1976

Delignification of Ponderosa Pine Sawdust and Bark by Peroxyacetic Treatments

L. D. Kamstra
South Dakota State University

D. Ronning

H. Schroeder

South Dakota State University
Brookings, South Dakota

Department of Animal Science
Agricultural Experiment Station

A.S. Series 76-12

Delignification of Ponderosa Pine Sawdust and Bark by Peroxyacetic Treatments

L. D. Kamstra, D. Ronning and H. Schroeder

Introduction

Previously it was shown that untreated ponderosa pine sawdust could serve as the roughage portion of high-concentrate rations. This fibrous material was too low in digestibility, however, to serve as a major ration component unless treated to remove encrusting lignin. Various treatments such as pressure, heat and sodium hydroxide, although effective with many fibrous waste material, were only marginal in improving utilization of pine sawdust.

The purpose of this study was to determine effectiveness of peroxyacetic acid in improving the digestibility of highly lignified fibrous materials such as ponderosa pine sawdust and bark. Peroxyacetic acid is used as a delignifying agent in the making of paper from tree fibers.

Materials and Methods

Wood chips from the Whitewood Post and Pole Company, Whitewood, South Dakota, were dried and ground to pass a 4.0 mm screen prior to treatments with peroxyacetic acid. Peroxyacetic acid was prepared by a controlled reaction between hydrogen peroxide and acetic anhydride in sufficient amounts to treat small amounts of wood material. Twenty gram samples of bark and sawdust were treated with various levels of peroxyacetic acid under various conditions. The treated and untreated wood and bark samples were also analyzed for neutral-detergent fiber (NDF), acid-detergent fiber (ADF), acid-detergent lignin (ADL) and evaluated for potential utilization by ruminants by *in vitro* dry matter digestibility (IVDMD) as well as cell wall digestibility (IVCWD). The untreated samples were also analyzed for cellulose, nitrogen and ash.

Results

Untreated ponderosa pine sawdust differed somewhat in analysis from ponderosa pine bark, with the bark having greater lignification and mineral content but less fiber. Note, however, that both ponderosa pine sawdust and bark are highly lignified materials (table 1).

A summary of a series of treatments of ponderosa pine sawdust and bark appears in table 2.

It would appear that peroxyacetic acid is an effective delignifying agent even at low solution concentrations. Almost complete delignification was accomplished with proper conditions of concentration, time and temperature. *In vitro* digestibility increased as lignin was removed from the fibrous material. Little damage to the cell walls or to hemicellulose was noted during removal of lignin by peroxyacetic acid. Usually greater lignification also means less digestibility. However, untreated bark has a higher digestibility than untreated sawdust with a lower lignin content. Lignin structure is known to vary from one plant to another and may also vary at locations within the same plant. As complete delignification is approached, the digestibility of sawdust and bark is similar.

Summary and Conclusions

It appears most practical to remove approximately 60% of the lignin to attain high potential for ruminant utilization of fibrous wastes as measured by *in vitro* digestion. It has a very desirable feature in being almost non-destructive to fibrous material and thus recovery of usable waste feed should be favorable to use. Treating methods such as high pressure, steam, heat or sodium hydroxide additions are more destructive in achieving similar levels of digestive potential. High pressure steam treatment for only 90 seconds, for example, destroys a large portion of hemicellulose as indicated by production of furfural during the reactions. Furfural production results from destruction of five carbon carbohydrates which comprise the major portion of the hemicellulose fraction. This would mean a loss of about a third of the digestible dry matter during treatments by such methods rather than by peroxyacetic acid. Peroxyacetic acid treatment demands more safety precautions and sophisticated treatment methodology, however. Its use in production of feeds from highly lignified wastes will depend on the demand for new feeds and the cost of traditional feeds, especially roughages. Animal trials using peroxyacetic acid-treated materials are planned as soon as better methods of synthesis of peroxyacetic acid are developed to treat greater volumes of wastes.

Table 1. Composition of Substrates Treated with Peroxyacetic Acid

	Ponderosa sawdust	Ponderosa bark
	%	%
Neutral-detergent fiber	92.8	74.4
Acid-detergent fiber	79.5	64.5
Acid-detergent lignin	27.4	33.7
Crampton and Maynard cellulose	49.1	26.2
Nitrogen	0.2	0.3
Ash	0.2	3.8

Table 2. Effect of Peroxyacetic Acid Treatment on Ponderosa Pine Sawdust and Bark

Peroxyacetic acid									
Concentration	G/100 g substrate	Time	Temperature	NDF[a]	ADF[b]	ADL[c]	Delignification	IVDMD[d]	IVCWD[e]
%		Hr	°C	%	%	%	%	%	%
				Sawdust					
---	---	---	--	92.8	79.5	27.4	0	7.3	0.2
2.50	20	168	25	88.6	75.9	17.6	35.8	12.6	1.3
3.75	30	168	25	85.7	73.2	14.3	47.8	26.9	14.7
5.00	40	168	25	82.6	71.1	8.7	68.2	48.6	37.7
6.25	50	168	25	79.8	69.5	5.8	78.8	61.5	48.2
7.50	60	168	25	78.5	67.2	3.9	85.8	68.3	59.6
8.75	70	168	25	78.3	65.8	1.5	94.5	72.5	64.9
20.0	200	1	75	73.0	60.8	0.2	99.4	81.1	69.0
20.0	200	2	75	79.0	68.1	0.3	99.1	77.4	71.4
20.0	200	3	75	76.5	67.3	0.1	99.5	80.3	74.2
10.0	100	1	75	77.8	66.2	0.3	99.1	80.5	75.0
10.0	100	2	75	80.4	69.9	0.1	99.5	81.8	77.3
10.0	100	3	75	83.3	73.2	0.2	99.4	81.0	77.2
5.0	50	1	75	77.3	65.7	4.7	82.7	67.9	58.5
5.0	50	2	75	77.0	64.7	1.9	93.2	75.1	67.6
5.0	50	3	75	75.9	64.9	0.9	96.7	78.0	76.7
2.5	25	1	75	90.7	76.3	13.5	50.8	19.1	10.8
2.5	25	2	75	89.6	76.0	11.2	59.0	30.3	22.2
2.5	25	3	75	89.1	76.4	9.6	64.9	38.7	31.2
2.5	25	1	85	88.8	76.2	14.0	49.0	28.4	14.1
2.5	25	2	85	89.7	75.8	13.0	52.6	38.2	27.0
2.5	25	3	85	88.6	76.1	13.2	51.9	37.8	25.6
2.0	20	1	85	87.1	76.4	16.3	40.7	15.5	2.9
2.0	20	2	85	86.1	76.7	15.7	42.8	18.9	5.9
2.0	20	3	85	85.9	77.2	15.6	43.2	19.0	5.8
				Bark					
0	0	---	---	74.4	64.5	33.7	0	30.0	5.9
4.0	20	168	25	67.3	60.8	24.8	26.3	46.6	20.6
6.0	30	168	25	68.1	57.9	20.5	39.3	53.2	31.3
8.0	40	168	25	69.4	56.8	16.4	51.3	56.5	37.3
10.0	50	168	25	69.8	55.6	13.8	59.1	60.0	42.7
12.0	60	168	25	68.3	52.9	8.6	74.6	66.9	51.5
14.0	70	168	25	66.1	51.1	5.7	83.2	73.3	59.6

[a] NDF = neutral-detergent fiber.
[b] ADF = acid-detergent fiber.
[c] ADL = acid-detergent lignin.
[d] IVDMD = *in vitro* dry matter digestibility.
[e] IVCWD = *in vitro* cell wall digestibility.