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EVALUATION OF HYBRID POPLAR LEAVES AS A FEEDSTUFF FOR RABBITS

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Abstract

Sixty New Zealand White weanling rabbits were fed diets containing 40% alfalfa (control), and 10%, 20% and 40% hybrid poplar leaves (PL) from the uncoppiced crown of the tree, and 10% and 20% PL from the regrowth after cutting of coppiced trees. Digestibilities of crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), dry matter (DM) and ash were measured, along with average daily gain (ADG), DM intake and feed efficiency. CP, NDF and ash were better digested for the control compared to PL treatments (respective p values $< .01$, $.02$ and $.01$). The 40% alfalfa control showed better utilization of CP, NDF and ash, than when the alfalfa was completely replaced in the diet by PL (respective p values $< .01$, $.01$ and $.01$). The only significant difference seen between uncoppiced and coppiced leaves of the 10% and 20% PL levels was at the 20% level where CP was better utilized for the coppiced PL ($p < .05$). No significant differences were evident in the ADG and feed efficiency; however, a trend was evident ($p < .06$) for the feed efficiency to be higher for the 40% PL diet than for the alfalfa control. DM intake increased significantly for all the PL treatments when compared to the control ($p < .01$) and when a complete substitution is made ($p < .01$). The literature suggests some anti-nutritive factors due to plant defense have been suspected of reducing digestibilities, such as tannins and other phenols; however, since ADG and feed efficiency did not decrease, it was concluded that PL are an acceptable replacement for alfalfa in rabbit rations if a slightly higher feed efficiency is acceptable.

Introduction

The use of tree foliage for animal feed has potential in the U.S. as a by-product from the forestry industry. In the U.S. Pacific Northwest, plantations of hybrid poplars for pulp and paper have been established. The foliage could be collected for use as a feedstuff when the trees are harvested. In developing countries which often suffer from severe deforestation, tree forage may have a broader use in agroforestry systems designed to use multiple purpose trees for improving soil conditions, crop interaction and as animal feed (Benge, 1987).

The family *Salicaceae*, poplars and willows, has a wide range of temperature tolerance and grows in cold parts of the northern hemisphere from the Arctic circle to latitude 30° (FAO, 1980). Aspen, *Populus tremuloides*, is the most widespread tree species in North America (Bas et al.,1985). Poplar species, known in the U.S. as cottonwood, are dioecious woody plants.

Tree leaves have been examined for their nutritive value, including the senescent leaves that fall to the ground every year which livestock have been seen to consume (Forwood and Owensby, 1985). Forwood and Owensby found poplar to be of intermediate feeding value to livestock. Tree forage has been tested for domestic ruminants and shown to have potential (Baertsche et al., 1986), but the literature for nonruminants is scarce.

Many trees may have secondary chemical defense mechanisms to protect against herbivory (Jakubas et al., 1989). It has been noted that livestock, while refraining from eating resprouted growth from coppiced hybrid poplar trees, will readily consume the leaves from the crown of felled trees (personal observation). We hypothesize that the resprouted growth from coppiced trees contains more chemical defenses than the leaves in the crown, since the coppiced plant has been "under attack". Basey et al. (1988) proposed that heavy cutting by beavers in an area causes increased chemical defenses in aspen suckers which leads beavers to select forage from mature trees, instead of the usually preferred juvenile trees.

The objectives of this study were to compare hybrid poplar leaves to alfalfa in rabbit diets, using growth rate and nutrient digestibility as indices of performance, and to compare leaves from uncoppiced versus coppiced hybrid poplar trees.

Materials and Methods

Sixty New Zealand White 5-week-old weanling rabbits aged 5 weeks old were randomly assigned to 6 treatments with 10 rabbits in each treatment. The treatments were:

1) 40% alfalfa (control)
2) 10% uncoppiced poplar leaves; 30% alfalfa
3) 20% uncoppiced poplar leaves; 20% alfalfa
4) 40% uncoppiced poplar leaves
5) 10% coppiced poplar leaves; 30% alfalfa
6) 20% coppiced poplar leaves; 20% alfalfa.

The trial consisted of a 14-day adaptation period followed by a 7-day digestibility period with 2 replicates of 5 animals per treatment. The second replicate was put on the experiment 40 days after the first replicate was set up. Rabbits were housed in individual cages with automatic dewdrop water valves. Feed intake was measured throughout the trial and during the digestibility period. Initial, weekly and final weights were taken, along with initial and final weights for the digestibility period. Total fecal output for the digestibility period was collected with screens suspended underneath each cage.

The animals were fed the diets *ad libitum* (Table 1). The poplar leaves were hand-harvested from a local farm in September 1990. The leaves considered as "uncoppiced" growth were taken

TABLE 1. PERCENTAGE COMPOSITION OF EXPERIMENTAL DIETS

Diet	1	2	3	4	5	6
Alfalfa meal, sun-cured	40	30	20	-	30	20
Corn oil	1	1	1	1	1	1
Dicalcium phosphate	0.25	0.5	0.5	0.5	0.5	0.5
Molasses	3	3	3	3	3	3
Limestone	-	0.25	0.5	0.5	0.25	0.5
Poplar uncoppiced	-	10	20	40	-	-
Poplar coppiced	-	-	-	-	10	20
Soybean meal	10	10	10	10	10	10
Trace mineral salt*	0.5	0.5	0.5	0.5	0.5	0.5
Wheat mill run	49	48.5	48.3	48.3	48.5	48.3
Vitamin mix**	0.25	0.25	0.25	0.25	0.25	0.25
Chemical Analysis:						
Crude Protein	18.9	18.0	18.1	18.7	19.1	19.2
ADF	20.0	19.7	19.8	18.4	18.9	18.4
NDF	38.8	37.3	34.7	33.3	37.1	36.2
Ash	7.4	7.6	7.9	7.7	7.9	8.3

*Ingredients: Sodium chloride, zinc oxide, manganous oxide, iron carbonate, copper oxide

**Vitamin	A	3,000,000 IU
	D-3	1,000,000 IU
	E	1000 IU
	K	0.5 gm
	B-12	5 mg
	Riboflavin	3 gm
	Pantothenic acid	5 gm
	Niacin	20 gm
	Choline chloride	200 gm
	Folic acid	200 mg
	Ethoxyquin	56.75 gm

* and ** manufactured by Inman & Co., Inc.; 12530 SE Jennifer St., Clackamas, OR 97015.

from the crowns of recently felled 10-year-old trees. The leaves considered as "coppiced" growth were collected from growth 5-7 feet high, sprouted from coppiced trunks cut earlier the same year. The leaves were air-dried on screens for 3 weeks and then put through a shredder until coarsely ground.

After the end of the digestibility period, the total wet feces were weighed and oven-dried at 60° C for 48 hours. Dry total feces were weighed and a subsample was ground in a Wiley mill to pass through a 1mm screen. Feed and feces samples were analyzed for DM and ash by standard procedures (AOAC, 1984). Samples were analyzed for ADF and NDF as described by Goering and Van Soest (1970), modified by a micro method (Waldern, 1971). Crude protein was determined by the Macro Kjeldahl method (AOAC, 1984).

The data were analyzed following the general linear model procedure (SAS, 1985). Initial F-screening was done at the .05 level. Treatment means were compared using a series of orthogonal contrasts from four pre-planned comparisons. Of the 60 animals on the experiment, the records of 57 were included in the analyses. One rabbit from the second replicate died and was not replaced. Two rabbits were removed from all analyses because one spilled its fecal collecting tray and the other was considered an outlier.

Results and Discussion

Composition of the alfalfa and poplar leaves is shown in Table 2. The leaves from uncoppiced trees were lower in crude protein and higher in fiber than alfalfa. The leaves from coppiced trees were similiar in composition to alfalfa. Digestibility data are given in Table 3 and growth performance shown in Table 4.

TABLE 2. NUTRIENT COMPOSITION OF POPLAR LEAVES AND ALFALFA.

	Crude Protein	ADF	NDF	Ash	N-ADF*
Poplar leaves Uncoppiced	14.77	29.26	42.09	8.98	0.94
Poplar leaves Coppiced	21.63	21.03	31.53	9.49	0.79
Alfalfa	20.29	29.45	38.65	10.12	0.41

*Nitrogen contained in the ADF fraction

The digestibilities of dry matter, crude protein, ADF, NDF and ash were higher for the 40% alfalfa diet (control) than for the treatments with poplar leaves (Table 3). The values for crude protein, NDF and ash were statistically higher (respective p values < .01, .02 and .01) for the control than for the poplar diets (Table 5).

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TABLE 3. NUTRIENT DIGESTIBILITIES (MEANS ±SE) IN WEANLING RABBITS OF DIETS CONTAINING VARIOUS PROPORTIONS OF ALFALFA AND POPLAR LEAVES (PL).

Treatment	CP	ADF	NDF	DM	Ash
1. 40% Alfalfa Control	78.75 ± 2.11	26.28 ± 4.01	36.87 ± 3.82	64.35 ± 2.76	60.62 ± 2.02
2. 10% PL Uncoppiced	68.71 ± 2.11	19.04 ± 4.01	29.53 ± 3.82	59.02 ± 2.76	51.93 ± 2.02
3. 20% PL Uncoppiced	60.05 ± 2.11	18.40 ± 4.01	20.88 ± 3.82	55.72 ± 2.76	48.95 ± 2.02
4. 40% PL Uncoppiced	54.76 ± 2.36	10.15 ± 4.48	18.79 ± 4.27	57.63 ± 3.08	44.73 ± 2.26
5. 10% PL Coppiced	69.92 ± 2.22	21.07 ± 4.22	31.21 ± 4.03	59.88 ± 2.91	52.40 ± 2.13
6. 20% PL Coppiced	66.11 ± 2.11	21.97 ± 4.01	31.01 ± 3.82	59.34 ± 2.76	50.81 ± 2.02
Average of 2 3 4 5 6	63.91 ± 2.18	18.13 ± 4.15	26.28 ± 3.95	58.32 ± 2.85	49.76 ± 2.09

TABLE 4. GROWTH PERFORMANCE AND FEED INTAKES OF WEANLING RABBITS FED DIETS CONTAINING VARIOUS PROPORTIONS OF ALFALFA AND POPLAR LEAVES (PL).

Treatment	Ave. Daily Gain (g)	Daily DM Intake (g)	Feed/ Gain
1. 40% Alfalfa Control	35.5 ±2.7	105.6 ±4.9	3.4 ±0.2
2. 10% PL Uncoppiced	39.7 ±2.7	117.3 ±4.9	3.3 ±0.2
3. 20% PL Uncoppiced	36.7 ±2.7	122.3 ±4.9	3.8 ±0.2
4. 40% PL Uncoppiced	37.9 ±3.1	133.9 ±5.5	4.0 ±0.2
5. 10% PL Coppiced	37.3 ±2.9	119.4 ±5.2	3.7 ±0.2
6. 20% PL Coppiced	37.1 ±2.7	114.3 ±4.9	3.5 ±0.2
Average of 2 3 4 5 6	37.7 ±2.8	121.4 ±5.1	3.7 ±0.2

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TABLE 5. STATISTICAL COMPARISONS FOR DIGESTIBILITY (%) AND GROWTH PERFORMANCE DATA OF WEANLING RABBITS FED DIETS CONTAINING VARIOUS PROPORTIONS OF ALFALFA AND POPLAR LEAVES (PL) FROM UNCOPPICED (U) AND COPPICED (C) SOURCES.

Contrasts	Crude Protein	ADF	NDF	Dry Matter	Ash	ADG (g)	Dry Matter Intake (g)	Feed/ Gain
1. Control vs PL treatments (Groups 1 vs 2 3 4 5 6)	78.75 vs 63.91*	26.28 vs 18.13	36.87 vs 26.28*	64.35 vs 58.32	60.62 vs 49.76*	35.5 vs 37.7	105.6 vs 121.4*	3.4 vs 3.7
2. U vs C PL at 10% (Groups 2 vs 5)	68.71 vs 69.92	19.04 vs 21.07	29.53 vs 31.21	59.02 vs 59.88	51.93 vs 52.40	39.7 vs 37.3	117.3 vs 37.3	3.3 vs 3.7
3. U vs C PL at 20% (Groups 3 vs 6)	60.05 vs 66.11*	18.40 vs 21.97	20.88 vs 31.01	55.72 vs 59.34	48.95 vs 50.81	36.7 vs 37.1	122.3 vs 114.3	3.8 vs 3.5
4. Complete Substitution (Groups 1 vs 4)	78.75 vs 54.76*	26.28 vs 10.15	36.87 vs 18.79*	64.35 vs 57.63	60.62 vs 44.73*	35.5 vs 37.9	105.6 vs 133.9*	3.4 vs 4.0

* indicates statistical significance at .05 level

At a level of 20% poplar leaf meal in the diet, the crude protein digestibility was significantly higher ($p < .05$) for coppiced than for uncoppiced leaves (Table 5). This does not suggest a higher content of protein-binding phenolic compounds in the "attacked", resprouted trees.

For the average daily gain (ADG) and feed efficency (feed/gain), there were no statistical differences between treatments; however, there was a trend ($p < .06$) for the feed efficiency to be higher for the 40% PL diet than for the 40% alfalfa control. There was a statistical difference in dry matter intake; the control consumed less feed ($p < .01$) than all the other treatments (Comparison 1).

Poplar leaves contain tannins (Meyer and Montgomery, 1987). Tannins can bind dietary proteins and enzymatic proteins to reduce CP digestibility (Cheeke and Shull, 1985). Bas et al. (1985) fed pelleted aspen foliage to lambs at levels of 0, 25, 50 and 75%, with alfalfa as the other ingredient, and found that lamb weight and intake decreased as aspen level increased. Van Soest (1982) proposed that an insoluble tannin-protein complex is formed which is recovered in the ADF fraction. In the present study, the poplar leaves had about 2 times the amount of N bound to ADF fraction as the alfalfa (Table 2), which may have contributed to poorer crude protein digestibility. Bradshaw et al. (1989) found that when hybrid poplars are wounded in the lower leaves, the upper leaves code for 'defense' genes. The amino acid sequences for 2 of these are similiar to chitinases found in tobacco and barley. A third is similiar to trypsin inhibitors found in legume seeds.

The ADF utilization showed no significant difference betweem treatments whereas the NDF did. Thus the hemicellulose fraction was better utilized for alfalfa than for the PL treatments.

The minerals in the tree forage were not as well utilized as in alfalfa, as evidenced by the lower ash digestibility. Baertsche et al. (1986) found poplar to be lower than alfalfa in Ca and P, but higher in microminerals.

Jakubas et al. (1989) found that ruffed grouse preferred certain aspen trees over others. The nonpreferred trees had higher levels of a simple phenol, coniferyl benzoate. Grouse preferred catkins over buds. Buds were higher in coniferyl benzoate. Since grouse feeding preference was not related to tannins or total phenols, they proposed that the grouse may have adapted to tannins in the diet.

We offer the following explanation for the higher CP digestibility with 20% coppiced leaves than for the uncoppiced leaves in the diet. Meyer and Montgomery (1987) point out that *Populus deltoides* exhibits free shoot growth as opposed to fixed, meaning that the leaves are continously produced throughout the season instead of in a flush within a few weeks after budbreak. According to Kramer and Kozlowski (1979), the extent that later-season leaves are produced diminishes with tree age. Owing to this, the leaves from uncoppiced growth are generally older than those from the coppiced trees because they come from older mature trees less likely to be producing young leaves in September. Young leaves are higher in water and N and contain less fiber

(McKey, 1979) which agrees with the leaf composition analyzed in the present study (Table 2). The literature suggests that young leaves would contain more chemical defenses than older leaves. Meyer and Montgomery (1987) found that the gypsy moth prefers to feed on the old growth of poplar (*Populus deltiodes*) foliage rather than the new leaves. The moths showed 85% less growth when fed new leaves. They found that the concentration of phenols was 3 times higher in the new leaves than in the old leaves. The active phenol was not identified. Levels of flavenoids and condensed tannins did not differ between leaf ages. Tannic acid is not present in this type of poplar. The authors suspected phenolic glycosides. In our study, although the younger hybrid poplar leaves from the less mature coppiced trees may have contained more chemical defenses than the older leaves from the uncoppiced mature trees, it did not seem to be enough to cancel out the higher nutritive value. It would be of interest to carry out a similar experiment in which the leaves from uncoppiced and coppiced sources could be harvested early in the season before the effect of old vs young leaves could set in.

Growth rate was not adversely affected by any of the poplar leaf treatments. The slightly lower digestibility of diets containing poplar leaf meal was compensated for by increased feed intake. All the diets seemed to be palatable. The poplar leaf diets had a sweet odor, characteristic of poplar. This odor might be due to low molecular weight, phenolic compounds that are found in poplar.

Poplar can be intensively grown and coppiced. Baertsche et al. (1986) examined 10 short rotation, hardwood trees and found several had potential as livestock feed. Poplar (*Populus deltiodes*) contained 22% CP in the initial growth. When cut and regrown in the same season, it had 19% CP.

Hybrid poplar has been planted in some temperate developing countries such as Nepal. The trees could be planted as cuttings in contour hedgerows on hillsides to slow soil erosion from water runoff, coppiced to provide fuelwood and animal forage, in alley-cropping systems, and as a source of material for reforestation (Benge, 1987). The author cites Dula (1982) in reporting that poplar at close spacing can produce 65 tons of dry biomass per hectar per year.

Digestibility of diets containing PL is lower than those containing alfalfa due to some anti-nutritive qualities which the literature has suggested may include tannins or phenolic glycosides; however, since feed efficiency did not increase significantly, it may be concluded that poplar leaves are a satisfactory replacement of alfalfa in the diet when the leaves are economically available and if a slightly higher feed efficiency is acceptable. Poplar trees could be an integral part of an agroforestry system as animal feed.

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