Nutritive value and degradability of leaves from temperate woody resources for feeding ruminants in summer

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1/ Introduction

Integrating agroforestry in livestock farming systems may be a real opportunity in the current climatic, social and economic conditions. Trees can contribute to improve welfare of grazing ruminants. The production of leaves from woody plants may also constitute a forage resource for livestock (Papanastasis et al 2008) during periods of low grasslands production (summer and autumn). To know the potential of leaves from woody plants to be fed by ruminants, including dairy females, the nutritive value of these new forages has to be evaluated. References on nutritive values that already exist for woody plants come mainly from tropical or Mediterranean climatic conditions (http://www.feedipedia.org/) and very few data are currently available for the temperate regions. In the frame of a long term mixed crop-dairy system experiment integrating agroforestry (Novak et al., 2016), a large evaluation of leaves from woody resources has been initiated. The objective of this evaluation is to characterise leaves of woody forage resources potentially available for ruminants (hedgerows, coppices, shrubs, pollarded trees), either directly by browsing or fed after cutting. This paper presents the evaluation of a first set of 12 woody resources for which the feeding value is evaluated through their protein and fibre concentrations, *in vitro* digestibility (enzymatic method) and effective ruminal degradability.

2/ Material and methods

The leaves of 12 woody species were collected during summer 2014 in the neighbourhood of the INRA experimental farm located at Lusignan (Vienne, Poitou-Charentes, France). Leaves were sampled on either high stem trees, winter pollarded trees, regrowth of pruned trees or hedgerows (table 1). Fresh perennial ryegrass and lucerne were also collected as herbaceous forage controls, harvested above 5 cm from ground level after 6 weeks of regrowth. For these 2 species, the whole plant (leaves and stems) was considered.

All samples were oven dried at 60°C during 72 h, ground to pass a 1 mm-grid and then analysed for nitrogen (N, Dumas method with a Flash 2000 CHNS/O Analyzers from Thermofisher on samples ground again with a vibro-broyeur from Retsch), crude protein (CP, calculated as N × 6.25), fibre (NDF, ADF and ADL, Goering and van Soest method, 1970, *in vitro* DM digestibility (IVDMD) with the enzymatic method of Aufrère (1982) adapted with the DAISY Incubator from ANKOM, and ash (550°C during 3 h in a muffle furnace).

Another dry leaves subsamples were also ground to pass through a 0.8 mm-grid. Dry matter and nitrogen effective ruminal degradability (EDDM and EDN, respectively) were determined by the incubation of nylon bags (7.5 × 15 cm, 46 µm pore size) containing 3 g of fresh sample in the rumen of three ruminally fistulated dry cows, during 2, 4, 8, 16, 24 and 48 h (Michalet-Doreau et al., 1987). Dry cows were stall-fed 9 kg DM/day of a diet based on 70% of high-quality grass hay and 30% of a concentrate based on barley, beet pulp and soyabean.

3/ Results and discussion

The main characteristics of the woody leaves are given in table 2. The leaves DM concentration ranges from 34.6 % in vine to 51.5 % in field maple. The CP concentration varies from less than 120 g kg DM^{-1} in chestnut and vine to more than 190 g kg DM^{-1} in black alder, black locust, lime and white mulberry. The DM digestibility (IVDMD) ranges from less than 60 % in black locust and hazel to 89 % in white mulberry. We also notice some experimental difficulties in managing the NDF attack in the van Soest protocol for elm, lime and Italian alder, suggesting that an adaptation of this method is probably needed for woody resources.

The DM and CP degradation curves kinetics (figure 1) highlight large differences in the species degradation patterns and also the mid-term position of the herbaceous controls. The EDDM ranges from 37 % in red oak and 38 % in black locust to 64 % in ash and 70 % in mulberry. The EDN varied from less then10 % in hazel to 62 % in mulberry and is lower, except for mulberry, to the EDN of ryegrass and lucerne. The EDDM and IVDMD are highly correlated (EDDM = 0.733 IVDMD, R^2=0.74; $p<0.001$). The lower EDN of lime, alders and black locust (figure 2) suggests the presence of secondary compounds, especially tannins, reducing protein availability for ruminal microbes.

The most effective compromise between DM digestibility, protein concentration and protein degradability is obtained with mulberry and ash, which are species traditionally fed to cattle respectively in oceanic and Mediterranean conditions. Black and Italian alders and lime seem also potentially interesting to fed ruminants. At the opposite, chestnut, hazel and red oak seem of very poor nutritive quality for ruminants.

These results agreed with those of previous studies (Papachristou et al 1994, Doran et al 2007, Papanastasis et al 2008, Luske and Van Eekeren 2015).

4/ Discussion-conclusion

The nutritive value and ruminal degradability of leaves from woody resources collected during summer exhibit large variation between species. White mulberry but also ash, alders and lime seem to have sufficient digestibility and nitrogen degradability to be included in the diet of lactating cows in mixed crop-livestock systems, especially during the critical summer period. As great differences in nutritive value were found between species, our next studies will consider more species of trees, shrubs, lianas, natives or exotics, and also the effects of season (spring, summer, autumn) and tree management (pollarding, pruning). Tannins concentrations and intestinal true digestibility of nitrogen will also be investigated. One of the future challenges is also to quantify palatability and acceptability of these new forages by ruminants, particularly by lactating cows that are not a browsing species.

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Table 1. Main characteristics of the material collected in summer

Species	Latin name	Plant characteristics	Sampling date
Black alder	*Alnus glutinosa*	>10 years, regrowth	4 August
Italian alder	*Alnus cordata*	>20 years	5 August
Ash	*Fraxinus excelsior*	>10 years, regrowth	4 August
Chestnut	*Castanea sativa*	>10 years	4 August
Field elm	*Ulmus minor x resista*	8 years, pollard	5 August
Hazel	*Corylus avellana*	>10 years, hedge	4 August
Large leave lime	*Tilia platyphyllos*	>20 years, pollard	5 August
Black locust	*Robinia pseudoacacia*	>10 years, regrowth	4 August
Field maple	*Acer campestre*	>10 years, hedge	4 August
White mulberry	*Morus alba*	>20 years, pollard	22 July
Red oak	*Quercus rubra*	>10 years	4 August
Vine	*Vitis vinifera*	spontaneous regrowth	4 August
Perennial ryegrass	*Lolium perenne*	grassland, 6 week regrowth	7 August
Lucerne	*Medicago sativa*	grassland, 6 week regrowth	30 July

Table 2. Chemical composition, in vitro DM digestibility (IVDMD), and effective degradability of DM (EDDM) and of nitrogen (EDN) of leaves of woody species during summer.

Species	**DM** (g/kg DM)	**Ash** (g/kg DM)	**CP** (g/kg DM)	**NDF** (g/kg DM)	**IVDMD** (%)	**EDDM** (%)	**EDN** (%)
Black alder	373	56	197	296	77	51	31
Italian alder	369	59	170	358	69	52	32
Ash	376	85	145	279	75	64	50
Chestnut	426	34	118	340	68	42	23
Field elm	421	144	145	414	67	48	27
Hazel	420	60	144	324	53	44	10
Large leave lime	365	103	211	292	70	50	37
Black locust	398	64	204	278	49	38	18
Field maple	515	68	134	286	64	47	30
White mulberry	369	119	240	174	89	70	62
Red oak	473	41	142	400	61	37	14
Vine	346	63	106	193	80	57	29
Woody resources (mean)	*404*	*75*	*163*	*303*	*68*	*50*	*30*
Perennial Ryegrass	368	94	161	475	69	57	60
Alfalfa	284	93	159	465	56	58	68

Figure 1. Dry matter (left) and protein (right) degradation kinetics of two high-quality foliages (mulberry and ash), two low-quality foliages (chestnut and red oak) and lucerne and ryegrass (controls).

Mulberry —●—; Ash —▲—; Chestnut—○—; Red Oak—△—; Rye-grass - -●- -; Alfalfa - -▲- -

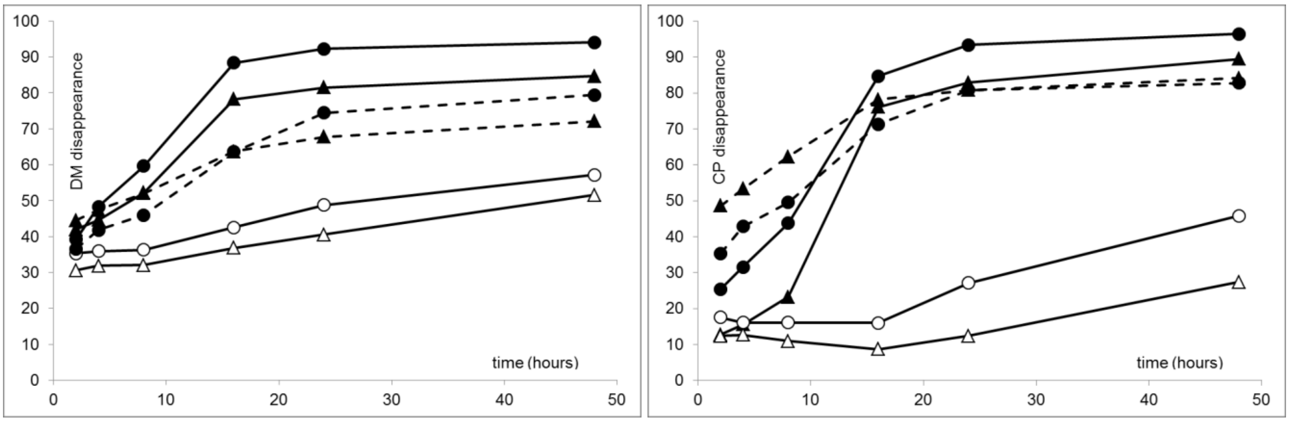

Figure 2. Relationship between effective degradability of nitrogen (EDN, %) and nitrogen concentration (CP, g/kg DM) in leaves of woody species during summer.