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CHANGE IN NUTRITIONAL QUALITY OF DETACHED ASPEN AND WILLOW FOLIAGE USED AS INSECT FOOD IN THE LABORATORY

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ABSTRACT

Leaves of *Populus tremuloides* and *Salix babylonica* held in the laboratory as for feeding insects were analyzed for total nitrogen, total phenolics, and total sugars at 0, 3, and 6 days. More often than not, the three components varied due to leaf age, time since excision, or temperature. Temporal changes altered nutritional balance and probable impact on insect performance. Results suggest that other woody plant species would not remain nutritionally stable for long in the laboratory.

Although artificial diets are available for feeding many kinds of insects in the laboratory, natural foods may be used for convenience or for more purposeful reasons. Natural foods are often used as controls in the evaluation of artificial diets (Singh 1977). For herbivores, foliage-bearing branchlets with cut ends usually in water are provided for stated periods or until consumed. While the nutritional quality of fresh foliage for insects is becoming better known, the stability of detached foliage is uncertain.

Reported here are chemical analyses of foliage from detached aspen and willow branchlets held in the laboratory as for insect feeding. The components analyzed are important indicators of nutritional quality: total nitrogen, total phenolics, and total sugars. The dietary significance of these components for insects might be succinctly characterized as positive for nitrogen (Mattson 1980) and sugars (House 1974), and negative for phenolics (Levin 1971).

MATERIALS AND METHODS

Mid-crown branch tips 20–30 cm long were cut at mid-day from 4-m-tall quaking aspen (*Populus tremuloides* Michx.) at one site. Similar sized pendant branch tips reachable from the ground were cut from a mature weeping willow (*Salix babylonica* L.). Cut ends were placed immediately in distilled water, and the branchlets promptly transferred to the laboratory for assignment to treatments. Cut ends were kept in distilled water throughout treatments.

Treatments consisted of 12-h fluorescent light photophase and four temperature regimes in controlled environment chambers: (1) constant 16°C, (2) constant 20°C, (3) day-night cycling 22-10°C, and (4) day-night cycling 28-16°C. Aspen branchlets were held at the first two temperatures, and willow branchlets at the last two. At intervals of 0, 3, and 6 days, 8–12 leaves with petioles were harvested from branchlets sampled along their length. Sampled branchlets were not returned to the experiment.

Harvested leaves of each treatment were pooled in a Petri dish, and immediately stored at -15°C. The contents of each Petri dish were later freeze-dried for 45 h and ground in

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a Wiley mill to pass a 40-mesh screen. Total nitrogen was measured by a micro- Kjeldahl method, total phenolics by photocolorimetry using Folin-Denis reagent (Rosenblatt and Peluso 1941), and total sugars by high-pressure liquid chromatography.

Analyses of both species were carried out with branchlets of different ages: partly expanded leaves collected 16 May, and fully expanded leaves collected 10 June. On neither date was there noticeable natural insect or other injury to the foliage of either species. Foliage from the same sources in other years was used to feed insects in studies published (Miller 1977, Muggli and Miller 1980) and unpublished.

RESULTS

Nitrogen was the most stable component (Fig. 1). In aspen expanding (May) foliage, it ranged from 5.0 to 6.0%, apparently increasing at both temperatures at first, then leveling off. It persisted near 2.0% at both temperatures in expanded (June) foliage. In willow expanding (May) foliage, it ranged from 4.3 to 4.9%, and in expanded (June) foliage, from 3.6 to 3.8%, varying little with temperature regime.

Phenolic content was nearly stable over the treatment period (Fig. 1). In aspen expanding (May) foliage, phenolic content ranged from 6.1 to 7.2%, and in expanded (June) foliage, from 13.8 to 15.6%, where it appeared to increase at both temperatures. In willow expanding (May) foliage, it varied from 3.9 to 5.0%, and in expanded (June) foliage, from 4.7 to 7.5%. It appeared to increase in willow leaves at both temperature regimes.

Sugar content declined steadily from 15 to less than 11% in aspen expanding (May) foliage at both temperatures, and from 16 to less than 14% in expanded (June) foliage (Fig. 1). In willow foliage of both ages, sugar content increased from 16% at the lower temperature regime, then declined, and at the higher temperature regime, it changed in the opposite way.

DISCUSSION

Because this study was replicated but once, sampling variation in components is largely unknown. Results are therefore preliminary.

The large differences in total nitrogen and total phenolics between aspen expanding (May) and expanded (June) foliage (Fig. 1) conform with well known seasonal changes in these components (Mattson 1980). The lesser corresponding differences between willow expanding (May) and expanded (June) foliage are partly due to willow flushing a week or more earlier than aspen, and there being less difference in willow leaf expansion between collection dates.

No pronounced trends related to temperature emerged for nitrogen in either species. For total phenolics, there may have been more accumulation in expanding (May) leaves of both species at lower than at higher temperatures, and the opposite in expanded (June) foliage. Temperature effects for total sugars were mostly nondescript, except for the divergence-convergence sequence in willow leaves (Fig. 1).

Insects benefit in direct proportion to foliar nitrogen content (Mattson 1980). Other things being equal, an increase in total nitrogen from 5.0 to 5.5 or 6.0%, as occurred in aspen expanding (May) foliage (Fig. 1), should benefit insects measurably. However, concurrent increase in phenolics can reduce nitrogen availability to insects (Mattson 1980).

The temporal increases in phenolics (Fig. 1) are similar to those following mechanical damage to intact foliage (Rhoades 1983). Results here supplement evidence of a localized phenolic response. Few dosage-response studies of phenolics and insects are available. Those reported show that for one-compound tests, amounts from 0.2 to 0.4% in artificial diets prolonged development, reduced pupal weights, and increased mortality compared with amounts from 0.1 to 0.2% (Shaver and Lukefahr 1969). Because phenolics appear

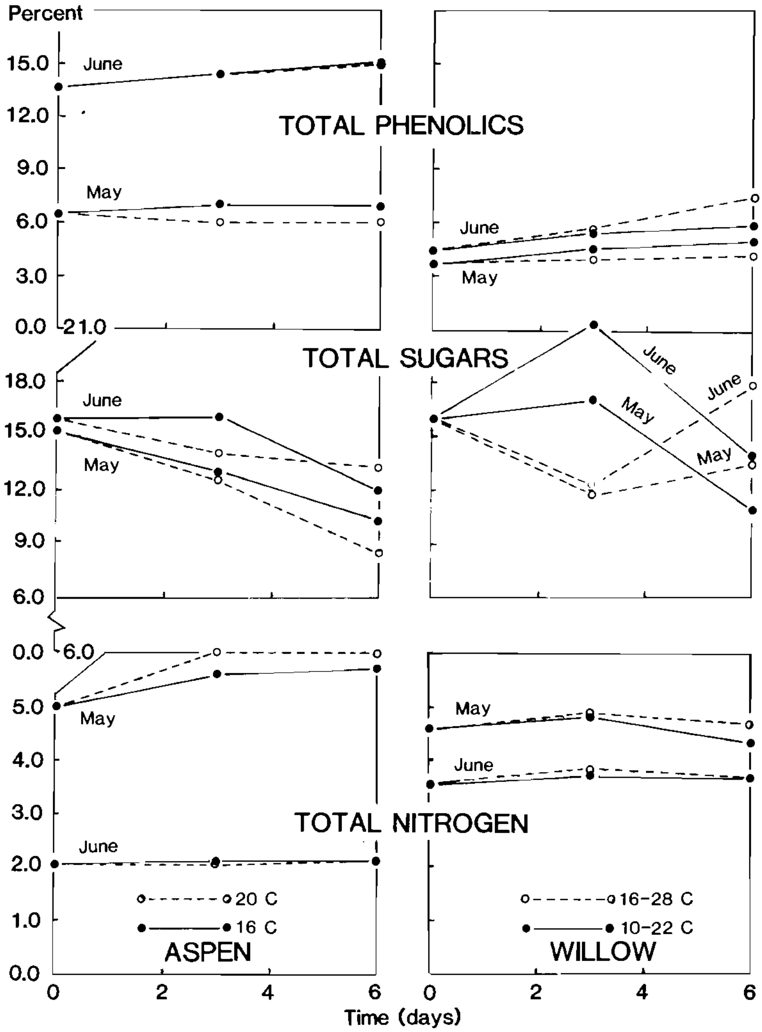

Fig. 1. Dry weight percentages of three chemical components of expanding (May) and expanded (June) aspen and willow foliage on days 0, 3, and 6 at different temperatures in the laboratory.

to act in a dosage-dependent manner, buildups as in aspen and willow expanded (June) foliage may adversely affect insect performance. However, undetermined facors like specific composition of the phenolics, and capacity of some insects to overcome their adverse effects, may be important.

Although sugars are important feeding stimulants, their temporal fluctuation in detached aspen and willow foliage (Fig. 1) lies in a nutritionally significant range.

Different insects have different qualitative and quantitative sugar requirements and tolerances (House 1974); despite such complexities, insects investigated by Beck (1957) and Matsuoka (1965) benefited in direct proportion to sugar concentrations between threshold and inhibitory levels. For another species investigated by Harvey (1974), change in sucrose concentration from 1 to 4% in artificial diets produced female pupae 65% heavier in less time. If insects of similar constitutions consumed aspen and willow foliage at some combinations of leaf age and temperature in this study, they would encounter marked temporal changes in extractable energy.

CONCLUSION

Detached aspen and willow foliage not immediately consumed does not retain its original balance of nutritionally important components, although some components may persist at original levels under some conditions. Conditions of change in investigated components include age or degree of leaf expansion, time, and temperature. The changes in detached leaves may not differ greatly from those on intact leaves of the source plants. Overall nutritional quality cannot be estimated for detached aspen and willow foliage because not enough is known about interactive or compensatory effects of changing components for specific insects. However, to avoid unknown and unwanted variation in insect performance, investigators should discard detached foliage not consumed within a few hours.

The similarity in changes observed here between aspen and willow foliage suggests that detached foliage of other woody plant species likewise does not remain nutritionally stable for long under insect rearing conditions in the laboratory.

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