Composition of Liliifloreae from Mediterranean Pastures

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Moisture, lipid, fatty acid, protein, amino acid, ash, starch, free sugars, and cellulose concentrations in the aerial part of nine wild Liliifloreae (*Aphyllantes monspeliensis*, *Carex humilis*, *Brachypodium ramosum*, *Brachypodium phoenicoides*, *Bromus erectus*, *Dactylis glomerata*, *Festuca glauca*, *Phleum nodosum*, and *Stipa pennata)* growing in Mediterranean pastures were determined. The dried aerial part of these plants contained cellulose as the major component (15.6−20.9%), 4.25−9.57% protein, and 0.95−1.62% lipid. Amino acid analysis showed that proteins contained mainly glutamic acid + glutamine (0.41−1.05%) and aspartic acid + asparagine (0.33−0.86%). The main fatty acids were linolenic and palmitic acids.

Keywords: *Aphyllantes monspeliensis; Carex humilis; Brachypodium ramosum; Brachypodium phoenicoides; Bromus erectus; Dactylis glomerata; Festuca glauca; Phleum nodosum; Stipa pennata; Liliifloreae; fatty acids; amino acids*

INTRODUCTION

In order to define and optimize the French Mediterranean pastures from a nutritional point of view, the knowledge of grazed species and their metabolic constituents is important, particularly their protein and lipid compositions. As Legumes, studied in a previous work (Viano *et al.*, 1995), another important group of forage plants are Liliifloreae; among them, nine species (*Aphyllantes monspeliensis*, *Carex humilis*, *Brachypodium ramosum*, *Brachypodium phoenicoides*, *Bromus erectus*, *Dactylis glomerata*, *Festuca glauca*, *Phleum nodosum*, and *Stipa pennata*) common in Southern France meadows but also in Mediterranean areas all around the world are particularly grazed by sheep and goats. From a systematic point of view, the above-cited species belongs to three families: Liliaceae (*A. monspeliensis*), Graminaceae (genera *Brachypodium*, *Bromus*, *Dactylis*, *Festuca*, *Phleum*, and *Stipa*), and Cyperaceae (*C. humilis*) (Tutin *et al.*, 1980). Emberger (1960) linked these families in the Liliifloreae phylum.

The chemical composition of the complete aerial part of these species is very scarce in literature. Bourreil *et al.* (1995) reported on some biochemical investigations on the genus *Stipa* (Graminaceae) and presented data on the amino acid levels in fruits. Marta Vargas (1982) defined the nutritional value of *D. glomerata* from Chile. The sterol and fatty acid contents of *A. monspeliensis* fruits were determined previously (Viano and Gaydou, 1984). To our knowledge, the grazed parts of the nine wild species cited above have never been investigated for their proximate protein and lipid compositions.

MATERIALS AND METHODS

Materials. The healthy-looking aerial parts of the wild Liliifloreae were collected in April−May, during florescense, in the Parc Naturel Régional du Lubéron (PNRL) located 60 km North of Marseilles (France). Table 1 lists the scientific, local, and English names of the nine plants investigated and the number of samples analyzed following their location. The whole aerial part of plants was dried at ambient temperature for 2 weeks and ground through a Tecator cyclone mill with a 0.5 mm mesh width standard sieve.

Methods. Standard methods were used to determine moisture, protein, ash, starch, free sugar, and cellulose contents (AFNOR, 1993). A micromethod for the estimation of oil content and fatty acid composition was used (Viano *et al.*, 1995; Gaydou *et al.*, 1983b). The fatty acid methyl esters (FAME) were analyzed using gas chromatography (GC) with a Delsi 30 gas chromatograph fitted with a flame ionization detector. Helium was used as carrier gas, and the column, injection port, and detector were maintained at 190, 220, and 230 °C, respectively. A polar (Carbowax 20M) capillary column (25 m × 0.32 mm, 0.15 μm phase thickness) was used to separate the FAME.

The amino acid analysis procedure was described in detail in an earlier paper (Bourreil *et al.*, 1991, 1995). Amino acids were measured in samples hydrolyzed with HCl (6 N) for 18 h at 120 °C with a Technicon amino acid analyzer. Cysteine and methionine were determined separately as cysteic acid and methionine sulfone after performic acid oxidation as described by Moore (1963).

RESULTS AND DISCUSSION

Scientific and local names of the nine wild Liliifloreae investigated are given in Table 1. Proximate analyses are shown in Table 2. The moisture content ranged between 5.8 and 8.1%. The protein content, using 6.25 as nitrogen (N) to protein (P) factor ratio (N:P) (Mossé, 1990), ranged from 4.25% in the case of *B. ramosum* to 9.6.% for *C. humilis*. The protein content of *D. glomerata* (4.7%) was lower than that observed for South American (Chile) specimens with a range of 12.6−16.1% (Marta Vargas, 1982). The ash content ranged from 5.3% for *B. erectus* to 9.0% for *D. glomerata*. This result is consistent with specimens collected in South American (Chile) green pastures (Marta Vargas, 1982).

The lipid content was very poor and ranged from 0.9 to 1.6%. Although the lipid content could change in an important scale in seeds (Gaydou *et al.*, 1983a), the lipid mean content of Liliifloreae aerial part was about 1.2%. As shown in Table 2, some minor differences in ash, starch, free sugar, and cellulose contents were also noted for these nine wild Liliifloreae. Significant differences

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Table 1. Scientific and Local Names of Liliifloreae Samples Collected in Mediterranean Pastures

scientific name	local name	English name	abbreviation[a]	No.[b]
Liliaceae family				
Aphyllantes monspeliensis	bragalou		Am	7
Cyperaceae family				
Carex humilis	laîche	sedge	Ch	2
Graminaceae family				
Brachypodium phoenicoides	brachypode	false brome grass	Bp	4
Brachypodium ramosum	brachypode rameux	false brome grass	Br	2
Bromus erectus	brome dressé	meadow brome	Be	3
Dactylis glomerata	dactyle aggloméré	orchard grass	Dg	2
Festuca glauca	fétuque glauque	blue fescue	Fg	3
Phleum nodosum	phléole noueuse	timothy, herd grass	Pn	2
Stipa pennata	plumet, herbe aux plumets	European feather grass	Sp	2

[a] Abbreviation used in this paper. [b] Number of samples (total 27).

Table 2. Proximate Composition of Liliifloreae Samples Collected in Mediterranean Pastures

analysis (%)	plant name[a]									
	Am[c,g]	Ch[d]	Bp[e]	Br[d]	Be[f]	Dg[d]	Fg[f]	Pn[d]	Sp[d]	$\bar{X}$
moisture	7.27 (6.20−8.34)	7.48	6.32	7.20	6.14	8.06	5.78	7.56	7.19	7.00 (6.42−7.58)
protein content[b] (conversion factor used, 5.2)	5.68 (4.73−6.64)	7.96	5.66	3.54	4.89	3.90	5.83	3.64	5.67	5.20 (4.12−6.28)
protein content[b] (conversion factor used, 6.25)	6.83 (6.36−7.30)	9.57	6.81	4.25	5.87	4.69	6.83	4.38	6.75	6.22 (4.84−7.59)
ash[b]	6.01 (5.65−6.37)	5.40	8.81	8.81	5.35	9.00	5.79	5.52	6.42	6.79 (5.56−8.02)
fat[b]	1.20 (1.09−1.31)	1.62	1.00	1.08	0.95	1.12	1.28	1.11	1.18	1.17 (1.05−1.35)
starch[b]	0.80 (0.70−0.90)	0.59	0.81	1.54	0.74	0.91	1.07	0.74	0.53	0.86 (0.63−1.09)
free sugar[b]	2.96 (1.94−3.98)	5.14	1.73	3.40	2.73	1.30	2.83	1.18	2.20	2.61 (1.67−3.55)
cellulose[b]	19.6 (16.5−22.7)	11.9	18.6	15.6	20.1	19.4	19.3	18.0	20.9	18.2 (16.1−20.3)

[a] See Table 1 for abbreviations used for scientific plant names. [b] Moisture basis. [c] Mean of seven samples. [d] Mean of two samples. [e] Mean of four samples. [f] Mean of three samples. [g] Mean with 95% confidence level in parentheses. $\bar{X}$: mean of the nine mean values with 95% confidence level in parentheses, as representative of the overall Liliifloreae.

($P < 0.05$) were observed between *C. humilis* and other species, particularly the lower cellulose content and a higher free sugar level.

The amino acid compositions of the aerial part of investigated plants are given in Table 3. The data show that the amino acid pattern falls between dried seeds and vegetables (Sosulski and Imafidon, 1990; Mazza *et al.*, 1992). The content of the sulfur amino acids, cysteine (Cys) and methionine (Met), was relatively low in all species investigated, by comparison with the values given by the Food and Agricultural Organization of the United Nations (FAO, 1970) from a dietary component point of view. Analyses indicated that glutamic acid (Glu) + glutamine (Gln) and aspartic acid (Asp) + asparagine (Asn) are the major amino acids with ranges of 0.41−1.05% and 0.33−0.86%, respectively. However, the proline value, indicator of dryness resistance (Hubac and Guerrier, 1972 in Bourreil *et al.*, 1976), is more important in *A. monspeliensis* than the Asp + Asn. It is known that the composition ranges of each amino acid are relatively large, and their proportions in proteins would have a marked influence on the N:P factor (Sosulski and Imafidon, 1990). Taking into account the N:P factors obtained by these workers for fresh vegetables and fruits, we retained the 5.2 value; since 6.25 is generally used in the literature, we have reported in Table 2 calculated values of protein content with each conversion factor. By comparison of these calculated values with the sum of amino acids listed in Table 3, it is notable that calculated values using the conversion factor fit better than those calculated with 6.25. We can compare the amino acid content of the Liliifloreae with one of the principally grazed Legumes, determined in the same conditions (Viano *et al.*, 1995). Legumes have higher protein content (7.0−13.0%) than Liliifloreae (3.5−8.0%).

The major fatty acids of the neutral lipids are given in Table 4. Among the 13 fatty acids, 6 were present in high amount. Palmitic acid was the main saturated fatty acid in all species and ranged from 14.4 to 45.5%. The other saturated fatty acids, myristic (0.7−3.1%), stearic (3.9−11.3%), and arachidic (0.0−8.8%) acids, were in low amount. Among the unsaturated fatty acids, linolenic (6.6−41.5%) and linoleic (13.1−21.2%) acids were the main fatty acids. Oleic and vaccenic acids were the main monounsatured fatty acids (6.4−19.4%). Fatty acid composition was determined previously for *A. monspeliensis* fruits (Viano and Gaydou, 1984) and showed approximately the same proportions of each fatty acid as the complete aerial part (palmitic, linoleic, and oleic acids were the main components). The presence, in high amount, of linolenic acid in leaves was also observed in various edible plant leaves (Hitchcock and Nichols, 1971; Sundar-Rao *et al.*, 1990; Sundar-Rao and Lakshminarayana, 1988). Oleic acid was the main unsaturated fatty acid with ranges between 6.4 and 19.4%. Linolenic amounts were lower than those observed in Legumes (Viano *et al.*, 1995), with the exception of *C. humilis* which showed a particularly high level of linolenic acid (41.4%). As in the Legumes, long chain fatty acids, such as gadoleic, behenic, and lignoceric acids, were identified in only some species. The unsaturated/saturated ratio was relatively low, in the same order as that observed for Legumes. A relationship

Table 3. Average of Amino Acid Content of Liliifloreae Samples Collected in Mediterranean Pastures

amino acid[a]	plant name[b]								
	Am[d,h]	Ch[e]	Bp[f]	Br[e]	Be[g]	Dg[e]	Fg[g]	Pn[e]	Sp[e]
Asp + Asn	0.51 (0.43−0.59)	0.86	0.57	0.33	0.45	0.35	0.69	0.42	0.64
Thr	0.26 (0.20−0.32)	0.27	0.24	0.15	0.21	0.17	0.25	0.16	0.20
Ser	0.28 (0.20−0.36)	0.33	0.24	0.15	0.21	0.15	0.25	0.17	0.19
Glu + Gln	0.68 (0.56−0.80)	1.05	0.70	0.41	0.67	0.46	0.52	0.48	0.70
Pro	0.66 (0.34−0.98)	0.49	0.32	0.16	0.29	0.26	0.28	0.28	0.36
Gly	0.36 (0.28−0.44)	0.45	0.34	0.23	0.31	0.26	0.38	0.28	0.26
Ala	0.28 (0.20−0.36)	0.41	0.33	0.20	0.31	0.21	0.26	0.24	0.33
Val	0.27 (0.19−0.35)	0.26	0.26	0.16	0.23	0.18	0.27	0.19	0.31
Cys	0.02 (ϵ−0.05)	0.03	0.02	0.01	0.01	0.01	0.02	0.02	0.01
Met	0.004 (ϵ−0.01)	0.07	0.03	0.01	0.03	0.01	0.01	0.01	0.01
Ile	0.23 (0.18−0.28)	0.21	0.22	0.13	0.18	0.15	0.22	0.17	0.22
Leu	0.47 (0.35−0.59)	0.52	0.43	0.26	0.37	0.28	0.39	0.32	0.39
Tyr	0.18 (0.14−0.22)	0.26	0.15	0.10	0.13	0.09	0.13	0.09	0.14
Phe	0.28 (0.22−0.34)	0.34	0.29	0.17	0.24	0.19	0.26	0.25	0.27
Lys	0.29 (0.21−0.37)	0.37	0.30	0.19	0.24	0.19	0.25	0.21	0.23
His	0.13 (0.10−0.16)	0.18	0.12	0.08	0.11	0.11	0.12	0.12	0.12
Arg	0.29 (0.24−0.34)	0.39	0.30	0.22	0.25	0.19	0.27	0.20	0.35
S	5.02 (3.99−6.05)	6.43	5.04	2.95	4.23	3.25	4.64	3.61	4.71
protein content[c]	5.68 (4.73−6.64)	7.96	5.66	3.54	4.89	3.90	5.83	3.64	5.67

[a] In g/100 g of powder. [b] See Table 1 for abbreviations used for scientific names. [c] Protein content using 5.2 as nitrogen to protein factor ratio. [d] Mean of seven samples. [e] Mean of two samples. [f] Mean of four samples. [g] Mean of three samples. [h] Mean with 95% confidence interval in parentheses.

appears between palmitic and linolenic acids (reciprocal increase and decrease); the calculated value of the correlation coefficient based on overall 27 samples ($r = -0.7992$) shows a significant negative correlation with $P < 0.01$.

CONCLUSION

According to the first investigations, based on the chemical composition of 10 wild Legumes, we intended to estimate the nutritional value of the Mediterranean pastures through the chemical composition of the grazed species. Among the nine Liliifloreae reported in this paper, *C. humilis* showed high concentrations of free sugar and polyunsaturated fatty acids and can be utilized (by sowing) in the pastures as cattle-feeding supplementation. Taking into account these present biochemical results and the last ecological studies (Bichard *et al.*, 1982), *A. monspeliensis* must also be considered as an important forage source. Differences between Liliifloreae and Legume were insignificant although they belong to very different botanical families; this feature can be linked with ecological conditions, which were strictly identical because all the species grow in the same meadow. Further research is now needed to determine vitamin content, mineral elements,

Table 4. Fatty Acid Composition of Neutral Lipids from Liliifloreae Samples Collected in Mediterranean Pastures

fatty acid[a]	plant name[b]								
	Am[c,g]	Ch[d]	Bp[e]	Br[d]	Be[f]	Dg[d]	Fg[f]	Pn[d]	Sp[d]
myristic (14:0)	2.01 (1.25−2.77)	0.70	2.58	3.10	1.97	2.70	3.07	2.30	1.70
palmitic (16:0)	32.1 (27.12−37.28)	14.3	44.9	45.0	35.9	38.8	29.9	39.0	45.5
palmitoleic (16:ln-7)	1.55 (0.91−2.19)	0.00	3.35	1.50	2.10	1.80	1.17	2.90	4.40
stearic (18:0)	4.55 (3.68−5.42)	4.00	5.85	11.3	3.93	5.30	4.30	5.50	6.20
oleic (18:ln-9) + vaccenic (18:ln-7)	8.11 (6.04−10.2)	6.70	4.15	8.30	6.33	19.4	7.93	9.40	6.40
linoleic (18:2n-6)	21.19 (17.1−25.2)	15.9	12.5	13.3	16.9	19.7	16.7	13.9	13.1
linolenic (18:3n-3)	20.07 (14.6−25.5)	41.4	14.1	7.90	22.1	6.60	17.0	14.7	16.4
arachidic (20:0)	2.59 (1.48−3.70)	0.00	0.88	3.80	1.57	3.30	8.80	3.50	2.60
gadoleic (20:1n-9)	0.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00
behenic (22:0)	1.07 (0.38−1.76)	0.00	0.40	0.00	0.33	0.50	1.83	1.50	0.00
lignoceric (24:0)	0.43 (ϵ−0.94)	0.00	0.00	0.00	0.27	0.00	1.57	0.00	0.00
total unsaturated	50.9 (46.2−55.6)	64.1	34.1	31.0	47.4	47.5	45.0	40.9	40.3
unsaturated/saturated	1.25 (0.91−1.59)	3.37	0.64	0.49	1.12	0.94	0.94	0.79	0.72

[a] Percent by weight of total fatty acid determinated by GC as FAME. [b] See Table 1 for abbreviations used for scientific plant names. [c] Mean of seven samples. [d] Mean of two samples. [e] Mean of four samples. [f] Mean of three samples. [g] Mean with 95% confidence interval in parentheses.

and unsaponifiable matter to define the agronomic potential of the typical Mediterranean meadows.

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