Mineral composition of ash leaves (Fraxinus excelsior L.) used as fodder for the ruminants in summer

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MINERAL COMPOSITION OF ASH LEAVES (*FRAXINUS EXCELSIOR* L.) USED AS FODDER FOR THE RUMINANTS IN SUMMER

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Abstract

In this paper, our objective was to study the consistency of the mineral composition of leaves from *Fraxinus excelsior* L. according to their provenance and management, *i.e.* pollarded *vs*. high stem trees. The leaves were collected in August 2016 on 7 sites spread out in 3 regions of France. The concentrations in Ca, Na, Fe, Mn and Cu of ash tree leaves, exhibited a high variability (coefficient of variation, C.V.>30%), while the concentrations in N, K, Mg, P, and Zn varied in a lesser extent (C.V.<30%). Pollarded trees exhibited higher N contents ($P<0.001$) and lower Ca contents ($P<0.05$) than high stem trees. There was no significant effect of tree management for the other elements. Our results confirm that ash leaves are rich in Ca, mineral of interest for dairy herd feeding. This tree species is also interesting to provide N, Mg, Fe, Zn and Cu.

Keywords: forage; mineral elements; fodder trees; nutritive value; agroforestry; *Fraxinus excelsior*

Introduction

The use of fodder trees may help to adapt and mitigate effects of livestock production to ongoing climatic change in Europe and increasing demand in animal products. Tree leaves constitute a forage resource which could be used during periods of low grassland production (especially during the summer and autumn) when other feed resources get depleted (Vandermeulen et al. 2018). Previous studies have shown that the leaves of temperate woody species exhibit a great diversity in chemical compositions and they are generally well suited for livestock feeding (Emile et al. 2016; Luske and Van Eekeren 2017). However little is known about the effects of pedoclimatic conditions and tree management.

Ash (*Fraxinus excelsior* L.) is a fodder tree species widespread in all of the Western Europe from the Urals to the south of Scandinavia that was formerly used to complete feeding dietary of ruminants. This specie exhibits a rapid growth and a good aptitude to emit new branches due to its ability to develop a strong root system under weak luminosity conditions (Marty et al. 2012). Analyses of its nutritive value showed that ash presents sufficient *in vitro* digestibility and nitrogen characteristics to be included in the diet of ruminants (Emile et al. 2017). The aim here was to explore minerals content of ash leaves. Many minerals are essentials for ruminants for getting optimum production such as calcium or phosphorus while deficiency or excess may cause poor performances. Ash tree leaves were collected in different regions of France in order to study consistency of macro and trace mineral concentrations in the leaves according to the provenance and the management (pollarded or high stem tree) of ash trees. Results are compared to those of herbaceous forage traditionally used for dairy cows feeding.

Materials and methods

The leaves of 23 ash trees were collected in August 2016 on seven sites located in North, Centre and West of France (see details Table 1). In two locations (Lusignan-Vauchiron and St Gènes Champanelle) samples were collected on high stem and winter pollarded trees. 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 two species, the whole plant (leaves and stems) was considered.

All samples were oven dried at 60°C during 72 h, weighed for dry matter measurement (DM). One subsample was ground to 1 mm, then ground again with a vibro-broyeur from Retsch for measuring total N concentration according to the Dumas method (1831) with a Flash 2000 CHNS/O Analyzers from Thermofisher. Another dry leaves subsamples were ground to pass through a 0.1 mm-grid crude and analysed for minerals P, K, Ca, Mg, Na, Fe, Mn, Zn, and Cu by radial ICP and ash (550°C during 3 h in a muffle furnace).

Table 1: Location and characteristics of the sampling sites in France

Geographic area	Sites	Tree ages	Altitude	Climate	Temperature	Rainfall
North	Brunembert Enquin sur Baillon Zoteux	20-25 y.	46-180 m	Temperate oceanic	Min.:8.4°C Max.:13.4°C	777.9 mm
Center	Saint Gervais Saint genes Champanelle	20-25 y.	390-742 m 660-1252 m	Subcontinental dry	Min.:6.6°C Max.:16.8°C	578.9 mm
West	Lusignan- Les Verrines Lusignan-Vauchiron	3 y. ≈10 y.	99-150 m	Oceanic with relatively dry and hot summer	Min.:6.9°C Max.:16.6°C	685.6 mm

Mineral concentrations were analysed using analysis of variance (ANOVA) using the software program Rstudio Version 1.0.153 – © 2009-2017 RStudio, Inc. Factors studied in this experiment were provenance: site or region and trees management (high stem vs pollarded tree)*provenance. When assumptions of data normality or equality of variances were not met, comparisons of means were carried out using nonparametric Kruskal–Wallis tests with a confidence level of α=0.05.

Results and discussion

Histograms presented in figures 1 A and B show that the shapes of distribution of Ca, K, Mg, P, Fe, Zn and Cu concentrations were similar to a normal distribution pattern ($p>0.05$) while those of N, Na and Mn showed concentrated distribution in the lower concentrations ranges (Figure 1).

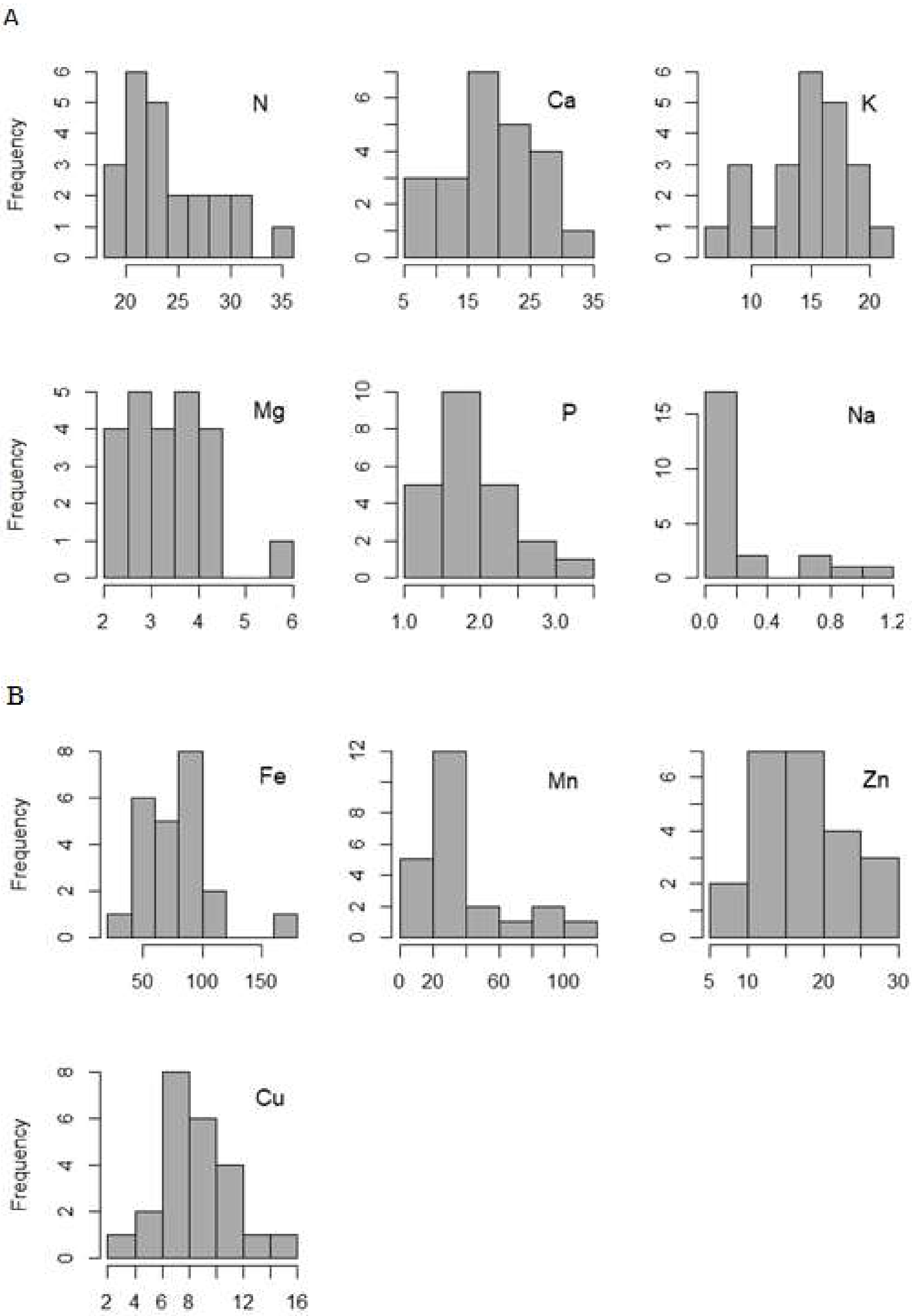

Figure 1: Frequency distribution of the concentrations in major (g kg^{-1}, A) and trace (mg kg^{-1}, B) elements in the leaves of ash trees collected in August 2016.

The distribution of some major and trace elements vary in a wide range indicating that the chemical composition of ash leaves probably depends on multifactorial effects (genetic, climate, growth conditions or soil characteristics). N, K, Mg, P and Zn displayed the lower coefficients of variation ranging from 16.7% to 30% and there was no effect of the provenance (site or geographic area) for those elements (Table 2). The coefficients of variation were slightly higher in Ca (34.6%) and Cu (32.3%), mean concentrations of the two elements were similar between the sites of the same geographic area but were highly different between geographic area North, Centre or West ($p<0.0001$ and $p< 0.01$, respectively). Inversely the concentrations in Fe and Mn were different between sites ($p<0.001$ and $p<0.05$, respectively) but there was no significant difference between geographic area. Na exhibited the highest coefficient of variation (129%) since the concentrations of four samples were below the detection limits while two sites from the

North exhibited concentrations quite higher than in the other sites (p<0.05). These differences could be due to soil mineral composition (not measured).

Pollarded trees exhibited higher N than high stem trees (P<0.001) and a lower Ca (P<0.05), there was no significant effect of tree management for the other elements (Table 2).

Average concentrations in major elements in ash leaves i.e N ≥ Ca > K > Mg > P > Na did not range in the same order than in the grasses lucerne and ryegrass i.e N > K > Ca > P > Mg > Na. Ca and N concentrations in ash leaves were similar with sometimes Ca being higher than N such as in the leaves from ash trees collected in Enquin-sur-Baillons, Lusignan-Les-Verrines and Vauchiron. The order of trace elements was the same in ash leaves and the grasses i.e Fe > Mn > Zn > Cu. Total ashes were slightly lower in ash leaves (8.8%) than in ryegrass (10.2%) or lucerne (9.4%) due to a lower content in K, P, Zn, Fe and Mn. Nevertheless the ash leaves were higher in Ca, Cu and Mg and contain N and Fe concentrations higher than in ryegrass. Especially N content was more than twice higher than in ryegrass.

Table 2: Composition in some major and trace minerals of high stem and pollarded ash tree leaves collected in August 2016 and in the grasses lucerne and ryegrass. Upper case letters (N), (C) and (W) indicate the corresponding geographic area of the sites North, Centre and West of France, respectively.

		major minerals($g\ kg^{-1}$)						trace minerals ($mg\ kg^{-1}$)			
	n	N	Ca	K	Mg	P	Na	Fe	Mn	Zn	Cu
Brunembert (N)	2	21.7	20.1ac(1)	16.8	3.4	1.9	0.8a	78.4ab	20.0b	14.2	8.3
Enquin sur B. (N)	2	21.8	24.4ac	13.8	3.5	2.2	0.9a	39.3b	27.5b	15.0	8.3
Zoteux (N)	2	26.2	20.9ac	9.2	2.5	1.7	0.1b	58.9ab	41.5ab	14.4	8.9
St Gervais (C)	2	23.8	13.0cb	12.7	3.5	1.8	0.3b	120.6a	65.9ab	22.8	10.0
St Genes Ch. (C)	3	22.7	12.8c	18.6	3.4	1.6	0.1b	73.8ab	18.0b	16.4	10.5
Lusignan – Vauchiron (W)	3	21.7	24.7ab	12.2	3.5	1.9	0.2b	69.5ab	24.0b	18.0	5.7
Lusignan - Les Verrines (W)	3	21.0	28.8a	16.6	3.8	1.9	0.1b	100.1ab	89.6a	14.3	5.4
P (site effect)	17	ns	<0.01	ns	ns	ns	<0.05	ns	<0.05	ns	ns
P (Geographic origin effect)	23	ns	<0.0001	ns	ns	ns	ns	<0.001	ns	ns	<0.01
High stem	6	22.4	18.8	15.4	3.5	1.8	0.1	71.6	21.0	17.2	8.1
Pollarded	6	29.6**(2)	14.3*	15.6	3.5	2.3	0.0	83.1	28.6	22.0	10.1
Ash leaves mean	23	24.4	19.2	14.8	3.4	2.0	0.2	79.3	38.1	17.8	8.5
Min.	23	19.8	9.1	7.2	2.4	1.3	0	38.1	11.4	9.7	3.8
Max.	23	34.1	32.8	21.7	5.6	3.4	1.1	167	103	27.8	15.9
C.V. (%)(3)	23	16.7	34.6	25.2	23.7	26.5	129.0	34.6	69.8	30.0	32.3
Lucerne	2	35.7	17.5	20.6	3.1	4.0	0.9	99.0	60.3	23.9	7.8
Rygrass	2	10.1	7.0	28.3	2.0	3.5	0.2	47.0	58.4	11.8	3.6

(1)Lower case letters indicate significant difference between sites
(2)Level of significance of the comparison between pollarded and high stem ash trees using two way ANOVA sites*tree management. signification code *0.05, **0.001
(3) Coefficient of variation

Conclusion

Composition in Ca, Na, Fe, Mn and Cu of ash tree leaves collected in August exhibited large variations probably arising from multifactorial effects (genetic, climate, growth conditions or soil characteristics) while concentrations in N, K, Mg, P, and Zn were relatively constant. Tree management was also shown to have a strong effect on N content and to a lesser extent on Ca content. Overall, our results confirm that ash leaves are rich in Ca, mineral of interest for dairy herd feeding. This species is also interesting to provide N, Mg, Fe, Zn and Cu. Further investigations have to be conducted to compare these results with other tree species, to precise the effects of tree management, to adapt this fodder resource to the dietary of ruminants and to determine the effects of soil composition.

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