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Short communication

# Design and fabrication of a multipurpose table using a composite of epoxy and banana pseudostem fibres

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**Abstract**

This paper describes the fabrication of a multipurpose table using banana trunk fibre-woven fabric-reinforced composite material. The aesthetic value coupled with strength and mechanical properties make banana trunk fibre-woven fabric-reinforced composites a suitable material for furniture making. Design and fabrication details using hand lay up process are described.

**Keywords**: Biocomposites, Household furniture, Natural fibre composites.

Composites as engineering materials have shown steady and continuous development since 1942, when they were discovered (Sapuan, 1998). In view of its versatility, they are used in aerospace, automobile, electrical, construction, and sports equipment industries. Composites involving natural fibres have additional advantages such as environmental friendliness, and renewability (Sapuan et al., 2005). Banana (*Musa acuminata* Colla) psuedostem-fibre is an abundant agricultural waste product in many tropical countries; however, it has been seldom used for commercial purposes. It is rich in cellulose and bonded by lignin to form the cellulose fibre. The engineering properties of banana fibre include width (diameter) of 80 to 250 mm, density of 1.35 g $cm^{-3}$, volume resistivity at 100 V of 6.5 to 7 W cm x $10^5$, elastic modulus of 8 to 20 G $Nm^{-2}$ and elongation of 1.0 to 3.5% (Sapuan and Maleque, 2005). Although many studies have been conducted in which widely used conventional materials were substituted in engineering applications with natural fibre components (Lai et al., 2005; Sapuan and Maleque, 2005; Arib et al., 2006), use of woven banana-based fibre composites in the development of household furniture was seldom tried. Hence an attempt was made to design and fabricate a household multipurpose table using an epoxy composite reinforced with banana fibre-woven fabric.

Trunk fibres of *M. acuminata* (locally known as *berangan*) were extracted from mature banana pseudostem sheaths after the fruit bunch was harvested. *Berangan* was chosen as the source of reinforcing fibres in our study because of its abundance in Malaysia. For fibre extraction, the pseudostems were cut into lengths of convenient size, and peeled layer-wise (Fig 1 b and c). The individual sheaths were dried under sun for two weeks and thereafter soaked in water (another two weeks). After separating the lignin and cellulose, the sheaths were dried again and the fibres ripped off (Fig. 1 d and e). To orientate the fibres correctly in the composite material, the dried banana fibres were hand-woven into a soft and flexible mat (Fig. 1f).

To design the multipurpose table, eight concepts (Table 1) were evaluated using criteria such as stability of the product, cost of production, ease of manufacture, reliability of service, ergonomic aspects, low setup time, and ease of transport (Sapuan, 1998). The design team

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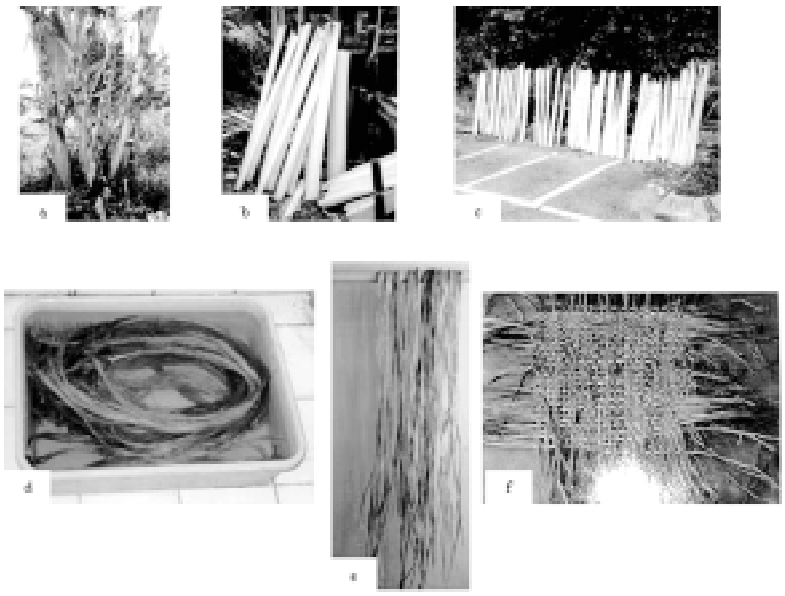

*Figure 1*. Extraction and pre-processing of banana trunk fibres (a) banana trees (b and c) banana pseudostems (d and e) loose fibres (f) woven fabric of banana stem fibre.

gathered information on cost, stability, and other criteria, and all concepts were evaluated using a five-point-scale. Different *R* values (rating for a characteristic) were tried during the brainstorming session carried out in the engineering design laboratory. Concept 8, which got the highest score (Table 2) was finally chosen and the design prepared (Fig. 2).

Fabrication involved preparation of the mould using a square plate of plywood with 500 mm side, and several rectangular pieces. Plywood was chosen because of its surface stiffness and good finish. The rectangular pieces (length 45 mm, and width 20 mm) were arranged to form the mould on a piece of plywood and silicon glue was used to join them. Separate moulds were prepared for the horizontal table-top and vertical stands. The matrix used for laying banana fibre was a mixture (4:1 ratio by weight) of epoxy 3554A (density of 1.15 g $cm^{-3}$) and

*Table 1*: Concept evaluation of a multipurpose table.

| Concepts | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Characteristic | W | R | S | R | S | R | S | R | S | R | S | R | S | R | S | R | S |
| Stability of product | 5 | 4 | 20 | 5 | 25 | 5 | 25 | 3 | 15 | 5 | 25 | 2 | 10 | 5 | 25 | 4 | 20 |
| Cost of manufacture | 5 | 3 | 15 | 2 | 10 | 2 | 10 | 2 | 10 | 2 | 10 | 3 | 15 | 2 | 10 | 5 | 25 |
| Ease of manufacture | 4 | 3 | 12 | 3 | 12 | 2 | 8 | 2 | 8 | 3 | 12 | 5 | 20 | 3 | 12 | 5 | 20 |
| Reliability of service | 5 | 4 | 20 | 4 | 20 | 4 | 20 | 4 | 20 | 4 | 20 | 3 | 15 | 4 | 20 | 3 | 15 |
| Ergonomic to user | 3 | 2 | 6 | 3 | 9 | 4 | 12 | 4 | 12 | 2 | 6 | 3 | 9 | 4 | 12 | 4 | 12 |
| Low setup time | 3 | 3 | 9 | 2 | 6 | 1 | 3 | 1 | 3 | 3 | 9 | 4 | 12 | 2 | 6 | 4 | 12 |
| Ease to carry and light | 3 | 3 | 9 | 3 | 9 | 3 | 9 | 4 | 12 | 3 | 9 | 4 | 12 | 2 | 6 | 4 | 12 |
| Total Score | | | 91 | | 91 | | 87 | | 80 | | 91 | | 93 | | 91 | | 116 |

Note: W is the weight factor for a characteristic; the higher weight factor for a characteristic means the said characteristic is more important to the design. R is the rating for a characteristic. S is the product of W and R. The total score for a concept is obtained by the summation of all values of S.

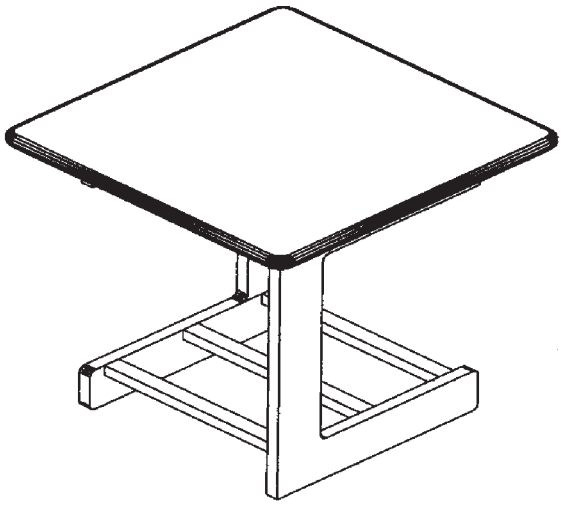

*Figure 2*. Design of composite multipurpose table (height = 430 mm and side of rectangular table top = 400 mm).

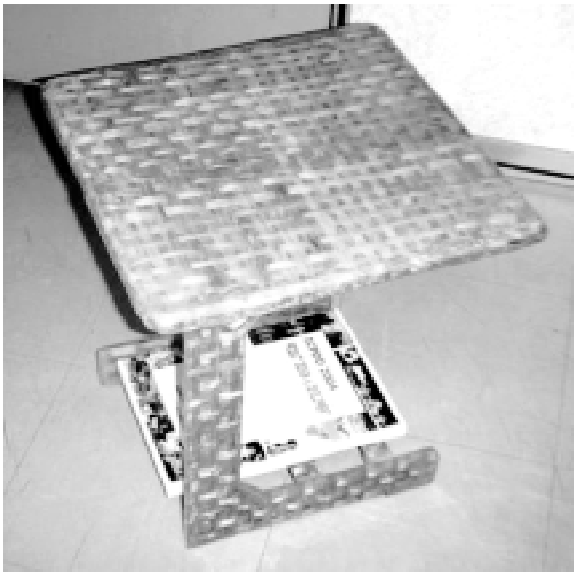

*Figure 3*. A banana pseudostem fibre epoxy composite multi-purpose table.

hardener 3554B (density 1.05 g $cm^{-3}$) prepared by gentle stirring to avoid air bubble formation. Commercially available epoxy and hardener were used for this purpose. The mould was cleaned and dried, and the release agent laid on the mould's inner surface using a brush to which the banana woven fabric was added. This process was repeated until four layers of epoxy and fibre were obtained. Thereafter, the composite was consolidated and cured at room temperature (24 h), after which it was detached from the mould. Mechanical fasteners were used for joining the vertical stands and horizontal tabletop. Slotted countersunk screws with 6 mm length were used with L-type PVC bracket to join the top and middle plates to the vertical stand. The item (Fig. 3) so made was lightweight (4.25 kg), compact, stable, and easy to transport with an aesthetically pleasing golden brown colour. Banana fibre, which otherwise is considered a waste product, could thus become a useful raw material for producing reinforced composites with household furniture applications and may replace the conventional metallic, non-metallic, wood, and plastic materials to some extent.

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