supported in part by research grant (RP 83/81) from the National University of Singapore

### REFERENCES

1 VanEtten, C H, Miller, R W, Wolff, I A and Jones, Q (1963)

- Agric Food Chem 11, 399
- 2 VanEtten, C H, Kwolek, W F, Peters, J E and Barclay, A S (1967) Agric Food Chem 15, 1077
- 3 Gibbs, A and Watson, L (1980) Advances in Legume Science (Summerfield, R J and Bunting, A H, eds) Vol 1, p 239 Brit Mus Nat His, England
- 4 Watson, L and Creaser, E H (1975) Phytochemistry 14, 1211
- 5 Yeoh, H H and Watson, L (1981) Phytochemistry 20, 1041
- 6 Yeoh, H H and Watson, L (1982) Phytochemistry 21, 71
- 7 Yeoh, H H and Watson, L (1982) Phytochemistry 21, 615
- 8 Polhill, R M and Raven, P H (1981) Advances in Legume Systematics Royal Botanic Gardens, Kew Crown