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EFFECT ON WEANLING RABBITS OF BLACK LOCUST (*ROBINA PSEUDOACACIA*) BARK, OAK SAWDUST, RED ALDER (*ALNUS RUBRA*) BARK AND RED ALDER SAWDUST IN THE DIET

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Abstract

Forty-eight New Zealand White weanling rabbits were fed diets containing 25% black locust (*Robinia pseudoacacia*) bark, oak sawdust, red alder (*Alnus rubra*) bark, or red alder sawdust (all diets also included 25% alfalfa). A 50% alfalfa diet served as a control, along with a standard OSU fryer diet which provided a performance reference. Average daily weight gain (ADG) was higher for the alfalfa control as compared to the treatments, as were the nutrient digestibilties, with the exception of the ADF and NDF fractions. The NDF fraction was higher for the treatments. Nutrient digestibilities of black locust bark were higher than those of alder bark with the exception of NDF; however, the ADG was much lower for the black locust bark diet. According to the literature, black locust bark contains lectins that disrupt gut function. The bark should be avoided in use of black locust forage for animal feeding. On the basis of ADG, alder bark appears to have a slightly higher feeding value than alder sawdust, and oak sawdust appears to have a higher feeding value than alder sawdust.

Introduction

The use of tree forage has potential for animal feeding as a by-product from the forestry industry or from multipurpose trees in agroforestry systems. Although the leaves of black locust (*Robinia pseudoacacia)* have a nutrient composition similiar to alfalfa, feeding trials have generally given poor results (Cheeke, 1992). The lower availability of nutrients is probably due to tannins and lectins. Robin is a lectin which is reputed to be present in black locust (BL) (Cheeke, 1992).

Lectins (hemagglutins) are glycoproteins that cause clumping of red blood cells in vitro (Cheeke and Shull, 1985). They are present in beans and a number of other plants including BL. Lectins have a high affinity for sugars, binding to carbohydrate moieties in the intestinal epithelium and interfering with digestion. Some symptoms of lectin poisoning include anorexia, weakness, diarrhea and death. Horses have been poisoned by stripping the bark of black locust trees to which they have been tied (Cheeke and Shull, 1985).

It is of interest to determine if it is suitable to include

BL bark in the diet when the leaves are harvested for use as leaf meal and to examine feeding value of bark in general. It may be hypothesized that most of the lectins that exert a toxic effect on animals are contained in the bark. Consumption of bark is common among wildlife, but is not usually a major part of a mammal's diet (Whitten and Whitten, 1987). Aspen twigs, buds, leaves and bark are adequate forage sources for deer and elk and could also be utilized by domestic ruminants (Tengerdy and Nagy, 1988).

Other forestry by-products such as sawdust have been tested for animal feeding with some success, especially when chemically or physically treated to improve digestibilty (Vidal and Molinier, 1988; Tengerdy and Nagy, 1988). In Australia, ecalyptus sawdaust was treated with high temperature, pressure and a catalyst to break up lignin-cellulose association, cooked, adding nonprotein nitrogen and minerals to create a product used as 34% of sheep diets. (Anonymous, 1979).

The objectives of this study were to evaluate the effect of adding BL bark to the diet of growing rabbits as compared to alder bark (another nitrogen-fixing tree) and alfalfa control in order to determine whether BL bark has a toxic effect on rabbits; and, secondarily, to examine the feeding value of bark compared to sawdust (alder bark vs. alder sawdust) and oak sawdust compared to alder sawdust.

Materials and Methods

Forty-eight New Zealand White weanling rabbits approximately 5 weeks old were randomly assigned to 6 treatments with 8 rabbits being allocated to each treatment. The treatments were:

1) 25% alfalfa and 25% black locust bark
2) 25% alfalfa and 25% oak sawdust
3) 25% alfalfa and 25% alder bark
4) 25% alfalfa and 25% alder sawdust
5) 50% alfalfa control
6) standard OSU fryer diet.

The trial consisted of a 10-day adaptation period followed by a 10-day digestibility perod. Rabbits were housed in individual cages with automatic dewdrop water valves. Feed intake was measured throughout the trial and during the digestibility period. Feed intake was adjusted by collecting and measuring wasted feed. Initial and weekly 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.

Throughout the trial, animals were fed the diets (Table 1) *ad libitum*. The black locust bark was harvested from recently felled trees on a local farm in June 1991. It was stripped from the trunks and branches and air-dried for 3 weeks. Bark was put through a shredder and oven-dried at 50° C for 5 days. It was then ground through a 2mm screen. The oak sawdust came from a commercial source. The alder bark was collected from recently felled trees at a local sawmill. Bark was sent through a

TABLE 1. PERCENT COMPOSITION OF EXPERIMENTAL DIETS

Ingredients	1	2	3	4	5
Alder bark	-	-	25	-	-
Alder sawdust	-	-	-	25	-
Alfalfa meal	25	25	25	25	50
Black locust bark	25	-	-	-	-
Ground barley	42.5	42.5	42.5	42.5	42.5
Molasses	5	5	5	5	5
Oak sawdust	-	25	-	-	-
Trace mineral salt*	0.25	0.25	0.25	0.25	0.25
Vegetable oil	2	2	2	2	2
Vitamin mix**	0.25	0.25	0.25	0.25	0.25
Chemical Analysis					
Crude Protein	13.2	11.0	10.3	6.4	11.4
ADF	22.5	23.9	19.5	31.7	17.6
NDF	36.8	81.2	80.9	88.4	31.7
Ash	6.6	5.3	6.1	4.6	8.2

*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.

chipper. These pieces were oven-dried at 50° c for 5 days and then ground through a 2mm screen. The alder sawdust came from accumulated piles at the same sawmill. It was oven-dried at 50°

C for 72 hours.

After the end of the digestibility period, the total wet feces were weighed and a subsample taken which was oven-dried at 60° C for 72 hours. The dry subsample was weighed and then ground through a 1mm screen. Feed and feces samples were analyzed for dry matter 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 4 pre-planned comparisons. Three rabbits with very poor performance were removed from the trial.

Results and Discussion

The compositions of the experimental feed ingredients are given in Table 2. The digestibility and growth performance data are given in Table 3 and the statistical comparisons in Table 4.

TABLE 2. NUTRIENT COMPOSITION OF EXPERIMENTAL TREE PRODUCTS

Ingredient	Crude Protein	ADF	NDF	Ash
Black locust bark	16.91	42.34	56.08	7.40
Oak sawdust	<.01	62.92	91.60	0.53
Alder bark	1.90	47.36	66.09	4.15
Alder sawdust	<.01	69.25	95.02	0.56
Alfalfa	20.29	29.45	38.65	10.12

In Comparison 1, the digestibilities of crude protein (CP), dry matter (DM), and ash were higher for the alfalfa control than for all the treatments (respective p values $< .01, .01, .01$). The NDF fraction was lower for the alfalfa control than for the treatments ($p < .01$). The ADF digestibilty did not differ significantly in Comparison 1; however, this is due to the means of 1, 2, 3 and 4 cancelling each other out. If all possible pairs are compared, they were all significantly different except for the means of 1 and 4 at the .05 level. Therefore, it is evident that the ADF fraction was better digested for black locust bark (BLB) and alder sawdust (AS) treatments than for the alfalfa control. Average daily weight gain and DM intake were significantly lower for all treatments than for the alfalfa control ($p < .01$ and .01) and feed/gain was significantly higher for the treatments compared to the alfalfa control ($p < .01$).

In Comparison 2, the CP, ADF and DM were better digested in the BLB diet than the alder bark (AB) diet ($p < .01, .01, .01$), whereas NDF was better digested in the AB diet than in the BLB diet ($p < .01$); however, average daily weight gain and DM intake

TABLE 3. MEANS (±SE) OF NUTRIENT DIGESTIBILITY (%) AND GROWTH PERFORMANCE DATA OF WEANLING RABBITS FED DIETS CONTAINING 25% ALFALFA AND 25% BLACK LOCUST BARK, OAK SAWDUST, ALDER BARK AND ALDER SAWDUST OR 50% ALFALFA CONTROL OR STANDARD FRYER DIET.

Treatments	Crude Protein	ADF	NDF	Dry Matter	Ash	DM Intake (g)	ADG (g)	Feed/ Gain
1. Black Locust Bark	66.94 ±1.95	21.91 ±1.78	29.47 ±1.05	63.73 ±0.85	54.07 ±1.91	53.0 ±3.6	4.4 ±1.4	20.26 ±2.10
2. Oak Sawdust	75.88* ±1.54	2.24 ±1.41	54.37 ±0.83	55.92 ±0.68	62.66 ±1.51	88.9 ±2.9	18.1 ±1.1	5.51 ±1.66
3. Alder Bark	58.81* ±1.54	-9.46 ±1.41	58.29 ±0.83	57.22 ±0.68	57.98 ±1.51	80.1 ±2.9	13.3 ±1.1	6.70 ±1.66
4. Alder Sawdust	54.15* ±1.54	22.10 ±1.41	58.05 ±0.83	56.08 ±0.68	53.59 ±1.51	80.2 ±2.9	10.3 ±1.1	8.72 ±1.66
5. Alfalfa Control	69.15 ±1.54	9.37 ±1.41	21.08 ±0.83	66.29 ±0.68	64.72 ±1.51	91.1 ±2.9	26.9 ±1.1	3.77 ±1.66
6. Standard Fryer Diet	NA	NA	NA	NA	NA	117.6 ±2.9	40.3 ±1.1	3.18 ±1.66
Average of 1, 2, 3, and 4	63.95 ±1.64	9.20 ±1.50	50.05 ±0.89	58.24 ±0.72	57.08 ±1.61	75.6 ±3.1	11.5 ±1.2	10.30 ±1.77

NA: Not Applicable (Treatment 6 served only as a reference for overall growth performance and was not included in nutrient digestibility analyses.)

* The protein digestibility values for these diets reflect the digestibilities of the protein in alfalfa and barley due to the very low values of protein in oak sawdust, alder bark and alder sawdust.

TABLE 4. STATISTICAL COMPARISONS FOR DIGESTIBILITY (%) AND GROWTH PERFORMANCE DATA OF WEANLING RABBITS FED ALFALFA CONTROL OR DIETS CONTAINING BLACK LOCUST BARK, OAK SAWDUST, ALDER BARK AND ALDER SAWDUST.

Contrasts	Crude Protein	ADF	NDF	Dry Matter	Ash	DM Intake (g)	ADG (g)	Feed/ Gain
1. Treatments vs Alfalfa Control (Groups 1 2 3 4 vs 5)	63.95 vs 69.15*	9.20 vs 9.37	50.05 vs 21.08*	58.24 vs 66.29*	57.08 vs 64.72*	75.6 vs 91.1*	11.5 vs 26.9*	10.30 vs 3.77*
2. BLB Bark vs Alder Bark (Groups 1 vs 3)	66.94 vs 58.81*	21.91 vs -9.46*	29.47 vs 58.29*	63.73 vs 57.22*	54.07 vs 57.98	53.0 vs 80.1*	4.4 vs 13.3*	20.26 vs 6.70*
3. Alder Bark vs Alder Sawdust (Groups 3 vs 4)	58.81 vs 54.15*	-9.46 vs 22.10*	58.29 vs 58.05	57.22 vs 56.08	57.98 vs 53.59*	80.1 vs 80.2	13.3 vs 10.3*	6.70 vs 8.72
4. Oak Sawdust vs Alder Sawdust (Groups 2 vs 4)	75.88 vs 54.15*	2.24 vs 22.10*	54.37 vs 58.05*	55.92 vs 56.08	62.66 vs 53.59*	88.9 vs 80.2*	18.1 vs 10.3*	5.51 vs 8.72

* indicates statistical significance at .05 level

were significantly lower for the BLB diet than for the AB diet ($p < .01$ and .01) and feed/gain was higher for the BLB than the AB diet ($p < .01$). This may indicate a toxic effect of the BLB diet.

In Comparison 3, the CP and ash digestibilities were higher for the AB diet than for the AS diet ($p < .04$ and .05), whereas the ADF digestibility was higher for the AS ($p < .01$). Average daily weight gain was slightly, although not significantly higher for the AB than the AS diet ($p < .06$).

In Comparison 4, CP and ash were better digested in the oak sawdust (OS) treatment ($p < .01$, .01), whereas ADF and NDF digestibility were higher for the AS treatment ($p < .01$, .01). Dry matter intake and ADG were higher for the OS treatment ($p < .04$, .01).

The bark of trees includes dead cells of phloem, the cortex where food is stored and the cork which protects the cambium from temperature changes and fungal attack and prevents dehydration (Feininger, 1968). Whitten and Whitten (1987) found that for a tropical squirrel which feeds mostly on bark (49% of stomach contents), selection of feed trees was not influenced by concentrations of CP, crude fiber, fat, calorific value or condensed tannin levels in bark. Most barks are low in N and carbohydrate calories. The authors theorized that the squirrels were selecting for something such as a combination of trace elements in the bark.

The BLB had a high level of CP (16.9%) whereas AB had a much lower level (1.9%) (Table 2). Whitten and Whitten (1987) found that the CP level of the barks of 13 tropical trees ranged from 0.48 to 3.79%. The high CP level in BLB may be due to the presence of lectins. Nsimba-Lubaki and Peumans (1986), in a study examining the seasonal fluctuations of lectins in BL bark, found that bark lectins made up 5% of the total protein content. BL lectins were not exclusively found in bark. According to the literature, most of the work done with lectins has been with seeds, but lectins are present in other tissues such as roots and leaves as well. Nsimba-Lubaki and Peumans considered the bark of trees to be a vegetative storage tissue and bark lectins to behave as typical storage proteins. In the late spring, lectins were equally present in bark and other vegetative tissues such as leaves, roots, stems and flowers, but in the winter, they found that lectins increased by 50 fold in the bark compared to summer levels. Nitrogen is normally stored in the form of protein in the bark at the end of the growing season until the following spring. This decreases with age: older trees showed less disappearance of lectins in the summer.

In a diet identical to the experimental BLB diet in which BLB was replaced by BL leaves (Ayers et al., 1992), rabbits showed weight gains 8 times higher than the gains obtained by the rabbits consuming BLB diet. This indicates a lower feeding value and a toxic effect of the bark, probably due to lectins. The animals on the BLB performed so poorly that 3 of them had to be removed from the trial so they would not die. The bark used in our study was harvested in the summer, when the lectin levels would be relatively low, but the lectins still appeared to be of a such a higher level than the leaves to show a toxic effect. The involvement of toxins other than lectins cannot be excluded.

Sawdust is about 60% cellulose and 40% lignin and tannins (Anonymous, 1979). The ligno-cellulose structure and cellulose crystallinity prevents enymes from degrading the cellulose. This may not be a problem for rabbit rations because rabbits do not normally digest fiber to a great extent. Fiber does seem to be necessary to keep intestinal lining of the gut healthy (Cheeke et al., 1987). Fayek et al. (1989) found no difference in weanling rabbit performance between urea-treated and untreated sawdust at levels of 5, 7.5 and 10% of the diet. They concluded that sawdust can be incorporated into the diet at levels up to 10% without deleterious effects on growth. El-Sabban et al. (1970) found that up to 15% sawdust in finishing beef cattle rations did not affect carcass characteristics.

Sawdust has been treated by chemical or physical means to improve digestibility by disrupting the ligno-cellulose structure (Tengerdy and Nagy, 1988). Vidal and Molinier (1988) treated poplar sawdust (an abundant industry by-product in southern Europe) with ozone to increase its value as cattle feed. Ozonolysis of lignan improved in vitro digestibility. Tengerdy and Nagy (1988) used an ammonia freeze explosion treatment to decrease lignin of aspen twigs and chips by 30% and aspen bark by 20%. This improved the in vitro digestibility of twigs and chips. Bark, already high in IVD, did not increase further. According to the authors, most of the digestibility in bark is due to about 40% soluble materials.

In our study, none of the treatments, including the alfalfa control, gave satisfactory ADG when compared to the standard OSU fryer diet. This is due to the deliberate omission of a protein supplement in the experimental diets, in order that the digestibility values would reflect the test substances as much as possible.

It can be concluded that BL bark is very toxic to rabbits, possibly because of its lectins. This would suggest that when BL forage is harvested for animal feeding, the harvesting procedure should be conducted so as to maximize the leaf component and minimize the inclusion of bark from stems. On the basis of ADG, bark appears to have a slightly higher feeding value than sawdust, and in comparing 2 types of sawdust, OS appears to have higher feeding value than AS.

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