

Tree of heaven (*Ailanthus altissima* (Mill.) Swingle): an underappreciated agroforestry tree

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Highlights

- *Ailanthus* leaves from older trees are palatable to livestock and nutritious
- Leaves from younger trees are not consumed, thus older trees must be felled as livestock forage
- Different contents in alkaloids and quassinoids might explain difference in palatability between young and older *Ailanthus* foliage

Introduction

The tree of heaven (*Ailanthus altissima* (Mill) Swingle) is a highly successful invasive species. However, it is also recognized for several useful applications. One of these is the use of fresh or dried leaves as forage for livestock. Chemical analyses of the leaves indicate a favorable nutritional profile with high digestibility, suggesting potential suitability as forage for ruminants (Terzopoulou et al., 2023). However, some authors reported that cattle strongly refused to browse on *A. altissima* (Nota, 2024). We observed that livestock (including cows, sheep, goats, and pigs) consume only sporadically, if at all, fresh leaves from young, reachable trees. However, they eagerly consume foliage from taller/older trees, when such trees are felled, making available the foliage that would be otherwise out of reach (a brief video will be presented). The aim of this work was to (i) determine the potential nutritive value of *Ailanthus altissima* leaves, (ii) assess whether they contain toxic or unpalatable compounds that could harm livestock or deter browsing, and (iii) investigate whether the concentration of such compounds varies with plant age, size, and season, possibly explaining observed variations in palatability by common livestock species.

Materials and methods

Leaves of *Ailanthus altissima* were collected in Central Italy (42.771554 °N, 12.858953 °E), on a hilly area at about 400 m asl. Trees grew as volunteers (i.e. invasive) in the pastures and field margins of a family farm, where cows, sheep, goats and pigs are raised at pasture, allowing the observation that all these animals consume abundantly *Ailanthus* leaves from felled tall trees, but not from young, reachable trees. Two sets of samples were collected: one for the analysis of nutritional value and one for the analysis of metabolites that are potentially toxic or repellent to livestock.

Nutritional value: Leaves were collected from many young trees (collected into a single sample) that were <1.25 m tall, so that their leaves were potentially easily reachable by livestock, and from many older trees (collected into a single sample) that were >4 m tall, with leaves out of reach. Leaves were sampled in morning hours and dried at 65 °C for 3-4 days. Sampling was carried out on 13 July, 4 August

and 10 September 2022. Dry samples were then utilized for the analysis of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), ash content, and several elements (N, P, K, Ca, Mg, Fe, Mn, Zn, Cu), using the standard laboratory techniques for these analyses.

Metabolites of *Ailanthus altissima*: Leaves were collected on 29 July 2025, from the same area as for the nutritional value samples, but from five very young trees and suckers with an height of between 0.3 and 1.25 m (i.e. plants that could easily be browsed by livestock), and five older/taller plants, with an height of between 3 and 7 m (i.e. out of reach for browsing animals). Samples, were immediately frozen at -18 °C. Analyses were conducted separately for each tree, on a Vanquish UHPLC system coupled to a Orbitrap Exploris 120 (Thermo Fisher Scientific, Germany). This LC-HRMS approach allowed a screening investigation for the identification of metabolites associated with *Ailanthus altissima*, including quassinoids and canthin-6-one alkaloids, for a total of over 50 compounds.

Results and discussion

The fiber content values for both young and older trees were on the low range of values typically found for fodder trees (18-27% NDF; 13-19% ADF; 4.5-10% ADL), suggesting high digestibility. The NDF and ADF contents tended to be higher, and ADL lower, in the older trees in July, but an opposite trend was detected in September, while values were nearly identical between young and mature trees in August. Therefore, the differences between ages were not consistent. A more apparent trend was the slight decrease in NDF and ADF from August to September, while ADL was mostly constant. The crude protein content ranged between 9.1% to 15.2%, with no detectable trend due to tree age or season. These values are lower than the 18% reported for *A. altissima* leaves (Ganai et al., 2010). This is probably due to the fact that we included part of the petiole in the samples (mimicking the observed browsing): the variable proportion of petioles probably explains both the lower and the more variable CP content. It also implies that fiber content in the sole leaflets is probably even lower (and digestibility even higher) than here reported. The leaf nutrient content of the other elements analyzed was not particularly different from other tree species, nor did it differ between leaves of young vs. older trees.

Out of the many secondary metabolites investigated, 20 were detected in the leaves of *A. altissima*. Some of these secondary metabolites were detected only or predominantly in young trees, others only or predominantly in older trees, while others were found in both young and old trees. In particular the metabolites belonging to the class of canthin-6-one alkaloids were present only in young trees. These compounds may be responsible for the lack of palatability observed in young-tree leaves, as they are associated with a bitter taste. The presence of Ailanthone, the major phytotoxic quassinoid in plant extracts of *Ailanthus altissima*, also seems to decrease from young trees to older trees.

In conclusion no notable differences in nutritional value were observed between leaves of young vs. older trees, thus the difference in palatability is probably related to differences in secondary metabolites. Further research will have to clarify the possible role of these compounds in terms of both palatability and possible toxicity, but also in terms of nutritional and medicinal value for livestock.

Keywords

Palatability, Livestock, Silvopasture, Toxicity, Tree forage.

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