

COMPARISON OF THE ABSORPTIVE CAPACITY OF SHAVINGS OF WESTERN JUNIPER, WESTERN REDCEDAR, AND DOUGLAS-FIR FOR ANIMAL BEDDING

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ABSTRACT

The absorptive capacity and moisture release rate for shavings of two species commonly used for animal bedding, western redcedar (*Thuja plicata*) and Douglas-fir (*Pseudotsuga menziesii*) were compared with western juniper (*Juniperus occidentalis*), a species not commonly used for bedding. Comparisons are made for four particle size classes for each species. In general, moisture absorption increased as particle size decreased. On the basis of weight of urine absorbed per weight of shavings material, western redcedar shavings absorbed significantly more urine than the other two species for all particle sizes. On the basis of volume of urine absorbed per volume of shavings material, mixed particle sizes of western juniper absorbed significantly more moisture than the other two species. Rate of moisture release was fastest for Douglas-fir shavings and slowest for western redcedar shavings.

Animal bedding is used to provide padding for animals, to absorb moisture from urine, to provide insulation, and to alleviate some odors. If a bedding material absorbs more water or urine, a lesser amount will be needed, which can save labor and material cost. Commonly used bedding materials include various species of grain and grass straws, shredded paper, peanut hulls, reusable plastic, hardwood bark, sawdust, and wood shavings (1,3,13,14). Some of these materials have been evaluated for preference by animals (5), cleanliness of hair coat (6), dust production (8), and moisture absorption properties for rodent and poultry litter (3,8-10).

A number of factors determine the amount of water absorbed by a material. The amount of water present in the original product will reduce the amount of additional water that can be absorbed.

Material that is in smaller particles will usually absorb more water (14); however, one study reported that litter with a smaller particle size absorbed less moisture than larger particles (10). If the material is too fine, the dust could be detrimental to the animals. The critical parameter in moisture absorption is probably the specific active surface area (m²/gram) rather than bulk density or particle size (11).

The particle size and density of wood shavings vary with the product (e.g.,

planer shavings, sawdust, or wood chips), feed rate (e.g., effect on chip thickness), presence or absence of bark, method of production (e.g., if planer shavings are produced from green vs. dry material), and wood species.

The water absorption of various bedding materials has been reported in the literature. In most cases, it has been reported as pounds of water absorbed per pound of bedding. The *Dairy Housing and Equipment Handbook* (4) lists water absorption of straw at 2.1, pine sawdust at 2.5, and pine shavings at 2.0 pounds of water per pound of bedding. The *Dairy Reference Manual* (1) reports water absorption (pounds of water per pound of bedding) at 2.4 for chopped oat straw, 3.0 for chopped mature hay, 2.5 for pine sawdust, and 1.3 to 1.5 for wood shavings (wood species not reported).

The moisture-holding capacity of shredded pallets has been compared to duck litter and turkey litter (14). Percent moisture absorption was reported as weight of water retained divided by dry weight of bedding material. Shredded

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TABLE 1. — Percent size of shavings by weight.

Species	7 to 10 mm	3 to 7 mm	< 3 mm
----- (%) -----			
Douglas-fir	56.3	24.2	19.6
W. redcedar	47.9	39.1	13.0
W. juniper	28.3	53.5	18.1

TABLE 2. — Density of unpacked shavings.

Species	Mixed shavings	7 to 10 mm	3 to 7 mm	< 3 mm
----- (g/mL) -----				
Douglas-fir	0.037	0.039	0.058	0.111
W. redcedar	0.026	0.027	0.053	0.090
W. juniper	0.076	0.062	0.079	0.116

TABLE 3. — Percent moisture absorbed by weight.

Species	Mixed shavings	7 to 10 mm	3 to 7 mm	< 3 mm
----- (%) -----				
Douglas-fir	215	204	223.3	358
W. redcedar	328	322	316	464
W. juniper	214	192	216.2	291

TABLE 4. — Percent moisture absorbed by volume.

Species	Mixed shavings	7 to 10 mm	3 to 7 mm	< 3 mm
----- (%) -----				
Douglas-fir	8.1	7.8	12.8	40.5
W. redcedar	8.4	8.6	16.5	41.2
W. juniper	16.0	11.7	16.8	31.5

pallets held more moisture than litter, and smaller particle sizes held more moisture: 1.25-inch (31.75-mm) screened material absorbed 240 percent and 0.5-inch (12.7-mm) screened material absorbed 436 percent moisture.

Hardwood bark has been compared to pine planer shavings for moisture-absorbing capacity. Percent moisture absorption was calculated as the weight of water retained divided by the dry weight of bedding material. Planer shavings absorbed 199.5 percent and the hardwood bark absorbed 118.5 percent (3).

A literature review found no reports comparing the absorptive capacities of western juniper, Douglas-fir, and western redcedar shavings. This study compares the amount of horse urine retained and the rate of moisture release for four particle-size classes for two wood species commonly used in the western United States for animal bedding, western redcedar (*Thuja plicata*) and Douglas-fir (*Pseudotsuga menziesii*),

and a species not commonly used for bedding, western juniper (*Juniperus occidentalis*).

MATERIALS AND METHODS

Samples of shavings were placed in a temperature- and humidity-controlled room until the samples equilibrated to approximately 10.0 percent moisture content (MC). Shavings of each species were separated into four particle-size classes by screening. The size classes were: mixed shavings (material as it arrived from the production mill), > 7 mm (0.28 in.) in diameter, 3 to 7 mm (0.12 to 0.28 in.) in diameter, and < 3 mm (0.12 in.) in diameter.

The uncompressed volume of each material was determined by placing the shavings in a beaker and gently shaking but not compressing the material. The volume was weighed and the bulk density, defined as the uncompressed density of a material, was determined (12).

ABSORPTION

Ten 20-g samples of each particle-size class and species were placed in an 8-g bag made of plastic window screen of 15 mesh. For the < 3-mm (0.12-in.) samples, a brass screen of 40 mesh was used to keep the particles from falling through. The weighed samples were submerged for 30 minutes in horse urine with a specific gravity of 1.015. The sample was removed from the urine bath and allowed to drain for 5 minutes, shaken gently three times to remove excess urine from the screen, and re-weighed. This soaking was repeated with the same sample until no more absorption of urine could be detected. The samples were weighed to the nearest 0.001 g. Each subsequent sample was allowed to soak in the urine to determine the time of maximum absorption for that species.

Moisture-holding capacity on a weight basis was calculated as:

$$\frac{\text{wet weight} - \text{bag weight} - 20 \text{ g}}{20 \text{ g}} \times 100$$

The moisture-holding capacity on a volume basis was calculated by using the bulk density of shavings to determine the volume used, and the specific gravity of the horse urine to determine the volume absorbed:

$$\text{Moisture-holding capacity} = \frac{\text{wet volume of shavings and urine} - \text{dry volume}}{\text{dry volume of shavings}} \times 100$$

Absorption data were analyzed using Number Cruncher Statistical Systems software (7). Multi-factor analysis of variance (ANOVA) was used to detect statistically significant differences between species and size classes. Bonferroni (All-Pairwise) tests were used to detect significant differences between interactions of species and particle-size classes.

MOISTURE RELEASE

Saturated material was spread out 1 cm deep at a constant temperature of 24°C. Samples were weighed every hour for 6 hours, and at 24 and 48 hours, to determine the rate of moisture release. Samples of the mixed wet shavings of each species were spread out 1 cm deep and allowed to dry at a constant temperature of 24°C. Five-gram samples were taken at 2-hour intervals and placed in a desiccating oven at 50°C to determine the MC for each time. The

MC remaining over time and the rate of moisture release were recorded.

RESULTS AND DISCUSSION

The size of the mill-run shavings varied among the three species (Table 1). The Douglas-fir had more larger particles with over 50 percent being larger than 7 mm (0.28 in.) in diameter. The western juniper had smaller particles with over 50 percent in the 3- to 7-mm (0.12- to 0.28-in.) size class. The percent of fine particles (< 3 mm, 0.12 in.) was similar for all species.

Bulk density of uncompressed shavings varied with the different species (Table 2). For all particle sizes, the western juniper was most dense and the western redcedar was least dense.

The average percent of urine absorbed by weight for the various species and particle-size classes is shown in Table 3. On the basis of weight of urine absorbed by weight of shavings, western redcedar shavings absorbed significantly more ($p < 0.05$) moisture than the other species in all size classes. There was no significant difference in the absorption for western juniper and Douglas-fir except for fine particles (< 3 mm, 0.12 in.) where Douglas-fir absorbed more moisture than western juniper.

The average percent of urine absorbed by volume for the various species and particle-size classes is given in Table 4. On the basis of volume of urine absorbed by volume of shavings, mixed western juniper shavings absorbed significantly more ($p < 0.05$) moisture than Douglas-fir or western redcedar shavings. In the 3- to 7-mm (0.12- to 0.28-in.) and > 7-mm (0.28-in.) size classes, western juniper shavings absorbed significantly more ($p < .05$) moisture than Douglas-fir shavings. In the 3- to 7-mm (0.12 to 0.28 in.) and > 7 mm (0.28 in.) size classes, western juniper and western redcedar shavings absorbed comparable amounts of urine. In the < 3-mm (0.12-in.) size class, western juniper shavings absorbed significantly less ($p < 0.05$) moisture than Douglas-fir or western redcedar shavings.

The percent of moisture lost by the saturated shavings over time is indicated in Figure 1, which shows the results for mixed particle sizes; however, the pattern was approximately the same for all particle-size classes. By 72 hours, all the samples lost weight equal to the total moisture absorbed. There was some re-

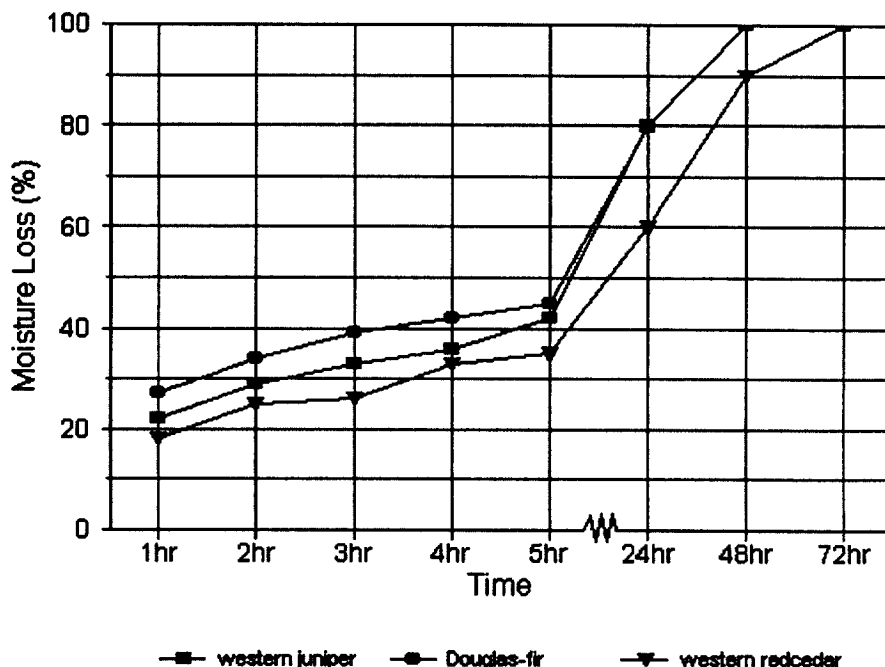


Figure 1. — Moisture release by species for mixed particle sizes.

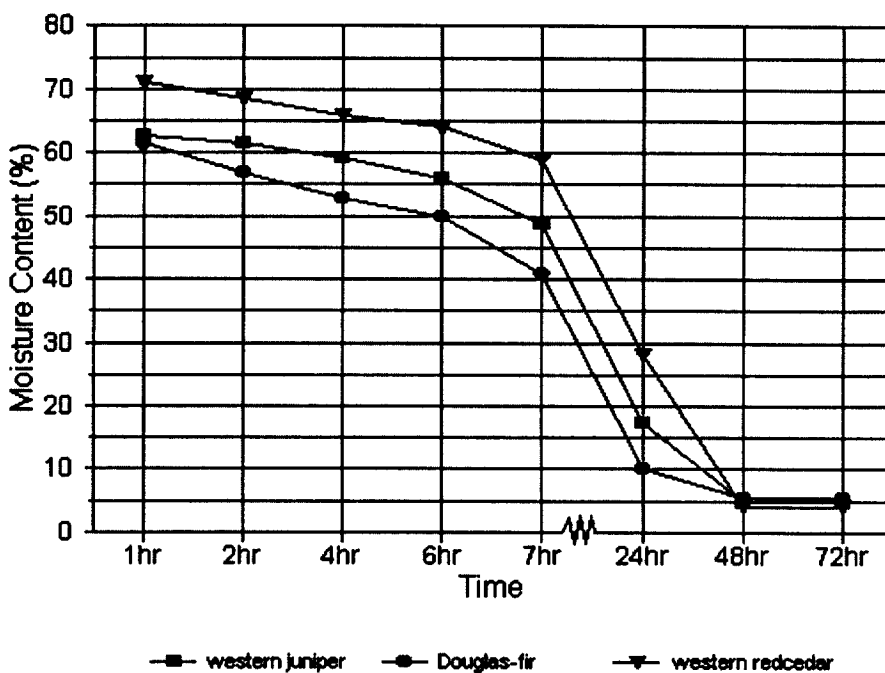


Figure 2. — Moisture retention by species for mixed particle sizes.

tention of moisture by the western redcedar shavings at 48 hours. Western juniper and Douglas-fir shavings had returned to their original weight by this time. The percent of moisture retained by each species of mixed shavings as determined by oven desiccating samples at

various times is shown in Figure 2. In general, Douglas-fir shavings released moisture most rapidly, followed by western juniper.

We measured all samples to the nearest 0.001 g. All samples were handled the same so a comparison could be

made. Twenty-gram samples were used rather than 5- or 10-g samples to minimize the proportion of error during the draining and weighing of the samples. We did not plot absorption over time beyond 60 minutes since we could not detect further absorption beyond that time when measuring to the nearest 0.001 g.

When desiccating the shavings in an oven prior to conducting the absorption Experiment, it became apparent that something in addition to water was being lost from the sample. Drying to a uniform MC was therefore performed in a drying room with constant temperature and humidity. The same problem presented itself when oven desiccating the samples being dried at room temperature to determine moisture content at various times. Perhaps some of the volatile oils were being removed in addition to the water.

Western redcedar shavings were less dense than Douglas-fir or western juniper shavings. An equal volume of redcedar shavings would weigh less than Douglas-fir or western juniper shavings.

Smaller particles absorbed more urine than larger particles of the same species. This is in agreement with White and McLeod (14). The less dense western redcedar shavings absorbed more moisture by weight. One possible reason is that the greater number of particles results in a larger specific surface area (11). On a volume basis, mixed western juniper shavings absorbed more urine than Douglas-fir or western redcedar shavings. Mid-sized (3 to 7 mm, 0.12 to 0.28 in.) and larger (> 7 mm, 0.28 in.)

western juniper shavings absorbed more urine than Douglas-fir shavings and comparable amounts as western redcedar shavings. It is unclear why the fine (< 3 mm, 0.12 in.) western juniper shavings absorbed less moisture than either Douglas-fir or western redcedar shavings on a volume basis. It is apparent that more research needs to be conducted on the hygroscopic nature of western juniper.

Western redcedar shavings retained moisture for a slightly longer time than Douglas-fir or western juniper shavings. This may be of limited practical importance for animal bedding since most soiled bedding is removed rather than being allowed to dry for continued use. The bedding material is contaminated with manure as well as urine, and needs to be removed to keep the animal clean. However, a bedding material that readily releases moisture may be beneficial in situations where stalls are cleaned infrequently.

CONCLUSIONS

If shavings are sold on a volume basis (cubic yards or units), western juniper shavings would be the most economical purchase if prices and MCs were similar. Although the western redcedar shavings absorbed more horse urine on a weight basis, the mixed mill run western juniper shavings absorbed more horse urine on a volume per volume basis than western redcedar or Douglas-fir shavings. Rate of moisture release for western juniper shavings was intermediate between Douglas-fir and western redcedar. All three species lost all moisture within 72 hours.

LITERATURE CITED

1. Adams, R.S. 1995. Dairy Reference Manual. 3rd ed. Northeast Regional Agri. Engineering Serv. Cooperative Ext. 293 pp.
2. Andrews L.D. and B.N. McPherson. 1963. Comparison of different types of materials for broiler litter. Poultry Sci. 41:249-254.
3. Brake J.D., T.N. Boyle, and C.D. Chamblee. 1992. Evaluation of the chemical and physical properties of hardwood bark used a broiler litter material. Poultry Sci. 71: 467-472.
4. Dairy Housing and Equipment Handbook, MWPS-7. 6th ed. Midwest Plan Service, Ames, Iowa. 136 pp.
5. Hunter L. and K.A. Houpt. 1989. Bedding material preference of ponies. J Animal Sci. 67:1986-1991.
6. McClain J., J.E. Wohlt, K.H. McKeever, and P.L. Ward. 1997. Horse hair coat cleanliness is affected by bedding material: A comparison of clean and used wheat straw, wood shavings, pelleted newspaper. J Equine Vet Sci. 17:156-160.
7. Number Cruncher Statistical Software. 1997. NCSS Software, Kaysville, Utah.
8. Potgieter F.J. and P.I. Wilke. 1996. The dust content, dust generation, ammonia production, and absorption properties of three different rodent bedding types. Laboratory Animals 30:790-87.
9. Ruzsler P.L. and J.R. Carson. 1974. Methods of evaluating the potential usefulness of selected litter materials. Poultry Sci. 53:1420-1427.
10. _____ and _____. 1968. Physical and biological evaluation of five litter materials. Poultry Sci. 47:1712.
11. Simonsen J. 1998. Dept. of Forest Prod., Oregon State Univ., Corvallis, Ore. Personal communication.
12. Suchsland O. and G.E. Woodson. 1991. Fiberboard manufacturing practices in the United States. Forest Prod. Soc., Madison, Wis. 263 pp.
13. Thompson K.N. 1995. Alternate bedding materials for horses. Equine Practice 17:20-23.
14. White M.S. and J.A. McLeod. 1989. Properties of shredded wood pallets. Forest Prod. J. 39(6):50-54.