SUSCEPTIBILITY OF COMPRESSED BAGASSE FIBER TO TERMITE ATTACK

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ABSTRACT

Compressed agricultural fiber panels have the potential to be useful building materials, particularly in situations where wood is scarce or expensive. Bagasse, or sugar cane rind, is an agricultural by-product that is suitable for use in such panels. However, in laboratory tests, Formosan subterranean termites survived as well on bagasse as on Douglas-fir wood. In field tests, termites penetrated both coated and uncoated compressed bagasse panels, causing swelling of the fibers from moisture sorption and deformation of the panels. For use in tropical regions, compressed fiber panels will likely require stabilization of the fibers to minimize swelling and an exterior coating that is impermeable or repellent to termites.

Bagasse, or sugar cane rind, is a fibrous by-product of sugar extraction from sugar cane (*Saccharum officinarum* L.). Large quantities of this fiber are produced each year by the sugar industry, of which small amounts are used in the manufacture of pulp and paper products and composite materials (10). Bagasse has a chemical composition similar to hardwoods, and bagasse fiber performs similarly to hardwood fiber in board products (10).

Although the environmental merits of cultivating agriculture fibers specifically as replacements for wood are debatable (2,3,12), efficient use of agricultural by-products is certainly desirable. Moreover, building materials made from local agricultural fibers are attractive options in regions of the world where wood is in short supply and wood products are expensive to import. The Envirocor™ panel (Mansion Industries, Inc., City of Industry, Calif.) is a panel made of compressed agricultural fiber such as rye, wheat, barley, rice, or bagasse; it is approximately 40 percent of the density of solid wood (8). Despite the adage against building ones home from straw, this panel has favorable strength and thermal characteristics for use in building construction, particularly when used in a specially-designed modular system (Pyramod™) (4,8). The manufacturing process, in which compacted fibers are forced through a heated extrusion tunnel and the resulting panel is covered by kraft paper bonded with a film of urea-formaldehyde resin adhesive, is adaptable to local raw materials and production needs in various regions (9).

In addition to the ever-present decay fungi, building materials used in tropical regions such as Hawaii must contend with two serious hazards: moisture and termites. Although panels manufactured from bagasse fiber are attractive as an economical building material in Hawaii, swelling of the fibers from water sorption is a potential problem (10). Therefore, the finished building panels are coated with a thick (ca. 2 mm) acrylic/vinyl latex coating to minimize moisture uptake by the interior fibers. But termite attack could breach this coating, resulting in swelling of the fibers and possibly their removal by feeding termites as well. Termites are known to attack living sugar cane (6,7), but the relative susceptibility of bagasse fiber to termite attack has not been previously established. In this study, both laboratory and field experiments were performed to determine the susceptibility of bagasse fiber and of coated compressed bagasse panels to attack by Hawaii's most damaging structural insect, the Formosan subterranean termite.

MATERIALS AND METHODS

The suitability of bagasse fiber as a food source for the Formosan subterranean termite *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) was evaluated in a laboratory no-choice feeding test based upon AWPA E1-72 (1). Termite survival was measured, rather than biomass removal, since the termite's habit of mixing soil into the fibrous bagasse made cleaning and weighing of the bagasse impractical. Termite survival on bagasse that was screened to eliminate fines (from two sources) was determined and compared to survival of termites fed

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Table 1. — Formosan subterranean termite survival on bagasse fiber, in comparison to those fed Douglas-fir or starved, in a 4-week laboratory test.

Treatment	Mean survival[a]
	------ (%) ------
Bagasse (Philippines)	77.50 (3.17) A
Bagasse (Maui, Hawaii)	71.45 (8.83) A
Douglas-fir	77.30 (7.69) A
Starved	38.35 (7.35) B

[a] Five replicates of 400 termites per treatment. Means followed by the same letter do not differ significantly at the 0.05 level. Values in parentheses are standard deviations.

Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) heartwood and termites that were starved for 4 weeks (28 days).

Bagasse from a Philippines source was supplied by Mansion Industries, Inc., in the form of miniature compressed bagasse panels (described later). Loose (uncompressed) bagasse from Hawaiian sugar cane was provided by Maui Commercial and Sugar Co., Maui, Hawaii. Douglas-fir samples were sliced from a locally purchased board. Formosan subterranean termites were collected from an active field colony on the Manoa campus of the University of Hawaii immediately before their use in laboratory assays (13). Test containers were 80 mm in diameter by 100 mm high screw-top plastic jars, each containing 150 g of washed and ovendried silica sand and 30 ml of distilled water. Termites in each container were provided with either 1) 8 g of bagasse removed from one of the compressed blocks; 2) 8 g of bagasse from Maui; 3) Douglas-fir wood; or 4) no food source. Termites (360 workers and 40 soldiers to approximate natural caste proportions) were added to each jar, with 5 replicates of each of the 4 treatments, and the jars were placed in an unlighted controlled-temperature cabinet at 28±0.5°C for 4 weeks. At the conclusion of this period, termite survival was recorded. Proportional termite survival was transformed by the arcsine of the square root and subjected to analysis of variance (ANOVA); means significantly different at the 0.05 level were separated by the Ryan-Einot-Gabriel-Welsch multiple F test (11).

For field tests of termite resistance of compressed bagasse panels manufactured by the Envirocor process (4,8,9), sample miniature panels (blocks) approximately 100 mm on each side were prepared by Mansion Industries, Inc., by heat extrusion (205°C) of the compressed fibers, with no additives. In order to test the termite resistance of the 2-mm exterior acrylic/vinyl coating, as well as the susceptibility of the bagasse fiber, one set of the finished miniature panels was coated on all six sides; another set was uncoated and wrapped only with kraft paper (bonded with a film of urea-formaldehyde resin adhesive) on four sides so as to leave two ends open and the compressed bagasse fibers readily exposed to foraging termites. Mean mass of the uncoated miniature panels was 80 g, while the acrylic/vinyl latex coating added an additional 20-g mass. A third set of fully coated samples was also prepared that had been dipped before coating in a 1 percent aqueous solution of disodium octaborate tetrahydrate (Tim-Bor®, U.S. Borax, Inc., Valencia, Calif.) to achieve retentions of approximately 1 percent in the bagasse fiber (based on mass change of the samples due to solution uptake).

Three panels from each of the three treatments (untreated + uncoated; untreated + coated; treated + coated) were placed, individually, in contact with foraging termites at an active field site on the Manoa campus of the University of Hawaii using procedures described by Grace et al. (5). To ensure high termite pressure on the panels, a single panel was placed within a wood box, open at the top and bottom, and the box was placed over a hollow concrete block (51 mm high) on the soil surface. Each of these individual replicates was covered by a 5-gallon metal can; termites had been actively foraging on wood within each of these "traps" prior to installation of the test materials. The two sets of untreated test samples (three replicates per set) were left in place for 4 weeks, with weekly observations; the three borate-treated samples were examined after 7 weeks in the field.

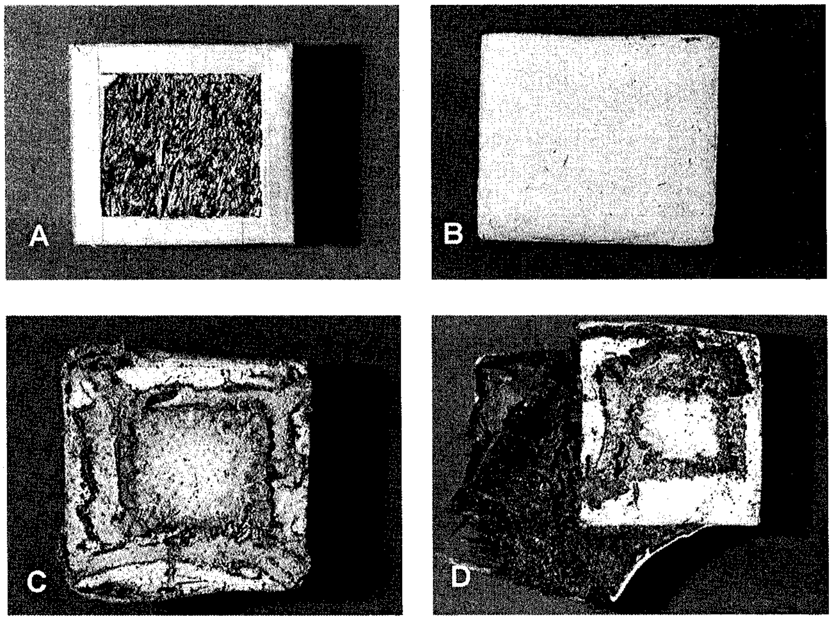

Figure 1. — Uncoated (A and C) and coated (B and D) bagasse fiber test panels before (top) and after (bottom) field exposure to termite attack for 4 weeks.

RESULTS AND DISCUSSION

As indicated in **Table 1**, termites survived about as well on a diet of bagasse as they did on Douglas-fir lumber. In the field test, termites also readily penetrated both the coated and uncoated panels and tunneled throughout the compressed bagasse fibers. Due to the propensity of the termites to move large amounts of soil into their food source, plus the swelling of the bagasse fibers, which severely deformed the panels, it was not possible to measure the amount of bagasse actually removed from the panels by termite feeding. However, the results of the laboratory test would certainly suggest that feeding occurred in the field, in addition to the damage resulting from extensive termite tunneling among the coarse fibers.

Multiple termite penetrations of the exterior latex coatings were apparent after 1 week in the field. At the conclusion of the 4-week exposure, the latex coating on each panel had been forced open on several sides by swelling and separation of the interior fibers, with the blocks increasing from 0.25 to almost 2 times in size as the fibers pushed outward and termites imported soil and constructed "carton" (a mix of soil, masticated cellulose fiber, and salivary and fecal secretions) within the panels (**Fig. 1**). At the conclusion of the 7-week exposure, the borate-treated panels were observed to have suffered the same penetrations and deformations as the untreated panels.

These results demonstrate that bagasse fiber is susceptible to Formosan subterranean termite attack. Although this study provided no evidence that bagasse fiber is actually preferred by termites to solid wood, bagasse proved to be equally suitable as a food source, and termites tunneled readily within the compressed fiber panels. Neither an acrylic/vinyl exterior coating nor preservative treatment of the fibers prevented termite penetration of the panels. Once such penetration occurred, moisture intrusion resulted in swelling of the fibers and deformation of the panels. This certainly does not negate the value of compressed fiber panels as a building material in more arid, termite-free environments. However, it indicates that stabilization of the fibers to decrease swelling, perhaps by acetylation (10), and the use of an exterior coating either impermeable or repellent to termite foragers is essential for this technology to be practical in tropical regions.

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