AGROTECHNOLOGY & FOOD INNOVATIONS
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Binderless board and moulded products produced from whole coconut husks

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A simple and efficient technology has been developed to produce high strength - high density board materials from whole coconut husks, without the addition of chemical binders. The board material has been shown to exhibit excellent properties, which are comparable with or even superior to commercial wood based panels.

Principle of the process

The coconut husk is composed of coir fibre and pith, which for traditional fibre applications in woven carpets, ropes, brushes and matting have to be separated. This can be achieved by retting procedures or mechanical decortication. The residual pith, however, contains a large amount of lignin, which has been demonstrated to act as a thermosetting binder resin for the coir fibres[1].

After separation from the coconut, the husk was refined to small particles and short fibres using a simple opening technique by dry hammer milling, yielding suitable material for conversion into boards by hot pressing (figure 1). The boards show mechanical properties (strength of 50 MPa and stiffness of 5 GPa) comparable to those of commercial MDF and surpassing those of particle board (strength of 15 MPa and stiffness of 3 GPa). The thickness swelling and water absorption of coconut husk board is lower than for MDF. After immersion in water, the coconut husk binderless boards show mechanical properties that surpass those of MDF by a factor of two. The density of the coconut husk boards (1.3 – 1.4 g/cm^3), however, is higher than for commercial MDF and particleboard (0.8 and 0.7 g/cm^3 respectively). This performance opens good possibilities for the development of cheap and strong building materials. In principle 3D moulded products can be produced as well, such as beams, laminates, cups, trays or plant

pots. Products of varying shapes or moulded parts with lower densities can be produced with proportional lower mechanical properties. Fine tuning of the processing conditions would therefore be required.

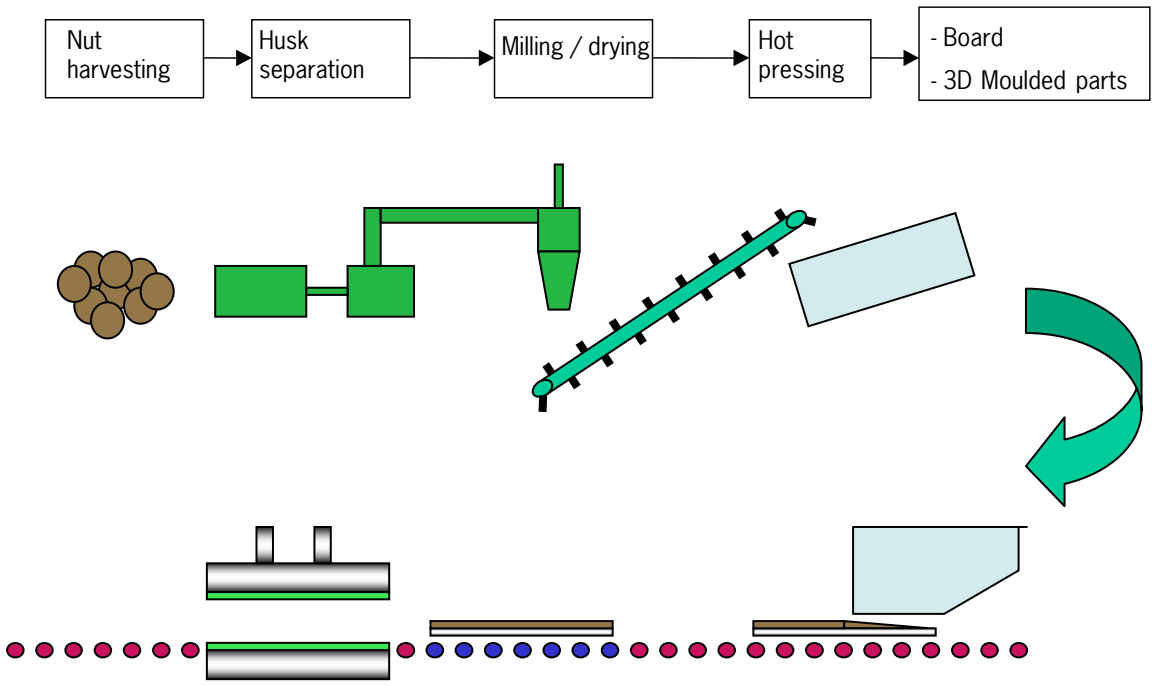

Figure 1. Overview of the processing chain from coconut to binderless board.

Availability and potential

Coconuts are abundantly growing in coastal areas of tropical countries. The husk surrounding the nutritious nut is abundantly available as cheap residue from coconut production, which is known to yield the coarse coir fibre and pith, that currently finds more and more use as peat moss substitute in artificial horticultural substrates. Those husks comprises circa 30 wt.% coir fibres and 70 wt.% pith based upon dry weight. Finding novel added value as wood substitute for building applications could create novel economic activities in rural areas.

The market potential for timber replacement is impressive. The annual world consumption of timber is in the order of 300 million tons. Annual world production of approximately 40 million tons of coconuts (corresponding to $\pm$ 25.000 million coconuts) yields more than 2 million tons of fibres of which only a small part is exploited. The world production of coir fibres is estimated at $\pm$400.000 tons annually. There is no need to enhance the volume of the annual production as only 15-20% of the available coir fibres is currently utilised.

Economic evaluation of the production process and price comparison with competing products

For production at industrial scale different scenarios are possible:

a) Primary board production plant with decentred husk processing at farmers' site;
b) Primary board production plant including central husk processing, and
c) Board production plant as a part of an integrated coconut refinery plant

Scenarios a) and b) have been economically evaluated. Scenario b) appears to be the most favourable option, which is due to cost reduction in energy consumption (economy of scale). In addition, practical constraints related to local husk processing - especially in mountainous areas - make scenario a) an undesirable choice.

Optimum annual production rate is estimated at 10-20 kilo tonnes of finished product. This requires an investment of 55-90 million Pesos. A production of 20 kilo tonnes board material (4*8 ft., 1/4 inch thick), which needs approx. 155.000.000 nuts (20,5 kilo tonnes raw material, 100 km^2 surface with PCA hybrids), can produce *export* quality at 240 peso/board and *local* quality at 180 peso/board. Return of investment is 25%.

Scenario c) is currently being evaluated. Assuming that both raw material- and energy cost can be reduced, which consume more than 70% of the production costs under scenario b), the market price of both export and local quality coirboard is expected to become significantly lower.

Status of development

The conditions for high performance board production have been determined on lab scale and semi industrial scale in The Philippines. The techno-economic calculations on production scale, investments and feasibility of the production have been critically evaluated. Demonstration of the production on pilot scale - three to six months continuously - will be performed in the coming period. The price performance ratio of products based on coir husk has been compared with competing market products. Comparison with large-scale wood based MDF board materials and with particleboard materials shows promising perspectives for binderless building board production. Involvement of industrial parties and investors in the process, design and marketing of products will be the first requirement for implementation of the technology.

Demonstration of the pilot-line facilities can be arranged for interested entrepreneurs. The technology is in principle available for contributing UN member countries[2] with interest in value addition for the coconut

fibre and husk. In process fine tuning and product design and development possibilities for market protection for commercial parties should be identified.

Steps to follow

Contacts with several interested commercial entrepreneurs in different countries are on-going and joint activities could be arranged. Parties are invited for participation in implementation projects using the technical know-how generated in this project. Involvement of investors and local governments, entrepreneurs and research institutions will be needed in the dissemination of the promising project results.

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[1] Jan E.G. van Dam, M.J.A. van den Oever, and Edwin R.P. Keijsers - "Production process for high density high performance binderless boards from whole coconut husk. *Industrial Crops and Products* 20 (2004) 97-101.

J.E.G. van Dam, M.J.A. van den Oever, W. Teunissen, E.R.P. Keijsers, and A.G. Peralta - Process for production of high density high performance binderless boards from whole coconut husk.
Part 1: Lignin as intrinsic thermosetting binder resin. *Industrial Crops and Products* 19 (2004) 207-216.
Part 2 - coconut husk morphology, composition and properties. *Industrial Crops and Products* (in print)
Part 3. husk pre-processing and compression conditions (in preparation)
Part 4. board properties (in preparation)
Part 5: techno-economic process evaluation (in preparation)

[2] This project has been funded by the Common Fund for Commodities (CFC), Amsterdam and was supervised by the FAO, Rome.