Republic of the Philippines
FOREST PRODUCTS RESEARCH & DEVELOPMENT INSTITUTE
Department of Science & Technology
College, Laguna

COCOWOOD UTILIZATION IN THE PHILIPPINES: A COMPILATION OF ABSTRACTS

(FPRDI/ITTO/CFC Project)

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FOREWORD

This publication represents the thousands of hours of labor, creativity and diligence put in by Filipino men and women who, during the past three decades, have studied the coconut wood. Judicious policies towards the sustained management of the resource in the next century will benefit from a careful documentation of past research efforts. It is hoped that this volume will be a tool towards this end, as well as a catalyst towards greater cooperation and sharing of information among all sectors who are serious in their bid to increase the significance of coconut wood utilization both in the Asia Pacific and African regions.

EMMANUEL D. BELLO
Director, FPRDI

GUIDE TO ACRONYMS

ASEAN	Association of Southeast Asian Nations
ASTM	American Society for Testing Materials
AUF	Araneta University Foundation
BBC	Basic Building Code
BCR	Benefit Cost Ratio
BOCAI	Building Officials Conference of America, Incorporated
BSMI	Bureau of Small & Medium Industry
CCA	Copper Chrome Arsenate
CEH	Chlorination-Extraction-Hypochlorite
CORD	Cabinet Officer for Regional Development
DAVI	Daraga Agribusiness Ventures Incorporated
DBT	Dry Bulb Temperature
DRC	Davao Research Center
DSS	Dry Shear Strength
EMC	Equilibrum Moisture Content
FAO	Food and Agriculture Organization
FORPRIDECOM	Forest Products Research & Industries Development Commission
FPRDI	Forest Products Research & Development Institute
FSEL	Fiber Stress at Elastic Limit Load
NHA	National Housing Authority
NIDC	National Industrial Development Corporation
NIST	National Institute of Science Technology
NPV	Net Present Value
NPW	Net Present Worth
NSSC	Neutral Sulfite and Semi-chemical
PPR	Philippine Pallet Resources
RC	Resin Content
RH	Relative Humidity
RMC	Research Manager Center
SC	Stoned-cut
SHPV	Spike-Holding-Power Values
SIDP	Samar Integrated Development Project
SU	Siliman University
T & G	Tongue & Groove
UCAP	United Coconut Association of the Philippines
UF	Urea Formaldehyde
UNDP	United Nation Industrial Development Organization
UPLB	University of the Philippines in Los Baños
WBT	Wet Bulb Temperature
ZRC	Zamboanga Research Center

INTRODUCTION

Coconut (Cocos nucifera L.), we all know, is the proud owner of the distinction "Tree of Life." The tree provides mankind with food, shelter, furniture, novelty items, fuelwood, household implements, and important industrial products.

In the Philippines, the decade of the 80's saw lumber from coconut becoming a popular alternative to lumber from traditional wood species. This was brought about mainly by the ban on logging of Philippine forests. Compared with conventional lumber, coconut wood is more available and affordable. However, it is structurally unique and thus needs serious study and consideration.

Over the years, the Forest Products Research & Development Institute (FPRDI) have actively conducted R and D projects on the utilization of coconut stem both for lumber and furniture.

This publication presents the synopses of one hundred thirty nine (139) studies on coconut wood by researchers of the FPRDI, University of the Philippines (UP), the Philippine Coconut Authority (PCA), and some foreign organizations. Aside from results of R & D studies, techno-transfer activities are also featured, along with synopses of some studies on the coconut husk, shell, and coir dust which are waste by-products of coco-trunks utilization.

This compilation is meant to provide cocowood researchers, funding agencies and entrepreneurs with a broad view on what has been done and what still needs to be done in cocowood R & D. The authors hope that the volume would stimulate action towards ensuring the sustainability of the resource and promotion of its efficient use via improved processing methods.

Basic Properties

BALLON C. H. 1984. *Natural Decay-Resistance of Coconut Timber.* Terminal Report. FPRDI, College, Laguna.

Fruiting structures of decay fungi were collected from coconut trunks lying on the ground or used either as fence posts or bridge foundations and girders. Isolates of *Fomes sp., Coriolus versicolor, Polyporus sanguineus, Polyporus sp. A., Polyporus sp. B and Hexagona sp.* from the specimens were used to test the natural decay-resistance of coconut trunks collected from four localities. Test blocks of coconut wood were obtained from the butt, middle and top portions, and from the outer and inner sections of each portion.

The resistance of coconut trunks decreased from the outer to the inner sections and from the butt to the top portions. The coconut trunks collected from four localities also varied in their response to the test fungi.

ESPILOY, E. B. 1985. *An Insight into the Engineering Properties of Coconut Sawnwood for Efficient Utilization.* Report. FPRDI.

This paper presented an overview on: a) the important strength properties of coconut timber; b) the timber strength properties compared with those of some Philippine structural timber species; and c) sorting of coconut sawnwood into grades before assigning an appropriate set of basic working stresses to be used in design.

It is suggested that graded coconut sawn timber be incorporated into the national building code in order to be accepted as a legitimate building material.

ESPILOY, E. B. and F. N. TAMOLANG. 1977. *Bending Strength of Full-Sized Coconut Trunk Poles* . Report. FPRDI.

This study determined the strength in bending of full-size coconut trunks for use as power and telecommunication poles. The strength properties evaluated were MOR, MOE, and FSEL. MOR and MOE were comparable with that of almon (*Shorea almon* Foxw.), mayapis (*Shorea squamata* Turcz. Dyer) and manggasinoro (*Shorea almon* Foxw.) although the FSEL of these species were almost twice as high as that obtained from the coconut trunk. Based on its strength properties, coconut trunks are deemed suitable for power and telecommunication poles for the rural areas.

ESPILOY, Z. B., M. M. MARUZZO, and M. SP. DIONGLAY. 1990. *Properties of Green and Yellow Varieties of Coconut (Cocos nucifera L.).* Report. FPRDI.

This study discussed the natural variation in wood quality arising from differences in anatomical, chemical, mechanical and physical properties of green and yellow varieties of coconut.

The yellow variety averaged higher values than the green variety in fibrovascular bundle frequency, fiber length, cell wall thickness, relative density, compressive and bending strengths, hardness, shear, toughness, amount of hot–water extractives, holocellulose and starch contents.

On the other hand, the green variety had higher values than the yellow variety in vessel length, vessel diameter, moisture content, shrinkage, ash content, alcohol-benzene extractives, one percent caustic soda solubility, lignin, pentosan, and silica contents.

FLORESCA, A. R. 1978. *Bolt-bearing Properties of Coconut Palm Timber Compared with those of Some Philippine Woods.* Terminal Report. FPRDI.

Bolt-bearing stresses of bolt-jointed specimens corresponding to 4 L/D ratio, tested both in compression parallel and perpendicular to the grain of green coconut timber using 1.3 cm (1 1/2 in.) and 1.6 cm (5/8 in) machine bolts were established.

A comparison was made of the average bolt-bearing properties of coconut timber and those of apitong and tangile.

FLORESCA, A. R., F.V. SABANGAN, F. B. TAMOLANG, and M. O. ALCACHUPAS. 1981. *Strength and Related Properties of Coconut Wood Submitted by SIDP.* Report. FPRDI.

Tests on mechanical and related properties were conducted on small clear specimens of two green coconut trees from Legaspi, Albay. The strength and related properties of the healthy coconut were compared with those of the diseased (infected by cadang-cadang) coconut wood.

FRANCIA, P. C. , E. U. ESCOLANO, and J. A. SEMANA. 1970. *The Chemical Composition of the Coconut Trunks, Petioles with Rachides and Leaflets with Midribs.* Report. FPRDI.

Compared to other parts of the coco palm, the leaf blades, including the midribs, had the highest amount of alcohol-benzene (7.6 percent), hot water (9.5 percent), and one percent caustic-soda solubles (47.2 percent); lignin, common with leaflets with midribs, (27.7 percent) and ash (8.1 percent) but had the lowest holocellulose (47.1 percent) and pentosan content (11.6 percent). Trunk fines and screened chips had similar composition except that the former had higher alpha-cellulose (7.5 percent), which was also the highest of all the coconut materials, but lower hot-water solubility (1.9 percent). These trunk materials had the highest holocellulose (68.2 to 68.9 percent) and pentosans (22.4 to 22.5 percent) but the lowest ash (1.2 to 1.5 percent), solubilities in alcohol-benzene (1.8 to 2.1 percent), solubilities in 1 percent NaOH (21.5 to 21.7 percent) and silica (0.02 to 0.03 percent).

MANAS, A. E. and F. N. TAMOLANG. 1976. *Tannin Content of Coconut Tree Bark, Coconut Trunk and Coconut Trunk Core.* Report. FPRDI.

Tannin analysis of representative samples of the bark of a coconut tree, coconut trunk, and coconut-trunk core was conducted using the method of the American Leather Chemist Association and the Method of Stiasny. The bark contained the highest amount of hot-water extractives (11.64 percent total solids), followed by the trunk core. The Stiasny number of the bark was 11.34 and approached the Stiasny number of coconut-coir dust (15.83). The trunk and trunk core had very low Stiasny number and their tannin to non-tannin ratio was less than 1. The bark tannin had a high purity contrary to the trunk and core tannins which were very low in purity. The three samples may not be considered as economical sources of tannin for tanning leather but the tannin from the bark may be suitable for the formulation of a tannin-formaldehyde adhesive .

MANAS, A. E. 1972. *Tannin Extraction of Philippine Tannin-Bearing Materials. Coconut* (Cocus nucifera L.) *Coir Dust.* Final Report. FPRDI.

Tannins were extracted from coconut-coir dust on a pilot-plant scale. A comparative study was made on 4 extraction conditions, using the countercurrent method at the following stages: 6 stages at 1:14 dust-to-water ratio at a temperature of 60°C; 3 and 4 stages at 1:10 dust-to-water ratio at a temperature of 60°C and 4 stages at 1:10 dust-to-water ratio at a temperature of 60°C; and 4 stages at 1:10 dust-to-aqueous-ammonia solution at a temperature of 80°C. Based on the extraction yield and extract analysis, the optimum condition for extracting tannin from coconut-coir dust was 6 stage countercurrent method at 1 hour per stage at 60°C.

MEDRANO, R. N. and F. M. LAURICIO. 1977. *Specific Gravity and Shrinkage of Coconut Palm Timber* (Cocos nucifera L.) *in the Philippines.* Report. FPRDI.

Five coconut trunks collected from Tiaong, Quezon were used in the specific gravity and shrinkage determination studies.

The specific gravity and shrinkage values of coconut timber were compared to common timbers of the country specifically apitong (*Dipterocarpus grandiflorus* Blanco) and yakal-gisok (*Shorea gisok* Foxw.). The radial shrinkage of coconut timber was comparable to those of apitong and yakal-gisok. Moreover, its tangential shrinkage was less than those of both wood species. In specific gravity, coconut timber had a lower value compared to both wood species.

Coconut lumber may be used for flooring, sidings, framings, and other related uses.

MOSTEIRO, A. P. 1982. *The Properties, Uses And Maintenance of Coconut Palm Timber As A Building Material.* Report. FPRDI.

The report summarized results of FPRDI studies in the 1970's on the properties, uses, and maintenance program of coconut palm timber as a building material.

RAMOS, A. N. JR. and R. J. MICIANO. 1966. *The Mechanical Properties of Coconut Palm* (Cocos nucifera L.). Report. FPRDI.

Small clear specimens from five coconut trees were tested for mechanical properties. Findings indicated that coconut palm timbers are not competitive commercially with solid wood having comparable specific gravity as a construction material.

TAMOLANG, F. B. 1985. *Variation in the Bending Strength Properties of Glue-Laminated Coconut Wood.* Report. FPRDI.

The strength properties of glued-laminated coconut wood varied in accordance to its position in the tree stem.

The most suitable combination in coconut wood lamination with regards to bending strength were hard-hard-hard and hard-soft-hard configurations.

Glue-laminated specimens using urea formaldehyde, phenol resorcinol and weldwood glues exhibited high blending properties. As such, any of the three glues can be used for coconut wood laminations for interior purposes.

The solid soft, the soft-hard-soft and the soft-soft-soft glue laminated specimens may be suitable for light construction such as ceiling, window, jalousies, and purlins, wall frames, cloddings, sash, panellings, novelties, household implements, and other ornaments requiring less strength.

On the basis of the MOR and MOE values, the solid hard and the hard-hard-hard or hard-soft-hard glue-laminated specimens may be used for general framing, conventional furniture and cabinetry, paneling, flooring, door and window frames, stairs and railings, sidings, pallets, joists, scaffolding, shingles and siding boards.

Working Properties

DE LA CRUZ, R. Z., D. V. SIBAYAN, and A. S. DECENA. 1976. *Sawing of Coconut Trunks into Lumber.* Report. FPRDI, College, Laguna .

The sawmilling of coconut trunks was carried out and found feasible. Different sawblade treatments and sawing techniques were studied to find suitable ways of breaking coconut trunks into lumber.

Of the three sawtooth treatments, stellite-tipped sawblade with average surface area of 46.19 sq. m. sawn per blade was found most efficient.

Chainsawing of coconut trunks into lumber

DE LA CRUZ, R. Z., A. S. DECENA, and D. V. SIBAYAN. 1975. *Study on the Sawing Characteristics of Coconut*. (Cocos nucifera L.) *Trunks*. Report. FPRDI.

The sawing performance of different sawblades, recovery and production standards in breaking down coconut trunks into dimensional pieces like lumber was investigated.

The two tooth-treatments applied on the blades, namely, the alternately swaged and the stellite-tipped, resulted into better sawing performance by 5 and 10 sq. m. respectively, over the all swaged control blades. The average percentage recovery of the coconut trunks with respect to its merchantable volume was 42.5 percent, while the rate of sawing per hour was 5.35 trunks (4 meters long each) which was equivalent to 0.963 cu. m.

EALA, R. C. and F. N. TAMOLANG. 1976. *Exploratory Study on Machining Properties of Coconut Lumber*. Report. FPRDI.

This study determined the suitability of coconut lumber for secondary-wood products such as furniture, fixture and the like. It focused on the behavior of coconut trunk when subjected to standard machining such as sawing, planing, boring, turning, mortising and shaping.

Coconut lumber had relatively good machining characteristics. Rip-sawing properties of 3-mm. thick fresh coconut lumber were acceptable even with the use of standard high-speed steel-blade circular saw. Planing fresh material seemed easier than planing the dried ones. Shaping along the grain produced 100 percent defect-free machined surfaces, although 10 percent had slight burnt surfaces in shaping across the grain. However, the rough and slight burnt surfaces could be removed by slight sanding.

Coconut lumber is promising for turned products, although the turning quality of the material is not as good as most hardwoods. Slight sanding technique could be developed to produce the desired results.

EALA, R. C. and F. N. TAMOLANG. 1976. *Special Treatment of "Soft" Coconut Lumber*. Report. FPRDI.

The study explored utilization techniques for the soft portion of the coco trunk. It evaluated the quality of seasoned soft coconut lumber subjected to treatments by boiling and steaming.

Stabilized dried-coconut lumber, 2-cm. thick can be attained by boiling the fresh boards for 3 hours or by steaming them for 2 hours under atmospheric condition.

GERMAN, E. C., F. R. SIRIBAN, and F. N. TAMOLANG. *Fire Resistance of Coconut Lumber Treated with Fire-Retardant Chemical.* Report. FPRDI.

A fire-tube test for determining the fire-resistance of untreated and treated coconut lumber was studied. Test results using ASTM Standard E69-50 indicated that a minimum retention of 48-64 kg dry salt per cubic meter of Pyrolith M on coconut lumber was effective in retarding the spread of fire. This retention provided protection which excelled the acceptance criteria of the BBC, BOCAI, for fire-tube test of wood which provided maximum loss of weight of 20 per cent.

Coconut lumber specimens were treated with fire-retardant chemical at five levels of concentration. Treatment efficiency of 50 percent provided enough protection against fire hazard. Treatment by pressure, which surpassed other methods such as brushing, dipping, and soaking, is recommended to obtain the desired loading or retention.

LAXAMANA, M. G. 1980. *The Drying of Coconut Sawn-Lumber and Pole.* Terminal Report. FPRDI.

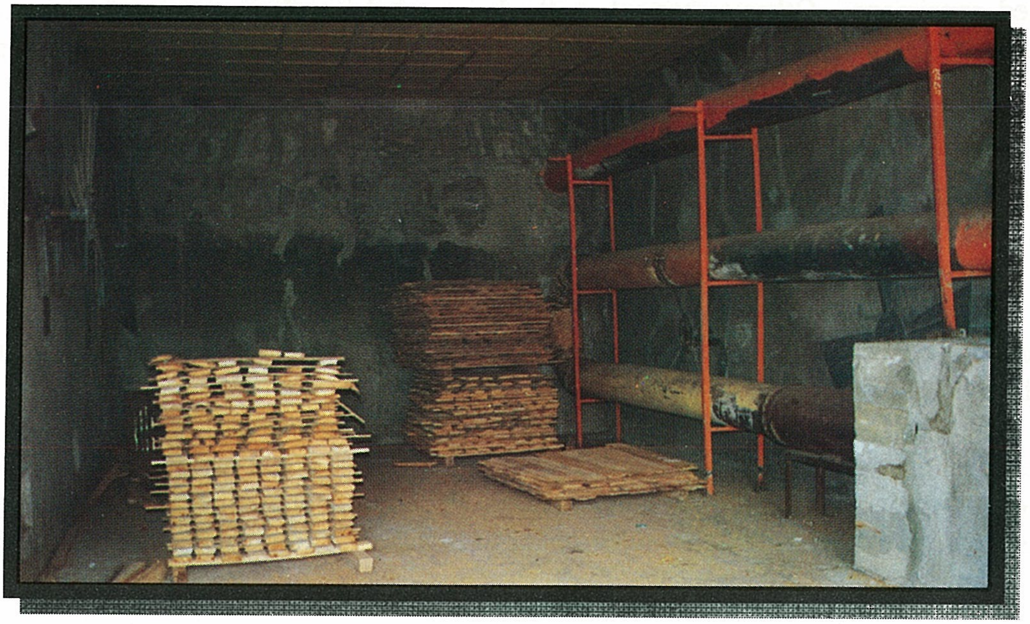
EMC of 13-18 percent by air-drying of 25- and 50- mm thick coconut lumber required 3-20 weeks and 16-21 weeks, respectively. The combination of pre-drying and kiln-drying reduced kiln -residence time. Drying time and quality were influenced by the initial MC, density of the boards, period of exposure, position of the board as well as kiln condition employed.

Average kiln-residence time of 25-mm thick board from green to 9.6-11.53 percent MC ranged between 106-96 hours (4 days). For 25-mm thick board the time from green to 10.91-18.56 percent MC was 12.5-20 days; and 18-20 days from green to 15.05-20.50 percent MC for the 50-mm thick.

LAXAMANA, M. G. 1984. *Drying and Conditioning Treatments to Control Warp in Coconut Trunk Lumber.* Terminal Report. FPRDI.

Mature coconut trunks sawn into 50-mm thick lumber were studied to determine the effects of three drying methods (air drying; kiln drying and forced-air drying) on the development and nature of drying degrades, identify the portion of the trunk susceptible to these defects and find measures to minimize and/or check their occurrence.

Coco lumber suitable for housing and furniture components were obtained from the butt than the middle and top portions of the trunk. Collapse was predominant in the core-containing board at the top portion of the trunk. Surface checks tended to develop more on the bark-side of the board sawn from the butt. Boards from the butt and middle sections were prone to twist. These defects were appreciably reduced by air-drying.



Kiln dried coco lumber

LAXAMANA, M. G. and G. Y. TAMAYO. 1976. *Study on Drying Characteristics of 2.54 cm. Thick Coconut Lumber.* Report. FPRDI.

Coconut lumber 2.54 cm thick x 152.4 cm long (1" x 60") was air and kiln-dried to obtain information on its drying characteristics.

"Green" or wet materials containing an average MC of 114.4 - 122.8 percent attained an average final MC of 10.6-10.7 percent after kiln drying for about 6 days, including a 10-hour conditioning treatment. Thorough air-drying of materials having same thickness reached EMC of 17-19 percent within 2 1/2 months.

The application of 2-hour "reconditioning" treatment appreciably removed collapse and warp that developed in some boards. Serious surface checks did not occur when an initial DBT of 65 °C (149°F) and 63°C (145°F) WBT were used.

MOSTEIRO, A. P. 1971. *A Preliminary Report on the Treatment of Coconut Trunk (Cocos nucifera L.) and Other Palm Species in the Philippines.* Report. FPRDI.

This report presented results of the preliminary studies conducted on the treatability of trunks of coconut and other common palm species in the Philippines, using coal-tar creosote as preservative.

Of the three treatment methods employed, conditioning by boiling-under-vacuum followed by the Full-Cell process gave almost total penetration of preservative in the treated specimens. Other treatment methods revealed insufficient creosote penetration and distribution, probably due to the high moisture content of the specimens, especially in the core portion.

MOSTEIRO, A. P. 1986. *The Need for an Industrial Utilization of Coconut Wood.* Report. FPRDI.

This paper was presented during the training-seminar on Coconut Wood Furniture Manufacturing, sponsored by the Small Business Advisory Center, BSMI, Ministry of Trade and Industry on March 27-29, 1985 in Davao City.

To find out the potential uses of coconut stem, initial investigations were undertaken on some of its basic wood properties. Research and development on coconut wood to replace conventional wood species for some commercial products became a major activity . These findings were acknowledged with interest by both coconut and non-coconut producing countries.

MOSTEIRO, A. P. 1979. *Machining Properties of Coconut Wood.* Report. FPRDI.

Machining coconut wood into various-end products using ordinary machine blades and tool bits led to the fast dulling of saw blades, planer blades, shaper knives, drill bits and other machine tools. The dulling effect could be attributed to the presence of silica-containing cells called "stegmata" which are associated with the vascular and non-vascular fibers. The problem was overcome by using carbide-tipped tools.

SIBAYAN, D. V., A. S. DECENA, and R. Z. DE LA CRUZ. 1976. *Study on the Sawmilling Characteristics and Recovery of Coconut (Cocos nucifera L.) Trunks.* Terminal Report. FPRDI.

The sawmilling characteristics and recovery of coconut trunks indicated the feasibility of milling coconut into lumber. Using stellite-tipped blades in a bandmill, the output recovery was 49.19 percent. Two other blade treatments namely, alternate-swaging and all-swaging were found less effective. The standard input production rate found for these two treatments were 0.47 and 0.35 cu. m. per hour, respectively.

SIRIBAN, F. R. and C. L. PABUAYON. 1990. *Preservative Treatment of Coconut Poles by HPSD Method.* Report. FPRDI.

Cocowood pole can be treated by HPSD using CCA preservative at a minimum pressure of 1.05 kg/m^2.

Treating time was dependent on the number of days that the stems have been felled. An average retention of 9.81 kg/m^3 based on average volume was attained at 6 percent CCA concentration. Assuming that 70 percent of the total volume is treated, the retention would be 14.01 kg/m^3, which is close to the minimum standard requirement of 16 kg/m^3. Retention can be increased by increasing the preservative concentration to 8 percent .

On-going HPSD *treatment*

Process and Product Development

Sawmilling of Coco Lumber

ALCACHUPAS, P. L., R. C. EALA, and D. G. QUINONES. 1984. *Sawmilling and Processing of Coconut Trunks into Lumber & Lumber Products for Flooring & Sidings.* Terminal Report. FPRDI.

The investigation assessed some sawmilling characteristics of coconut trunk, determined the economics of its conversion into lumber and lumber products such as flooring and sidings, and identified the market for coco lumber products.

The mill study was carried out at FPRDI sawmilling laboratory (Mill A- 1371 mm diameter flywheel; vertical type bandmill; McKay make), Madera Imelda Sawmill Plant in Sariaya, Quezon (Mill B- twin circular; 508 mm top and bottom; headsaw; 75 hp diesel run) and at the sawmill in Carcar, Cebu (Mill C- backyard type bandmill with 914 mm diameter wooden flywheel powered by 12 hp electric motor).

The daily average production (8-hr) of the mills were 1,440 bd. ft. (3.40 m^3) for Mill A, 1,085 bd. ft. (2.56 m^3) for Mill B and 619 bd. ft. (1.46 m^3) for Mill C.

The conventional high speed bandsaw blade produced the least volume of lumber among the three types of mill studied, i.e. FPRDI bandmill and Madera Imelda Sawmill.

BAUZA, E. B., F. M. LAURICIO, and L. V. VILLAVELEZ. 1984. *Development of Industrial Pallets Out of Coconut Lumber.* Report. FPRDI.

Pallets were fabricated from "coco-hard" and "coco-soft" and tangile lumber. A two-way entry, reversible, flush stringer pallet of 900 mm x 900 mm claimed to be practical and more efficient was adapted. Comparative performance of the pallets from these materials was tested in the laboratory based on ASTM standards.

In the corner-drop test, all the pallets withstood the drops on all the Four Corners at 60 cm and 120-cm height. At a height of 150 cm, coco-hard withstood 5.25 cycles, while the other pallets were heavily damaged and could no longer be used with usual mechanical handling devices.

In the incline-impact test, all pallets performed well. They withstood the impact from 140 cm to 550 cm on the 13° incline without major damage. Only slight splits and minor damage were observed.

CHAN, F. D. 1985. *Development of Extender Filler for Plywood Adhesives from Coconut Coir Dust.* Terminal Report. FPRDI.

The possibility of using coconut coirdust as extender filler in plywood adhesive was investigated.

The water taking capacity of the coconut coir dust samples was 2-4 which was comparable to that of imported wheat flour. The size of the particles, however, should be reduced to 300 mesh.

DECENA, A. S. 1976. *Hewn Lumber from Coconut Trunk - A New Business Venture.* Report. FPRDI.

An average-sized log, 22 cm in diameter and 8 m long can be hewn into 4 pieces of 2" x 6" x 24' lumber. When the soft core is removed, each quarter moon shaped piece contains 24 bd. ft. or 96 bd. ft. for each log length (a 62 percent recovery). Contract cost for hewing coconut trunks into this thickness and width is ₱ 1.25 per linear meter or ₱ 10.00 per piece. This kind of hewing cost ₱ 0.42 per bd. ft.

EALA, R. C., D. G. QUIÑONES, and A.A. SALITA. 1984. *Design, Fabrication & Evaluation of a Portable Sawmill for Processing Coconut Trunks & Small-Size Logs.* Terminal Report. FPRDI.

The study sought to design, fabricate and evaluate the performance of a portable sawmill which is transportable to areas having the raw materials.

The experimental bandmill had two basic components, namely, a head bandsaw and a carriage traveling on a pair of steel rail tracks. The head band saw consisted of a flywheel assembly that moved up and down on a pair of worm and screw mechanism or "setworks" mechanism. It also included an internal combustion engine.

The carriage component was a 3.00 x 1.20 platform with a dogging mechanism fitted to four machined wheels. The carriage platform can travel to and fro horizontally on a pair of 8 m steel rails. On the maximum, the bandmill could accommodate 60 cm diameter log.

EALA, R. C., F. N. TAMOLANG, and A.P. BATI. 1976 *Face Veneer from Coconut Trunk.* Report. FPRDI.

This study determined the suitability of coconut trunks for producing face veneer for use in the manufacture of plywood, furniture and fixture components.

Coconut trunk was not suitable for rotary veneer cutting under ordinary or preheated bolt treatment and standard peeling process. Veneer produced was non-continuous, corrugated, very rough, split-laden, and very weak along the grain.

Coconut trunk, however, was a potential source of sliced-face veneer from flitches cooked at 82° C for 10 hours, and dried in a wire-mesh type dryer with mild drying schedule. Its attractive glossy surface favors its use as face for high-priced plywood panels and other luxury items.

EALA, R. C. 1980. *Sliced Veneer from Coconut Trunk for Plywood.* Final Report. FPRDI.

The production of sliced-coconut- veneer face plywood was found to be highly feasible. Eighty panels were fabricated using the manpower, machines and manufacturing conditions in two plywood plants in Mindanao.

ELAZEGUI, T. A., E. P. VILLANUEVA, and B. O. BAWAGAN. 1978. *Dissolving Pulp from Coconut Trunk Chips.* Report. FPRDI.

A comparative study among prehydrolysis-kraft, prehydrolysis-soda and prehydrolysis-alkaline sulfite processes in the production of dissolving pulp from coconut trunk chips was conducted. The tested materials responded satisfactorily to the first two processes giving a permanganate number of 16.21 and 17.67, respectively.

Except for the relatively low pulp yield, the unbleached soda pulp purified chemically by multi-stage bleaching gave satisfactory results. The chemical and physical properties of the obtained high alpha pulp were within and in some aspects, better than the minimum specifications for viscose grade pulps.

ESPILOY E. B. 1977. *Coconut Trunks for Power and Telecommunication Poles.* Report. FPRDI.

The strength properties of coconut trunk in bending were more variable than those of solid wood. The variability of coconut trunk was about twice as high as some Philippine woods in bending.

ESTUDILLO, C. P. *Coconut Shell Charcoal and Briquettes: Their Quality, Production Cost and Uses.* Report. FPRDI.

The study presented the different methods for producing coconut shell charcoal practised in the Philippines.

The quality and various utilization aspects of the coco shell charcoal were briefly discussed. Production cost incurred in the manufacture of the charcoal and briquettes was determined.

Coconut shell charcoal and briquette production venture was found profitable.

EUSEBIO, D. A. and M. SUSUKI. 1990. *Production and Properties of Plant-Materials Cement-Bonded Composites.* Bulletin of the Experiment Forests. No. 27, pp. 27-38, Tokyo University of Agriculture and Technology, Tokyo, Japan.

The compatibility with cement of three plant-materials namely, giant ipil-ipil (*Leucaena sp.*), rice straw and coconut coir dust was investigated. The cold-water and alcohol-benzene soluble extractives of coconut coir dust had little adverse effect on the strength of hardened cement. For coconut coir dust board, maximum modulus of rupture is obtained with a water: cement ratio of 0.8 and optimum material ratio should be 20:70:10.

FLORESCA, A. R., F. R. SIRIBAN, and A. P. GESMUNDO, 1987. *Design and Development of Roof Shingles: Coconut Palm (Cocos nucifera L.) and Kaatoan Bangkal [Anthocephalus chinensis* (Lamk.) Rich. ex. Walp*].* Terminal Report. FPRDI.

Tapered roof shingles from coconut and Kaatoan bangkal woods differed in their fabrication, treatment and installation costs. Fabrication cost for coconut shingles was 42.9 percent higher than the kaatoan bangkal shingles. The treatment cost was higher in thicker shingles and medium density coconut shingles than the thinner shingles and high density coconut shingles. In installation cost, coconut shingles was 23.7 percent more expensive than the Kaatoan bangkal shingles.

The shingles were still in good condition after 11 months of outdoor exposure. The most suitable combination of thickness, nailing pattern and treatment for high density coconut shingles were any of the thicknesses tested with two nails and with treatment of either copper-chrome-arsenate or pentachlorophenol. In medium density coconut shingles, any of the thicknesses and nailing patterns and with treatment of either pentachlorophenol or copper-chromo-arsenate can be used. In both the high and medium density coconut wood shingles, the thinner with two nails and treatment of copper-chromo-arsenate was preferred for reasons of economy and ease of installation.

In the cost comparison study, coconut wood roof shingles was 1.23 percent cheaper than the GI corrugated sheets roofing based on ₱3.50/bdf sale price of coconut lumber. If the production cost of coconut lumber was ₱ 1.30/bdf., coconut wood shingles will be cheaper by 20.02 percent than the GI corrugated sheets roofing.

FLORO, M. 1963. *Mechanical Process of Defibering Coconut Husks.* Report. FPRDI.

About 30 percent of the coconut husk is useful fibers while the remaining 70 percent is waste. This waste consists of pulpy material (coir dust) and short fibers. Defibering of coconut husks is done either by hand labor or by machine.

It has been customary to ret coconut husks before the fibers are separated from the coir dust. Retting consists of soaking the coconut husks in water until the coir dust loosens from the fibers. Retting time usually takes about a year.

Coconut Fibers

Coconut-Wool Cement Boards

GENERALLA, N. C. 1985. *Formulation and Fabrication of Coconut-Wool Cement Boards.* Terminal Report. FPRDI.

The technical feasibility of producing cement-bonded panels using coconut trunk was studied through actual board manufacture. Suitable excelsior or "cocowool" was obtained by shredding fresh coconut trunk. Soaking the cocowool in water for 3 days prior to mixing with cement and water leached out some extractives, which inhibited cement curing.

Experimental boards were made with varying amount of cement, coco-wood, water and cement-setting accelerator. Board density was also varied. Optimum manufacturing formulations and conditions were evaluated by testing the modulus of rupture, internal bond, and thickness swelling of the different boards.

Strong cement-bonded boards may be made from the coconut trunk at board densities equal to or greater than 1100 kg/m^3 and at a proportion of cement equal to or greater than 70 percent by weight.

GENERALLA, N. C., G. A. EUSEBIO, and A.A. PABLO. 1984. *Studies on Improving the Properties of Coconut Trunk Particleboards.* Report. FPRDI.

The optimum particle type that will produce coconut trunk particleboard of acceptable strength and appearance was determined in the laboratory and confirmed in the pilot plant. In a laboratory -scale study, one-and 3-layer particleboard of 750 kg/m^3 board density were made using three types of coconut trunk particles (herein referred to as Levels A, B and C) and urea-formaldehyde resin. In the 3-layer boards, RC was 12 percent for the surface and 6 percent for the core while in one-layer boards, the RC was 9 percent.

Level C with surface particles retained in 0.25-mm (Mesh 60) screen and core particles retained in 1.0 mm screen (Mesh 16) was found to yield boards with adequate physical and mechanical properties. However, in terms of economy in labor and materials, level A with particles passing 10 mm screen may be considered the best.

GESMUNDO, A. P. and J. SIOPONGCO. 1990. *Cocowood Design Standards.* Terminal Report. FPRDI.

The Cocowood Design Standards was prepared to keep abreast with the latest developments in timber engineering technology and to assist engineers, architects designers and students in the more efficient design of structures using cocowood.

The Cocowood Design Standards is divided into five sections which include Specifications on General Requirements of Cocowood, Basic Properties of Structural Cocowood, Design of Basic Cocowood Elements, Connections, Round Coconut Trunk and Glued Laminated Construction.

GONZALES, E. V. 1977. *Prospects of Coconut Trunk Sawdust For Animal Feeds.* Report. FPRDI.

Coconut trunk sawdust was found to be one of the most promising woodwaste materials for feeds of ruminant animals.

The in-vitro dry-matter digestibility test of chemically-treated coconut-trunk sawdust, using the rumen-inoculum from a fistulated cow, showed an increase in carbohydrate digestibility of about 90 percent compared to a low-carbohydrate digestibility of about 12 percent in the untreated sawdust. Lignin content of the treated coconut trunk sawdust was about 4 percent compared to about 30 percent on the untreated sawdust.

GONZALES, E. V. 1979. *Cattle Feeds from Coconut Trunk Sawdust.* Report. FPRDI.

The average recovery of coconut trunk sawdust from the sawmill for animal feeds was 77.89 percent, based on the gross volume of sawdust generated. The total volume of sawdust generated during the process of sawmilling was 13.33 percent of the gross volume of the coconut trunk.

Coconut-trunk sawdust treated with 1 percent nitric acid had the highest average daily gain of 1.61 kg and the best feed efficiency. Treated coconut trunk sawdust was more efficient in producing gain than the silage used in this experiment. Untreated coconut trunk sawdust was comparable in performance with conventional silage.

LAURICIO, F. M. and A. R. FLORESCA. 1977. *Preliminary Tests on the Spike-holding Capacity of Coconut Palm Timber* (Cocos nucifera L.) *for Use as Railroad Sleeper (Railroad Tie).* Report. FPRDI.

The results of preliminary tests on the spikeholding capacity of coconut railroad ties were presented. The values were from green specimens where the spikes were driven and withdrawn immediately. The maximum driving force and maximum holding power were consistently greater in the 1.27 cm prebored hole than those in the 1.43 cm. prebored hole.

The comparative SHPV of coconut timber and some species of Philippine woods namely, broad-winged apitong (*Dipterocarpus speciosus* Brandis), molave (*Vitex parviflora* Juss.), yakal-gisok (*Shorea gisok* Foxw.) and malabayabas (*Tristania decorticata* Merr.) was evaluated. The SHPV of coconut timber was only about 60 percent of the SHPV of broad-winged apitong. Also, the SHPV of coconut timber was lower than the SHPV of the other hardwoods namely: molave, yakal-gisok and malabayabas.

LAURICIO, F. M. 1984. *Utilization of Coconut Coirdust as Building Material. I. Hollow Block.* Terminal Report. FPRDI.

Standard size experimental hollow blocks (10 cm x 20 cm x 40 cm) were fabricated utilizing coconut coirdust and soil as aggregates and cement as binder. In one study, the coirdust was used as the sole aggregate; in another, it was combined with soil at a ratio of 50-50 by volume. In both instances, the following aggregate-binder ratios by volume were: 3:1; 4:1; 5:1; 6:1; and 7:1. For each mixture ratio, 10 hollow blocks or a total of 100 pieces were prepared for laboratory compression test.

The procedure in the fabrication of the blocks was similar to that of the method followed in the fabrication of the traditional sand-cement commercial hollow blocks, using a hand-operated mold. The laboratory compression test followed the ASTM standard methods for testing concrete products.

The laboratory compression test showed that this type of hollow blocks was more favorable than the traditional or commercial hollow blocks. Its estimated cost was cheaper by 20-23 percent than the commercial hollow block.

LAXAMANA, M. G. and E. B. BAUZA. 1988. *Development and Evaluation of Cocosoft Lumber Core (Blockboard) for Furniture*. Terminal Report. FPRDI.

The DSS of laminated coconut wood taken from three different portions in the coconut trunk was evaluated by the shear block test method with two types of resin adhesives. Also, the solid shear for each height level was determined.

Higher gluebond strength is affected significantly by the type of glue and increasing glue spread. Height level does not affect glue bond strength. The study also showed that a 3 hour pressing time is needed to attain strong gluebond. Wood failure was not affected by the types of glue and within the trunk height. It was significantly influenced by the glue spread. Pressing beyond 3 hours had no appreciable advantage. The effects of the interaction on gluebond quality were also discussed.

LAXAMANA, M. G. 1985. *Particleboard Overlaid with Veneer and Coco-tile for Table Tops.* Report. FPRDI.

A 17-mm thick locally produced particleboard was overlaid with veneer and coco-tile (coconut wood tile) to determine the optimum gluing variables to meet desirable bonding requirements for furniture component. Of the three main variables studied, i.e. glue spread, specific pressure and pressure period, the latter was considered the most critical in overlaying 0.55 mm thick wooden veneer and/or 6 mm coco-tile on the particleboard using a cold-setting UF glue.

A 3-cycle delamination test of alternate soaking in tap water and drying of the overlaid particleboard was used to evaluate the integrity of gluebond. A cyclic exposure of veneer-overlaid particleboard to atmospheric and air-conditioned room was also performed to determine the effect of these variables on shrinkage and swelling of the materials.

On veneer-overlaid samples, regardless of the glue spread levels of 70 and 100 grams per square meter (g/m^2) and specific pressures of 4.23 kg/cm^2 and 8.46 kg/cm^2, the 4-hour pressing time showed better water-resistance than the 2-hour pressure period. On coco-tile overlayed samples the 140g/m^2 glue spread, 4-hour pressure period and specific pressure of 8.46 kg/cm^2 indicated the best treatment combination. Specimens with lower levels of glue spread, specific pressure and pressure period gave poor quality (i.e. early delaminated) gluebond.

The percentage shrinkage of the samples from the room temperature to an air-conditioned room of 66% RH ranged from 4.17 to 4.95; while percentage swelling was less than 1 percent from air-conditioned room to atmospheric condition with a RH ranging from 80 to 85 percent.

LAXAMANA, N. B. 1976. *Activated Carbon from Some Wood and Non-Wood Materials.* Final Report. FPRDI.

Samples of charcoal from ilang-ilang, taingang-babui [*Gonocaryum calleryanum* (Baill). Becc.], coconut trunk and carbonized rice hull were activated using the zinc chloride and high-temperature heat treatment methods. Activated samples were evaluated by the iodine-adsorption test. Their applicability for water purification and lambanog treatment was tested.

Zinc chloride activated carbon from taingang-babui gave the highest iodine values, followed by ilang-ilang, coconut trunk and rice hull. High-temperature activated carbon from coconut trunk exceeded that of commercial active carbon.

LAXAMANA, N. B. 1979. *Evaluation of Experimental Activated Philippine Wood and Non-Wood Charcoals Employing Iodine Adsorption.* Report. FPRDI.

Charcoals from eight Philippine wood species and coconut trunk sawdust were activated using the zinc chloride and high-temperature heat treatment methods. Activated samples were evaluated by iodine-adsorption test.

The zinc chloride process applied to charcoals caused the liberation of volatiles and the reduction of ash content. Zinc chloride produced a higher level of activation compared with the high-temperature process in a given charcoal species. However, the latter produced a level of activation comparable with commercial active carbon, giving it good prospects for commercial charcoal production using such species as maniknik (*Palaquium tenuipetiolatum* Merr.), dita (*Alstonia scholaris* L. R. Br.), and amugis (*Koordersiodendron pinnatum* Blanco Merr.).

Zinc-chloride-treated charcoals of manicnic, antsoan (*Cassia javanica* L.), dita, coconut trunk sawdust and amugis surpassed the iodine adsorptive capacities of the commercial active carbon.

MANAS, A. E. 1989. *Extraction and Utilization of Coconut Coir Dust Tannin for Plywood Adhesive.* Terminal Report. FPRDI.

Tannin was extracted from coconut coir dust by counter current leaching with water in four stages at 30 minutes per stage at 60± 3°C. The head liquors were collected and spray dried in a Bowen Conical Type Spray dryer. The yield after extraction was 77.32 percent, and after spray drying, 47.55 percent. The extract quality was influenced by the manner of collection and storage of the coconut coir dust sample before extraction.

Two types of tannin-based adhesives for plywood were prepared from the extract. The first type was copolymer resin composed of the tannin extract and phenol-formaldehyde prepared by substituting 20 to 40 percent of coconut coir dust tannin for phenol in the phenol formaldehyde adhesive. The second type of coconut dust tannin-based adhesive was prepared by addition of 50 to 70 percent laboratory -prepared phenol-formaldehyde resin as fortifier to the tannin-formaldehyde adhesive.

At 20 percent the net present worth is ₱ 18, 988,787 with an internal rate of return of 74 percent. Thus, the project was highly acceptable.

MANAS, A. E., M. S. S. ROMANA, and A. S. TORRES. 1990. *Utilization of Coconut Coir Dust for Water Treatment and Recovery of Heavy Metals.* Terminal Report. FPRDI.

The coconut coir dust cation exchange resin reduced the water hardness of boiler feed water from a total hardness of 562 parts per million to 25 parts per million (ppm) Ca CO_3. The amount of water treated was 59 times the weight of the coir dust exchange resin. Regeneration of the coir dust resin was done by passing 5 N HCL through the column. The regenerated coir dust was found more effective than the original coir dust cation exchanger. A lead battery waste water solution containing 18 parts per million lead was treated with coconut coir dust cation exchanger and synthetic cation exchange resin. The lead in the waste water was more effectively reduced by the synthetic cation resin when pH of both resins were acidic. After adjustment of pH of both resins to neutral coconut coir dust cation exchange resin exhibited better performance than the synthetic cation exchange resin. The developed coconut coir dust cation exchanger was also capable of treating spent chrome tanning liquor. Chromium ion was reduced from 2175 to 312 ppm and 1389 ppm was recovered with HCl. The coconut coir dust cation exchanger was also capable of recovering gold ions from dissolved solution.

MARI, E. L. 1985. *Development of Coco-Coir Dust/Wood Particleboard by Graft Polymerization.* Terminal Report. FPRDI.

A non-synthetic resin system of bonding wood particles to form a board was experimented on. Giant ipil-ipil wood particles and coconut coir dust were chemically activated with 30 percent solution of hydrogen peroxide at various levels of addition. Mixtures of formaldehyde, pulping spent liquor, and maleic anhydride served as the cross linkage agents. The boards failed initial strength MOR tests. Observations gathered from the experiment and recommendations were presented.

MARI, E. L., J.M.V. PABLO, and A. A. PABLO. 1992. *Production of Gypsum-Bonded Panels from Coconut Wood.* Terminal Report. FPRDI.

Bending strength, dimensional stability and fire resistances of gypsum-bonded boards from coconut wood excelsior were evaluated. Boards comparable to ordinary woodwool cement boards were produced at a board density of 800 kg/m^3 with gypsum to wood ratio of 2 or 3, water to gypsum ratio of 0.40 or 0.50 and without a chemical retarder. With the presence of retarder, mixing and matforming were more controlled but showed no significant positive effect on board properties. Greater proportion of gypsum (4 or 5) resulted in more dimensionally stable, fire-resistant but weaker boards. Replacement of a portion of gypsum with cement improved dimensional stability but decreased bending strength.

Results were encouraging but improvements are necessary before pilot scale manufacture could be done. The flash-setting behavior of gypsum should be put under control without adversely affecting board dimensional stability and strength.

MEDRANO, E. M. 1975. *Design of Drum Kilns for Charcoaling Coconut Shells.* Report. FPRDI.

Several designs of modified single and double-drum kilns for coaling coconut shells were made. A prototype was fabricated and tested. In all kiln designs, the systematic placement of sets of draft inlets around the circumference of the drum kiln was found effective in increasing charcoal yield and quality. In all test runs conducted, the yield of charcoal increased from 22 percent (conventional drum kiln) to 27 percent (modified drum kiln). Likewise, the fixed carbon content of the charcoal increased from 64.8 percent to 75.6 percent. Based on the cyclical data in operating the kiln of different designs, one man can operate 20 to 25 single drum kiln in one production cycle. For double-drum kiln, one man can operate about 12 units.

MOSTEIRO, A. P., R. F. CASIN, and F. R. SIRIBAN. 1975. *The Preservative Treatment of Coconut (Cocos nucifera L.) Palm Timber for Electric Power and Telecommunication Poles.* Final Report. FPRDI.

This study looked into the treatment of partially-seasoned coconut trunks with MC of 35-65 percent in the outer 3.81-5.08 cm (1.5-2.0 in.) from the surface for round and sawn pieces employing the hot-and-cold bath method of treatment. This process is simple, economical and is very adaptable in the rural areas where treating plants are inaccessible.

Satisfactory results were obtained from the study. A retention of 272-329.6 kg/cu.m (17.0-20.6 lb/cu. ft.) was obtained for a 6-8 hour hot-bath and 12-15 hour overnight cooling for the sawn timbers measuring 12.70 cm x 15.24 cm x 6.1- (5" x 6" x 20'). For the solid round coconut trunk without bark, a retention of 115.2 -172.8 kg/cu. m. (7.20 - 10.80 lb/cu. ft.) was obtained for a 8-10 hours heating and overnight cooling. Creosote temperature maintained during hot-bath was 92.4 - 97.9 °C (200 - 210°F).

Fabricated Classroom chair

MOSTEIRO, A. P. 1981. *Utilization of Coconut Lumber for Furniture Manufacture (Classroom Chairs).* Terminal Report. FPRDI.

The utilization of coconut trunk for the manufacture of classroom chairs involved different stages of processing. These processes included sawmilling of trunks into lumber, sorting or grading, drying, machining, fabrication and finishing.

To fabricate one proto-type chair, about 10 board feet of rough coconut lumber were required. In this study, 60 trunks of senile coconut measuring 25.5 cm to 30.5 cm in diameter and 3 m in length were collected for processing. Sawmilling was done using a 54 inch bandsaw with stellite tipped saw blade.

The production cost per unit of lacquer-finished chair was ₱ 45.90. Forty-five classroom chairs were installed in three elementary schools in Los Baños, Laguna Philippines. Individual chairs were still in very sound condition after 1.5 years in service.

PABLO, A.A., J. B. SEGUERRA, F. N. TAMOLANG, and A. B. ELLA. 1975. *Development of Particleboard on a Pilot-Plant and Semi-Commercial Scale Using Plantation and Secondary Wood Species And Agricultural Fibrous Waste Materials.* Report. FPRDI.

Particleboards were produced from 100 percent coconut particles and a 50:50 coconut and wood particles. A total of 520 panels with dimensions of each 12.70 mm x 1.22m. x 2.44 m.(1/2" x 4' x 8') were produced from 50 coconut trees with an average diameter of 30.48 cm. and length of 9.14 m. and 10 cubic meters of wood slabs.

PABLO, A.A., F. N. TAMOLANG, and E. U. CASAL. 1976. *Panel Products from Coconut Palm.* Report. FPRDI.

A study on the technical feasibility of coconut trunk and its petiole for particleboard manufacture was carried out on a pilot-plant scale. The panels produced, whether 100 percent coconut trunk or petiole or in mixture with wood particles at 8 percent, 10 percent and 12 percent resin-content levels of urea formalydehyde at 720 kg/m^3 board density, met the local and foreign standard specifications for commercial particleboard.

Optimum resin-content levels for coconut trunk were at 8 percent and 10 percent coconut petiole, applied singly or mixed with wood particles.

PABLO, A. A. and A. F. LOVIAN. 1987. *Utilization of Coconut Coir-Dust, Coir Fiber, Pineapple Fiber and Wood Particles for the Production of Particleboard.* Report. FPRDI.

Agro-waste materials, coconut coir dust, coir fiber, pineapple fiber, mixtures of coir fiber, and pineapple fiber and wood particles were made into three-layer, 14 mm. thick particleboard at 0.550 gm/cm3 board density. This was done by using urea formaldehyde and phenol formaldehyde adhesives at 10 percent and 12 percent resin content levels. Four material combination of 25/75 percent, 50/50 percent, 75/25 percent and 100 percent at 50/50 surface to core layer ratio (m) were prepared.

PALISOC, J. G., M. G. LAXAMANA, and N.B. LAXAMANA. 1991. *Effects of Bleaches on the Finishing Quality of Coconut and Tangile for Furniture and Furniture Components.* Terminal Report. FPRDI.

The effects of bleaches on the finishing quality of coconut and tangile lumber materials for furniture and furniture components were studied using 10 bleaching solutions. Brightness/whiteness of the bleached material was observed in all the treatments. Among the treatments applied, Treatments 1 and 2, which were the commercial bleaches, exhibited the highest value in whiteness. However, these bleaches affected brittleness on the applied lacquer and low resistance to scraping by outside force. Treatment 6 was found third best for whitening among the 10 solutions. Treatment 5 could also be recommended for bleaching since it had the least ill effect on the finishes applied though it had lower whiteness/brightness value.

PARAYNO, J. A., F. R. SIRIBAN, and C. L. PABUAYON, 1988. *Coconut Wood for Power and Telecommunication Cross Arm.* Terminal Report. FPRDI.

Mechanical property test of coconut trunk taken about 2000 mm from the groundline level which were prepared into standard cross-arms containing the hard and medium portions showed fiber stresses in MOR of 70.24 Mpa and 62.32 Mpa, respectively, compared with the commonly used apitong (*Dipterocarpus spp.)* with an average of 62.76 MPa.

QUIÑONES, D. G., P. L. ALCACHUPAS, and R. C. EALA, 1983. *Backyard Lumbering of Coconut Trunks with Two-Man Rip Saw.* Report. FPRDI.

The performance of a two-man rip saw in converting coconut trunks into lumber was studied. Daily production on sawing trunks into 2.54 cm. thick boards was 0.114 cu. m. (48.34/ bd. ft). At a market price of

₱ 848.00/cu.m. (₱ 2.00/bd.ft.) of coco lumber, the two-man rip saw operation is considered profitable.

QUIÑONES, D. G. and R.C. EALA. 1978. *Sawdust Yield From Coconut Trunks for Cattle Feeds.* Terminal Report. FPRDI.

Coconut trunks were sawn into 2.54 cm x 12.7 cm (1" x 5") lumber. Volumes of sawdust from each coconut trunk accumulated at the head rig and at the edger were determined separately. Sawdust volume for animal feeds was determined with the use of screen sieve no. 6.

Based on the study, about 13.33% sawdust was generated in sawing. Of this figure, 10.21 percent was produced at the headrig and 3.12 percent at the edger. About 77.89 percent were recovered for cattle feeds based on the gross volume of sawdust.

QUIÑONES, D. G., F.C. ORTIZ, and R.C. EALA. 1979. *Harvesting and Processing of Coconut Trunks for the Low-cost Housing Project of the Ministry of Human Settlements.* Report. FPRDI.

This study investigated the economics of harvesting coconut palms, sawnmilling trunks into lumber and processing T & G for flooring and S. C. for siding.

The study focused on the production of 3,492 pieces of 1" x 4" T & G equivalent to 10,470 bd. ft. and 815 pieces of similar dimension S. C. equivalent to 2,445 bd. ft. In addition, 250 pieces of rough coconut lumber equivalent to 3,000 bd. ft. were fabricated and some 180 pieces of coconut stumps equivalent to 4, 680 bd. ft. were gathered.

ROMANA, M.S.S., E.C. SALUD, and F. D. CHAN. 1988. *Lignin from Coconut Palm Wastes - Its Isolation, Characterization and Evaluation as an Adhesive for Plywood.* Terminal Report. FPRDI.

The ethanol digestion of coconut husk and coir dust was conducted following pre-extractions with water. The yield of lignin ranged from 0.02 to 3.9 percent in coconut husk and from 3.6 to 5.3 percent in coir dust.

Methoxyl determination in the islolated lignins from coconut husk and coir dust ranged from 2.77 to 5.73 percent and from 3.54 to 5.72 percent, respectively. The infrared absorption spectra of the isolated lignins were obtained and compared with the spectra of lignin from maniknik (*Palaquium tenuipetiolatum* Merr.) wood. The same characteristic bands were observed indicating the similarity in functional groups present in ethanol lignin and alkali lignin.

Formulations of adhesives for plywood were not prepared because of the very low yield of lignin obtained from both coconut husk and coir dust.

SALITA, A. A. and S. U. FORANDA. 1985. *Production of Coconut Parquet on a Cottage Level.* Terminal Report. FPRDI.

The study aimed to develop a low-cost, appropriate and locally fabricated equipment for processing coconut timber into parquet.

The low-cost equipment appropriate for the breakdown of short coconut trunk into lumber slats for parquet was developed.

SALITA, A. A. JR., and A. P. BATI. 1973. *Exploratory Rotary Veneer Cutting of Coconut Trunks.* Report. FPRDI.

Four 1.3- m. cold -soaked coconut bolts from 2 trees were rotary-cut into 1.40-mm. and 3.60-mm. veneers, applying a 90° knife angle and a mild nose bar compression.

Rotary veneer cutting of coconut trunks was impractical. The veneer produced was inferior to wood veneer because it had uneven thickness , corrugated rough surface and numerous longitudinal splits.

Coconut Parquet

SALITA, A. A. JR., F. N. TAMOLANG, and R. C. EALA. 1976. *Utilization of Coconut-Timber Residues for Parquet Flooring*. Report. FPRDI.

The study explored the possibility of using coconut-timber residues for the manufacture of parquet flooring.

The coconut-parquet-flooring installation was comparable to conventional parquet flooring except for the failure of some cocosoft components in service. The exclusive use of cocohard fingers is recommended for successful coconut-parquet flooring.

SAN LUIS, J. M., C.P. BANZUELA, C. P. ESTUDILLO, and P. L. CHAVEZ. 1976. *A Preliminary Study on the Production of Coconut Shell Charcoal Briquettes.* Report. FPRDI.

A study on the production of briquettes from coconut shell charcoal using sorghum [*Sorghum bicoler* (L). Moench] as binder was conducted.

An average charcoal yield of 34.00 percent was obtained, using modified single and double-drum kiln methods. The resultant charcoal was briquetted using 4, 6, and 8 percent binder. About 7,000 pieces of 48.5-gram briquettes were produced from one ton of coconut shell. The heating value test, proximate chemical analysis and other quality tests showed promising results.

SEMANA, J. A. and C. H. BALLON. 1977. *Hardboard from Coconut Trunk.* Report. FPRDI.

Hardboards were made from coconut trunks by the wet process. Under the experimental conditions used, the properties of the boards produced were relatively inferior to those of standard hardboards made from wood. However, the same were suitable for interior uses where strength and water resistance requirements are not stringent.

SEMANA, J. A. 1973. *Hardboard from a Coconut Coir-petiole Blend.* Final Report. FPRDI.

Coconut-coir and coconut-petiole materials were pulped separately in a laboratory Asplund Defibrator and a 50-50 blend of these 2 materials was processed into hardboard. The heat-treated and non-heat-treated boards had modulus of rupture surpassing the specifications for standard board. However, their thickness-swelling and water-absorption characteristics exceeded the allowable maximum values.

TAMOLANG, F. N. and R. C. EALA. 1976. *Coconut Stumps for Turned Products.* Report. FPRDI.

The study looked into the manufacture of turned articles such as cups, glasses, plates, saucers, bowls, night sticks, balusters, furniture supports, etc. from coconut stumps.

Acceptable finish was obtained in turning properly dried slender (5 cm. x 5 cm.) and thin (3 cm.) stocks. The M.C. of the stocks was 18 percent. The machining of the dried stocks effected the rapid dulling of conventional turning tool edges. However, improvised tools from expanded metal files exhibited better abrasive resistance to turning of coconut blanks.

Rough turning, an intermediate processing practice that is commercially employed to shorten seasoning time, was found suitable in processing large (13 cm. x 13 cm.) and thick (4 cm.) stocks. Roughly-turned plates developed buckling, a drying degrade. However, this defect was easily corrected during the final turning of the articles.

Turned Products

TAMOLANG, F. N. *Studies on the Potential Uses of Coconut Trunk in the Philippines.* Report. FPRDI.

Of the various coconut-palm materials analyzed, the trunk appeared to approach closely the chemical composition of Philippine hardwoods, softwoods and bamboo as far as holocellulose, lignin, pentosans content and extractives are concerned. The ash and silica contents were between those of the bamboo and wood. The trunk, therefore, could be possible raw materials for pulp and paper.

VILLAVELEZ, L. V. and O. E. ENRIQUEZ. 1994. *Production of Cocowood Grocery Pallets.* Terminal Report. FPRDI.

Producer-cooperators were selected to determine quality pallet manufacturers in Regions III and IV. The PPR, a Division in the Pacific Manufacturing Resources, was the most promising among the producer cooperators identified.

Based on the analysis of its operating performance, pallet manufacturing can be profitable and can contribute much to the generation of economic benefits in the locality. It is recommended that more cocowood dealers be challenged to engage and invest in the cocowood pallet manufacturing business to meet the demands of the country's pallet-using industries.

VILLAVELEZ, L. V., T. G. CUARESMA, V. M. EGUIA, E. C. CORTIGUERRA, and P. F. CRUZ. 1992. *Manual on Cocowood Pallet Manufacture.* Report. FPRDI.

The report presented classification, design and styles of wooden pallets; raw material requirement; wooden pallet construction; and assembly methods.

Producing cocowood pallet is a viable undertaking as indicated by a positive NPV, BCR of 1.38 and IRR is 156.75 percent, respectively.

YNALVEZ, L. A. 1965. *Tannins from Barks and Coconut Husks.* Report. FPRDI.

This report was presented on the 5th National Convention of Log Producers and Processors held in Manila from April 5 to 9, 1965.

Coconut husks extracts are promising as a tanning agent.

An average air-dry nut husk weighs 0.3 kilogram. The coarse and fine fibers are variously estimated to be about 30 to 43 percent. It is the coir dust that contains the tannins. The tannin content of the coir dust varies from 8 to 13 percent while stiasny number varies from 69 to 78.

YNALVEZ, L. A., F. N. TAMOLANG, and P. V. BAWAGAN. 1964. *Utilization of Philippine Forest and Agricultural Residues: I. Potential Use of Coconut Husks as Raw Material for Other Industries.* Report. FPRDI.

A nut-husk weighs, on the average, 300 grams or 0.3 kilograms when air-dry. It consists of fine and coarse fibers (coir) and coir dust. The coarse and fine fibers comprise 30 percent by weight of nut-husk and coir dust, about 70 percent. The coarse fibers or bristles are manufactured into ropes, doormats, brushes and coir-flex. The coconut husk fiber is also a potential raw material for pulping. A limited amount of these fibers is also exported but the very fine ones and dust are thrown away as wastes in the vicinity of the coir factory and constitute a great fire hazard to the processing plants.

ZAMORA, R. A. and A. P. GESMUNDO. 1986. *Design and Development of Standardized Doors: Coconut Wood.* Terminal Report. FPRDI.

Theoretical analysis of experimental doors showed that a 19.05 mm x 100 mm coconut board is sufficient to carry an impact and wind loads of 1601.28 N and 0.001148 N/mm^{2}, respectively and 12.7 mm diameter coconut dowel can carry an eccentrically applied load of 222.40N.

ZERUDO, J. V. and J. O. ESCOLANO. 1976. *Coconut Trunk for Paper Pulp.* Report. FPRDI.

Coconut trunk was pulped by the cold-soda and kraft processes. The cold-soda pulp had a low recovery but the kraft process gave a bleachable-pulp recovery comparable to the recovery of Philippine hardwoods. The kraft pulp was bleached by a 3-stage (CEH) process to a brightness of 76 percent. Both unbleached and bleached pulps showed moderate strength properties.

Bag paper and onionskin were made from 100 percent coconut-trunk sulfate pulps while corrugating medium was made from 100 percent coconut trunk cold-soda pulps. The bag paper met the requirements, except tear, for heavy-duty kraft paper. The onionskin also met the strength requirements for this type of paper, although the brightness was deficient. The corrugating medium had a high ring-crush resistance but had a low bursting strength.

Socio-economic

CORTIGUERRA , E. C. 1990. *Feasibility Study on the Production of Cocowood Grocery Product Pallets.* Terminal Report. FPRDI, College, Laguna.

An assessment on the use of cocowood pallets over the traditional or pallets gave favorable results as shown by a comparative production cost and alternative comparison by benefit-cost method. Production cost of cocowood pallets was 23 percent lower than traditional pallets.

The production of cocowood grocery product pallets was found to be viable as indicated by profitability indicators used in the study. The project cost was estimated at P 282,320.00 and could be recovered in less than two years. The net present value yielded a positive result, benefit-cost ratio was 1:16 and the internal rate of return was 100.72 percent. Return on investment was 73 percent. This project could be set-up on a backyard level.

DECENA, A. S. 1977. *Economics of Mass Producing T & G Coconut Lumber at the NHA Processing Plant.* Report. FPRDI.

Based on a fair market-selling price of ₱ 1.00 per lineal foot T & G, shipment No. 1 (230 pieces of 1" x 4" x 12' rough-sawn coconut lumber) had a net income of ₱ 288.00 or 32 percent of the total investment cost of ₱ 912.00.

DECENA, A. S. 1977. *Profit/Loss Mass Production of T & G Coconut Lumber at the NHA.* Report. FPRDI.

Based on a fair market selling price of ₱ 1.00 per lineal foot T & G, a shipment of coconut wood (230 pieces of 1" x 4" x 12') to the NHA had a net income of ₱ 336.00 or 39 percent of the total investment cost of ₱ 864.00 on the part of the FORPRIDECOM as compared to ₱ 684.00 net income or 132 percent on the part of NHA whose production cost was only ₱ 516.00.

DECENA, A. S., B. J. PENID, and F. N. TAMOLANG. 1976. *The Economics of Three Lumber Conversion Systems for Coconut Trunks.* Report. FPRDI.

This report presents an economic assessment of three lumber conversion systems for coconut trunks: manual sawing, FM backyard speedsaw and 54" bandmill. Within the limitations of this study, the production cost per board foot in System 1 was ₱ 2.47; System 2, P 0.55 (average of study 1 & 2); and System 3, P 0.94. It also presents the calculation of siding material sawn from a coconut trunk for low-cost house construction and some rough calculations on how many trunks were needed to fill the siding lumber needs of a given floor area of a house.

EALA, R. C. and P. L. ALCACHUPAS. 1983. *Cost of Coconut Lumber Production.* Report. FPRDI.

Production costs of harvesting coconut palm, sawmilling trunks into lumber and processing them into T&G for flooring and SC, for siding were assessed. Cost analyses showed the following: a) ₱ 0.82/bd m (₱ 0.130/bd ft) for felling, bucking and hauling; b) ₱ 5.52/bd m (₱ 1.30/bd. ft.) for sawmilling into rough lumber, and c) ₱ 6.44/bd m (₱ 1.52/bd ft) for T&G and S C Manufacture.

ESTUDILLO, C. P., J. M. SAN LUIS, A.Y. BANZUELA , and P. L. CHAVEZ. 1979. *A Study on the Production Cost of Briquettes from Coconut Shell Charcoal.* Report. FPRDI.

A study on the production of briquettes from coconut shell charcoal using sorghum [*Sorghum biceler(L).* Moench] as binder was conducted.

An average charcoal yield of 34 percent was obtained, using the modified single and double-drum kiln methods. The resultant charcoal was briquetted using 4, 6, and 8 percent binder. The suitable moisture content of the charcoal-binder mixture was 37 percent compared to 50 percent for coconut trunk and sawmill wastes charcoals. About 7,000 pieces of 48.5-gram briquettes were produced from 1 ton of coconut shell. The heating value test, proximate chemical analysis and other quality tests showed promising results.

Actual operating expenses for the yearly processing of 3,000 tons of coconut shells amounted to ₱ 969,798. Based on these expenses alone, a piece of 48.5 gram briquette will cost P 0.046.

GARCIA, C.M. C. 1990. *Availability and Distribution of Coconut Palms in the Philippines.* Terminal Report. FPRDI.

At the time of the study, the Philippines had a total of 3.36 million hectares planted to coconut and these were concentrated in the Mindanao region. Southern Tagalog had the most number of coconut palms with 91 million, followed by Southern Mindanao.

There was a thriving coco-lumber industry in the Philippines. Major markets were urban areas where construction work was concentrated. Coconut trunk pieces ranged between P 70-100 per trunk while coco-lumber pieces ranged between ₱ 2.50- ₱ 3.50 per bdft.

MATIBAG, M. C. C. 1986. *An Economic Analysis of Coconut Lumber Industry.* Terminal Report. FPRDI.

Personal interviews were conducted among chainsaw and sawmill operators using an interview schedule. Complete enumeration was done since there were only a few coco lumber producers in the survey areas. Chainsaw operators who offered sawing services only were excluded.

Survey areas were San Pablo City, Laguna; Lucena City, Candelaria, Quezon; Toledo City; Cebu City, Talisay, Carcar and Compostela, Cebu. Twelve sawmill operators and six chainsaw operators were interviewed. Economic indicators like benefit-cost, internal rate of return and net present worth value were used to evaluate the profitability of the operation.

Conversion of coconut trunks into lumber was more feasible in commercial sawmill operation than in chainsawing. Its internal rate of return was greater than 50 percent with a benefit-cost ratio of 1.99. On the other hand, internal rate of return and benefit cost ratio in chainsaw operation were 5.24 percent and 0.99 respectively. Net present worth value in both operations was positive.

MATIBAG, M. C. C. 1989. *Feasibility Study on Coco Lumber Production. (Chainsaw FPRDI Table Saw Tandem).* Terminal Report. FPRDI.

A feasibility study was done to determine the level of profitability of producing coco lumber as low-cost construction material. Based on the assumption that the sawmill will produce 2,000 bd ft coco lumber per day or 600,000 bd ft per annum in an eight -hour operation for 300 days. Of the production costs, 59 percent was attributed to raw materials, 15 percent to labor, 8 percent to utilities, 13 percent to repair and maintenance, 2 percent to factory and administrative costs, 2 percent to sales costs and 1 percent to depreciation. Taxable profit in one year operation was ₱ 786,661.

MATIBAG, M. C. C. 1985. *Project Feasibility Study on Classroom Chair Production from Coconut Lumber.* Terminal Report. FPRDI.

The project was found to be feasible at an IRR of 47 percent and a NPW of ₱ 15,000. At this rate, the earning capacity of the resources is high and the project could pay off its obligations.

MOSTEIRO, A. P. 1977. *Utilization of Coconut Palm Timber: Its Economic Significance in Some Countries in the Tropics.* Published. FORPRIDE Digest.

This article dealt on some basic and relevant information on the structure, physical and mechanical properties, drying and machining characteristics, natural durability, preservatives treatment, service performance and uses of coconut timber. Some of the important new uses of this material may apply to problem in low-cost housing and human settlement, rural electrification and forest conservation in developing countries in the tropics.

REVILLEZA, V. G. 1988. *Socio-cultural Dimensions of the Coconut Trunk Utilization Industry in Selected Areas in the Philippines.* Terminal Report. FPRDI.

The study was conducted in selected towns of Cebu and Quezon Provinces where coconut trunk are utilized for various end-uses. Households and coconut lumber producers in these areas were chosen as respondents and interviewed using a pre-tested interview schedule.

Considering the small number of respondents, the conclusions and recommendations are applicable only to the areas surveyed, results could not be generalized. Respondents used coconut wood because of its low price compared to commercial wood species.

Cocowood was commonly used for housing components.

Cocowood users found it difficult to work with coconut wood specially when the wood was dried.

Problems encountered by cocowood producers were maintaining the quality of wood after sawing; high cost of materials used in processing coconut trunks into lumber; unstable supply of coconut trunks for processing; and crude processing equipment for coconut trunk.

Cocowood utilization was an "old" technology to the respondents and the respondents were interested to know the other uses of cocowood and its potentials as source of livelihood.

TAMOLANG, F. N. 1986. *Utilization of Coconut Trunk: An Economic Conservation Approach and A Business Opportunity.* Report. FPRDI.

Experimental data on the utilization of coconut trunk for various end products, such as pulp and paper, charcoal, activated charcoal, charcoal briquettes, particleboard, lumber, electric and telecommunication poles, animal feed, veneer and plywood wooden shingles, parquet flooring, novelties, chopsticks, woodwool, firewood, tannin, wood plastic combination products, etc. are given on this report, including the basic data on anatomical, chemical and physical properties.

The utilization of the coconut trunk for the said products had direct beneficial economic effects towards the conservation of wood resources, although more research is needed on techno-economic feasibility.

Products from coconut trunks

Techno-transfer

BRIONES, L. P., H. C. UNCIANO, and C.P. ESTUDILLO. 1990. *Situational Analysis of Jordan Guimaras for the Establishment of Charcoal Briquetting and Other Coconut Based Industries.* Report. FPRDI.

A survey was undertaken in Jordan, Guimaras to assess the viability of establishing a briquetting industry in the area.

The survey indicated favorable results in terms of raw material sourcing, social acceptance and market potential and availability.

ESTUDILLO, C.P., L.P. BRIONES, W.G. TOROY, R.R. CABRAL, and C.M. MAMINO. 1984. *The Transfer of Charcoal Making and Briquetting Technologies in Negros Oriental.* Report. FPRDI.

Extension activity on charcoal production and briquetting technologies was conducted in a 5-day lecture/demonstration in Dumaguete City from 29 January to 3 February 1984 upon request of Governor Lorenzo G. Teves of Negros Oriental.

Two delegates from each municipality and personnel of the Provincial Development Staff, Office of the Governor participated in the training course.

The charcoal-making practices in some municipalities visited were evaluated. On the spot technical assistance was extended to charcoal makers. Technical problems that beset them were discussed and corresponding solutions were given.

ROBILLOS, Y. U. and R.C. EALA. 1989. *Delivery of the Coconut Wood Lumbering Technology. The DAVI Case.* Terminal Report. FPRDI.

The coconut wood lumbering technology was delivered to DAVI a client in Daraga, Albay, to 1) develop or enhance knowledge and skills in proper coco lumbering methods; 2) establishing an efficient and economical coco lumber processing system; 3) produce coco lumber in commercial scale using the FPRDI technology; and 4) determine the consequences of technology application to the user and the community.

Six persons were trained on appropriate coco lumbering procedure and these served as the core production manpower of the client firm. The establishment of a coco lumbering processing system in Daraga led to the creation of 10 new jobs and employment of 21 people in the area.

Other benefits attributed in the use of the technology were savings on costs to lumber users in the area, broadening of raw material base for wood-using industries, and helping meet the housing needs in the locality and other places in the region.

ROBILLOS, Y. U., R. A. NATIVIDAD, F. R. SIRIBAN, and C. L. PABUAYON. 1988. *Delivery of Wood Treatment Technology for Coconut Lumber and Bamboo Slats.* Final Report. FPRDI.

Treatment technology for application on coconut lumber and bamboo slats was delivered to a target beneficiary in Los Baños, Laguna. A promotional scheme involving free treatment for a limited volume of coco lumber and bamboo slats was adopted before "putting the technology in the hands of the user." This afforded the beneficiary a constant supply of treated coco lumber and bamboo slats and enabled him to provide treating services to the public.

Short-term assessment of the technology's consequences on the user showed an estimated 10 percent of the income derived from sales of coco lumber as, attributable to the treatment technology. This helped improve sales of coco lumber. Improved sales led to the firm's setting up of a coco lumber sales outlet in Calamba, Laguna.

SIRIBAN, F. R. and R. C. EALA *Transfer of Some Technologies in Coconut Wood Utilization.* Terminal Report. FPRDI.

A substantial volume of coco lumber are used in the construction of sheds, piggery and poultry houses. Coco lumber is used as posts, girders, trusses, studs and even door and window jambs in the low cost housing projects. Also in many resorts where coconut trees abound, coconut lumber are used in various structures in the area. Coco lumber is also becoming popular in construction of stalls in market places.

The application of coco lumber is being tried in the pallet industry as traditional wood are becoming scarce and expensive. Beverage companies are currently testing the suitability of coco lumber as pallets. Coco lumber is now used in limited volume as cross arms for power transmission purposes in rural areas in conjunction with treated coconut trunks as posts.

Although a lot of information on the coconut trunk and its utilization have been generated and technologies developed, application of these technologies has not been fully commercialized. It is the object of this study to disseminate the appropriate coconut trunk processing for lumber production. It is aimed to demonstrate sawmilling technology of coconut trunk to rural communities and to promote the use of treated lumber.

VILLAVELEZ, L. V. and O. E. ENRIQUEZ. 1990. *Pilot-Scale Production of Cocowood Grocery Pallets.* Terminal Report. FPRDI.

Field service tests were carried out in three different softdrink manufacturers in the Philippines and evaluation of results showed that cocowood is highly recommended for pallet manufacture. Economic and cost-benefit analyses showed that pallet-manufacturing business is highly profitable. The cost of the cocowood pallet was cheaper by ₱ 80.00 than pallets produced from the traditionally used species.

ZAMORA, R. A., W. M. TORDILLA, F. R. SIRIBAN, and C. L. PABUAYON. 1988. *Delivery & Utilization of the HPSD Treatment Technology for Green Round Poles to Electric Cooperatives in Regions V & XII.* Report. FPRDI.

One cooperator beneficiary each for Regions V and XII was selected. Initial contacts and discussions with the prospective cooperators were made before the implementation of the project. The cooperator's requirements on the number and sizes of treating cylinder and capacity of the HPSD system were determined based on their immediate and future requirements and demand for treated poles in their area.

The required HPSD system was fabricated by a local fabricator under close supervision of the technology generator, pre-tested and then delivered to the cooperator. The training and demonstration on the HPSD system was conducted at the project site usually near the green poles and lasted for about a week.

Since the project duration was one year, only the short term or immediate socio-economic impact of the technology on the cooperator and the project site was evaluated. This evaluation would provide initial indications of the relative success or failure of the transfer of the HPSD technology to its intended clienteles.

Training

CABANTAC, D. E. 1970. *A Training Report on the Extraction of Tannin from Coconut Coir Dust & on the Manufacture of Particle Board at theFORPRIDECOM.* Report. FPRDI.

The author was granted a training program for six months from January 9, 1970 to June 30, 1970 at the FORPRIDECOM. Two research projects namely: "The Extraction of Tannin" and "The Manufacture of Particleboard" were chosen for the said training.

Coconut husks dust was used with water as the extracting medium. Fresh coconut husks were passed through a hammer mill and then sieved manually in an improvised screen to separate the dust from the fiber. The dust was collected and stored until the time for the tannin extraction process. The results of the analysis were as follows: tannin content, 8.64 percent and non-tannin content, 9.75 percent.

Kaatoan bangkal was used as wood chips in this experiment. Based on the experiment, 60/40 percent ratio (wood chip-coco-dust) gave a satisfactory bond. A second pressing using a 70/30 percent (chip to dust) ratio blistered due to relatively high moisture content of the mat. All the three boards produced using coco-dust as the binder showed uneven distribution of color. This may be attributed to a deficiency of manual mixing of the chips and adhesive. On the other hand, the boards produced with the use of the U.F. appeared more uniform in texture.

FLORESCA, A. R. 1985. *Report on the General Technical Training Course on Coconut Wood Utilization.* Report. FPRDI.

The general technical training course on Coconut Wood Utilization was part of the Regional Coconut Wood Training Program, a project of the coconut producing countries of Asia and Pacific. The program was funded by the UNDP, executed by the FAO of the United Nations and hosted by the PCA.

This training course the second of a series, was conducted on August 13 to September 12, 1984 at ZRC of the PCA.

Sixteen trainees participated the course and composed of the following: two representatives each from Thailand, Indonesia, Sri Lanka, and Tonga; one each from India and Kiribati and six representatives from the Philippines which included the Author. Experts in coconut processing and utilization from FAO and UNIDO were some of the trainors. The other trainors include the staff of the ZRC and DRC of the PCA.

The main objective of the course was to introduce to the participants some of the basic facilities required for processing and basic techniques of coconut wood utilization.

PABUAYON, C. L. 1985. *Report of Training: General Technical Training Course on Coconut Wood Utilization.* Report. FPRDI.

This report covered the activities undertaken by the participant during a training on coconut wood utilization held at ZRC, PCA from August 15, to September 23, 1983. The objective was to assist the participating countries in pursuing their coconut replanting programs and to increase their supply of timber by training participants from the public and/or private sectors in the management and operation of coconut stem harvesting and processing activities and in the correct use and maintenance of suitable equipment.

ZAMORA, R. A. 1985. *Report on the General Technical Training Course on Coconut Wood Utilization. General Technical Training Course.* Report. FPRDI.

The training consisted of two parts, namely: (a) lectures on the subject matter and (b) the field practicum where applications of the principles and methods lectured are implemented. The subjects included (a) coconut palm logging operations, (b) primary conversion and sawmilling, (c) sawdoctoring and machinery maintenance, (d) coconut wood properties, grading and structural uses, (e) seasoning and preservation techniques, (f) processing and machining, and (g) cocowood for charcoal and energy.

Each of the subjects was programmed for a duration of 20 hours except in coconut palm logging operations which was programmed for 30 hours.

Ten Asian and Pacific countries were represented in the training course. The trainors were composed of experts from UNIDO, FAO and UNDP and the staff of the ZRC and DRC of the PCA.

Studies Generated by Other Agencies

ANONYMOUS. 1974. *Cocoshell Charcoal Produces Fuel Gas.* Business Day 8 (11):9-15. (NIST).

Fuel for gas stove, gas light, water pump or for automotive use can be produced by feeding coconut shell charcoal into a gas-producer machine adapted and assembled by the NIST. The machine compresses charcoal which when lighted releases a mixture of carbon dioxide, carbon monoxide and nitrogen gas. A series of processes change the composition of the produced gas into 2/3 nitrogen and only 1/3 carbon monoxide. In 30-60 minutes the machine starts to produce the gas which can be stored in a tank by using a compressor.

ANONYMOUS. 1974. *Coconut Charcoal Promises a New Source of Cheap Fuel.* Business Day 8 (183):18 (UPLB).

Fuel for gas stoves, gas light, water pumps or for automotive use can be produced from coconut charcoal by feeding it into a special machine. This gas-producer machine adapted and assembled at the Industrial Research Center, NIST can turn out gas within 30-60 minutes after the compressed charcoal in it has been lighted. The gas produced can be used directly for gas lighting and gas stove cooking. With the aid of a compressor, it can run automotive engines.

ANONYMOUS. 1974. *Coconut Shell Charcoal Fed into a Machine Produces Fuel Gas.* UCAP Weekly Bull 9(45): 16. (PCA), (UCAP).

An experimental gas producer which was assembled at the Industrial Research Center, NIST, uses coconut shell charcoal and functions in a similar manner to gas producers that run charcoal-fed vehicles. The machine starts to produce gas about 30 minutes to one hour and the gas produced can be used directly for gas lighting and gas stove cooking. If the gas is intended for running automotive engines, a compressor is needed.

ANONYMOUS. 1974. *Fibers. Coconut Farmers' Bull* 1 (1):14-15. (PCA, UPLB)

Coconut fibers were made into fine twine ropes, fishing ropes, yarns, brush mats, mattresses, cushions, brooms and curled fiber according to their classification. Training centers for these cottage industries were located in Marikina, Manila, Mandaluyong, Laguna, Muntinlupa, Quezon City, Lucban, Antimonan, Dagupan, Oroquieta, Pagsanjan and Tayabas and supervised by the PCA.

ANONYMOUS. 1974. *From Coconut Leaves to Carton.* Conserv Circ 10(2):7 (UPLB).

Researchers from NIST discovered the use of coconut petiole pulp into corrugated paper for cartons. Soda, sulfate and NSSC processes were used to pulp the chipped petiole to determine which of them could produce more pulp of higher quality. NSSC process yielded the least pulp but of light color which does not have to undergo bleaching. Soda and sulfate processes yielded dark pulp and had to be bleached requiring expensive chemicals. The paper produced could not be made into quality paper but it could be used for making cartons.

ANONYMOUS. 1974. *Integration, Key to Coconut Development.* Bus Day 8(130):9. (UPLB)

Coconut meat and its by-products should be utilized to the maximum. At present, there are only three local coconut processing plants - the Red V Desiccated Coconut Products, Inc. at Lucena City, the NIDC which processes 36,000 tons of copra/year, and a P 2.7 M coir- making plant at Oroquieta City. Besides copra making, the processing of coir fiber into twine or rope or fiber for board mat, coir dust for activated carbon and the manufacture of doormats, carpets, bags, etc., can be employed. In Misamis, the investment climate for coco-based industries seems good due to the presence of improved municipal ports, cheap electric power and realistic tax policies.

ANONYMOUS. 1977. *Building Blocks from Coco Palms Developed.* UCAP Weekly Bull 12 (36):2. (PCA, UCAP).

Experiments conducted in Britain showed that cement bonded building blocks can now be produced from mature coconut palms.

ANONYMOUS. 1977. *Coconut Charcoal Manufacturing.* Philippine Development 5(4):24-27 (UPLB).

The bright prospect of producing coco shell charcoal for the world market prompted the Philippine government to encourage its full development by giving incentives to those desiring to export product. Its quality is ensured by the standard grades established by the PCA. Charcoal production using the modified pit, drum, and the Japanese kiln, is briefly discussed. Sri Lanka, the country's keenest competitor, exports twice as much coco shell charcoal to Japan as the Philippines.

BANZON, J. A. and L.O. ESCARDA. *Coconut Processing and Utilization: An Overview.* Proc. 2nd National Coconut Resource Development Symposium, Los Banos, Laguna, Philippines. 1984. Coconut R & D. (1988) p. 178-183. Book series 59/88.

The papers presented various products from coconut and those responsible for their development.

CAPA, A. 1973. *Utilization of Coconut Coir from the Coconut Husk.* SU, Dumaguete City. 18p. (Thesis: BS) (SU)

This study was conducted to determine the variables that affect the production of a desirable coconut coir from coconut husks and to determine the conditions under which an acceptable coir product could be made from coconut husk.

The coconut husks were subjected to mechanical and chemical treatments. The mechanical treatment involved chopping of the husks, shredding of chopped husks, separating the fibers and cutting them to an average length. In the chemical method, the mechanically treated husks were treated with 1 percent caustic soda at room temperature using 10 percent NaOH as the cooking liquor for four hours. Two per cent sodium hypochlorite was the bleaching agent used and bleaching was done at room temperature and under ordinary pressure. The article was formed using the stock sample and then spraying it with rubber latex as the binding material.

CORNISTA, L. S. *State of the Art of the Coconut Industry. Social Aspects.* Proc. 2nd National Coconut Resource Development Symposium, Los Banos, Laguna, Philippines. 1984. Coconut R & D. (1988) p. 286-294. Book Series 59/88.

This paper is the second sequel of the state of the art on the coconut industry. It gave a picture of the industry viewed from its social perspective. In this regard, 30 empirical studies were reviewed from 1951 to 1984. Descriptive as well as substantive analyses of these studies are presented.

DE OMAMPO, N. R. *State of the Art: Coconut Economic Research.* Proc. 2nd National Coconut Research & Development Symp., Los Banos, Philippines; 1984. Coconut R & D. (1988) P. 267-285. Book Series 59/88.

The paper presented the state-of-the-art regarding economic researches in the coconut sector. Relevant studies conducted in line with coconut productivity, marketing, coconut based farming systems and related areas were put together. This specifically singles out areas of concern for research and development for the years ahead.

MASANA, A., E.T. PANGILINAN, V. PUNZALAN , and L. TORIO. 1977. *Project Study on Wallboard Production from Coconut Husks.* Adamson University Manila. 81 p. (Thesis:BS) (AUF).

This project proposed a pioneer in an industry that will manufacture 450,000 panels annually of wallboard from coir dusts and short fibers of the coconut husks and consequently will require the production of 3,577.49 tons of coir fiber and bristles.

MONTEMAYOR, L. S. 1977. *Wood Anatomy of Coconut Trunk (*Cocos nucifera L*) in the Philippines.* AUF, Malabon , Rizal. 31p. (Thesis: BS). (AUF).

A coconut stem of the Laguna variety (Yellow) collected from San Pablo City and about 33 cm in diameter at breast height was used.

Disc about 3.8-cm thick representing each of the butt, middle and top height levels about 32.4, 24.4 and 22-cm in diameter, respectively, were prepared. The cross-sectional surface of the discs were planed to render the tissues more visible.

Macroscopic and microscopic observations of the prepared samples were made.

The study suggested that the wood of the coconut palm is very hard in texture particularly the peripheral zone on account of the close distribution of fibrovascular bundles compared with the soft or spongy texture of the inner or central portion.

PALOMAR, R. N. *Evaluation of Some Chemicals for the Control of Blue Stain Fungus and Pinhole Borer on Freshly Sawn Coconut Timber.* CORD. (1989) v. 5(1) p. 1-13.

An investigation was made to determine the relative performance of some chemicals against growth of blue stain fungus and attack of pinhole borer on freshly-sawn coconut timber during the drying process. The fungicides used were Farmay Plus, Azaconazole and the standard chemical combination of Sodium Pentachlorophenate, BHC and Borax Pentahydrate. Cislin, an insecticide, was mixed with either Famay Plus or Azaconazole solution.

Results after 12 weeks of air drying showed that all fungicides failed to give the desired protection against blue staining. Performance ratings of planed wood samples were within the range of heavy to severe stain infection. On the other hand, Cislin showed an acceptable level of protection from pinhole borer infestation on coconut lumber.

PALOMAR, R. N., P. JENSEN, and V. K. SULC. *Exposure Tests of Surface-treated Sawn Coconut Timber.* CORD. (1989)) v. 5(1) 93-107.

An investigation was made to determine the relative performance of three readily available inorganic chemicals containing either copper or chromium when applied singly or in combination to sawn coconut timber surfaces. The treating solutions , consisting of chromic acid (H2CrO4), sodium dichromate(Na2CrO4) and copper sulfate (CuSO4), were applied by brushing on wood surfaces with one coating at the rate of approximately 155 grams per square meter. The specimens were exposed outdoors on racks inclined at 45 degree angle and facing south. Results after 3 years of test showed that treatments with mixture of H2CrO4 and CuSO4 or combination of Na2CrO4 and CO4 performed better than single application of either H2CrO4 or Na2CrO4. The former treatments still showed uniform and pleasing appearance after the exposure period.

SEASTRES, S. I. 1978. *Research Work and Fabrication of Coir Dust Dryer for Steam Power Plant.* Coirflex Philippines Inc. Rep. 15p. (PCA).

This research was conducted to study a method of utilizing coir waste as fuel.

The company was engaged in the manufacture of coir, and disposed an average of 31 tons per day of coir dust with moisture content of 82-83 percent. Upon moisture reduction to 45%, the material can be burned and used as fuel in operating a steam boiler.

It was feasible to dry mill-run coir dust to a level at which it can be suitable as fuel. The heat energy harnessed from burning the coir waste was adequate to operate a boiler which generated the steam requirement of the plant. Stretching the efficiency of mechanical pressing reduced the load of the rotary dryer, eventually achieving a balance in heat input to coir waste dried. Proper insulation of the rotary dryer and other ductwork in the actual facility will maximized heat utilization and improve drying.

STA. INES, R. R. 1978. *Fluidized-bed Combustion of Coconut Coir Dust.* UPCE Rep, Diliman, Quezon City. 151 p. (Thesis: MS). UP.

Combustion of coir dust in a fluidized-bed combustion system involved several important factors. It was found out that with bed temperature of about 1500 ^{0}F combustion was self-sustaining and as expected, an increase in excess air decreased the loss of carbon and of combustible gases present in the off-gas.

In fluidized combustion systems, fluidizing velocity determine the quantity of air per unit area which, in turn, determine the amount of fuel that can be burned per unit area. However, this quantity of fuel was insufficient to form a bed; hence, for complete combustion, an inert solid material should be made available. Sand and crushed refractories were tried as bed material, found to be suitable and used in most of the experimental runs.

The fluidized-bed combustor or incinerator appeared to be the most promising method of dealing with the problem of efficiency utilization of low-grade fuels.

Coco-coir Dust

Local Studies:

ALCASID, M.G.C. B. *Heat Treatment on the Microbial Load of Husked Coconuts.* RMC, UPLB.

This research looked into the effect of heat treatment on the microbial load of husked coconut.

Microbial loads of the polyethylene liner, nonheated and heated husked coconuts were determined by dilution pour plating in tryptone glucose yeast extract agar. Triplicate plates of each dilution were incubated at ambient room temperature for 48 hours. Gram stain and spore stain of the microorganisms were prepared.

BANZON, J. A. *Manual on Coconut Non-Food Processes.* RMC, UPLB.

The manual is a compilation of forty experiments on coconut non-food processes. The manual promises to benefit small entrepreneurs and prospective investors in coconut utilization.

FESTIN, T. F. *Small Technology Design for Energy Pyrolysis Products.* RMC, UPLB.

Under certain operating conditions, pyrolysis of agricultural wastes such as coir dust, sawdust, rice husk, and others, produce three relatively high calorific value fuels namely, charcoal, oil and a combustible gas.

The gas can power the pyrolyzer making the fiber extraction process self-sustaining. It can also provide the heat to dry both the coir fiber and coir dust from the decorticator which usually are wet. The charcoal and oil can be used in various ways to serve the demands for traditional fuels in rural areas. However, some treatment of these products especially the oil, and development of devices are needed to efficiently utilize the charcoal and the pyrolytic oil.

The first phase of the project aimed to study how pyrolytic oil derived from rice hull and coir dust can be used efficiently as substitute fuel and to design, fabricate and test a burner using the oil. The second phase, on the other hand attempted to study the briquetting of the granular charcoal and design, fabricate and test a low -cost manually operated briquetting device.

GOMEZ, E. D. *Socio-Economic and Communication Research on Coconut.* RMC, UPLB.

A review of the different studies on coconut production, utilization, marketing and other related subjects was conducted in the libraries of 16 universities and government and private agencies. The extent of research done in coconut in the socio-economic/communication aspects was determined. These will serve as basis for suggesting possible research areas specifically communication research on coconut.

The project summarized 47 empirical studies. Twenty-three studies were carried out in Southern Tagalog provinces, 11 in Bicol Region and the rest in various other coconut growing provinces. Except for 4, the studies were mainly on economics. Specifically, 10 studies dealt on marketing, 15 on farm management, 18 on socio-economics, 2 on socio-communication factors, 1 on cultural patterns associated with coconut, and 1 on the problems as perceived by the coconut farmer.

LANTIN, D. *The ASEAN Coconut Industry: A Status Report.* RMC, UPLB.

The study dealt on the industry covering the five countries composing the ASEAN to come out with more specific facts about the coconut industry seen from the ASEAN perspective.

The methodology involved both horizontal and vertical analyses assessing each coconut product within the framework of each member country and of ASEAN. Destination of output analysis, which showed where coconut products go, was also used. Analysis of the trading of coconut among ASEAN member countries and inter ASEAN trade was used to determine the percent share of each country's export and import of coconut products from the other countries within the ASEAN.

UYENCO, F. F. *Microbial Conversion of Coconut Waste Products (coir dust, sapal, and coconut water) into Animal Feeds.* RMC, UPLB.

The study explored the potential of microorganisms in converting coconut wastes into microbial proteins for incorporation in animal feeds. Several species of microorganisms were screened for the conversion of coir dust and coconut water into microbial biomass proteins. Cultures of coir dust with coconut water were studied for lignin biodegradation as a primary step towards protein enrichment. The most effective organism was Phanerochaete Chrysosportion UPCC 4003 which degraded the lignocellulose complex at a rate of about 25 percent in four weeks. The degradation process was carried on with minimal nitrogen concentration, coconut water supplementation and moisture levels between 85-90 percent. Stepping up the lignocellulose degradation step was effective only to a limited extent. The in-vitro dry matter digestibility of coir dust increased with microbiological treatment. Phenolic substances were detected as by-products of lignin degradation on coir dust. Coconut water was studied as a main substrate for producing yeasts for single cell protein.

Foreign Studies:

BROOKS, R. L. 1944. *Charcoal from Coconut Shells. Chem Abstr 38 (18):5064.*[6] *Also in Proc Agric Soc Trinidad Tobago 42:150-13.*

The adoption of a 40-gal oil drum as a metallic kiln was described.

CHILD, R. 1940. *The Destructive Distillation of Coconut Shells.* Chem Abstr 34 (8):2582.[9] Also in Trop Agric (Ceylon) 93:195-204.

About 40,000 tons of coconut shells were burned annually in Ceylon to produce about 13,600 tons of charcoal, without attempts to recover the by-products. The destructive distillation of coconut shells yielded charcoal 34, pyroligneous acid 40, tar 6, and gas 20 percent. The production of chemicals from by-products is discussed.

CHILD, R. 1941. *Coconut Shell Charcoal. Chem Abstr 35 (4): 1206.*[5] *Also in Trop Agric (Ceylon) 94:99-104.*

The procedure in manufacturing the by-products from and the economics of the production of coconut shell charcoal in Ceylon were discussed. Specifications for quality were given with respect to particle size and the ash, chloride, water and volatile matter contents.

CHITTENDEN, A. E., L. J. FLAWS, and A. J. HAWKES. 1970. *Particleboards from Coconut Palm Timber. Ceylon Coconut Q 21 (3): 107-112 (PCA, UPLB).*

Trials conducted at the TPI in London, U. K., showed that by using 8 percent of urea-formaldehyde resin binder, and between 0.5 and 1 percent of wax additive mixed with splinters 30 mm long and 0.6 mm thick, particleboards of a nominal density of 640 kg/m^3 can be made from coconut palm timber with normal commercial procedures, meeting all British standard requirements. The hygroscopic properties of this timber must be taken into account for industrial uses. The protection of the dried splinters from exposure to high humidity conditions by providing covered containers or bunkers should not prove very difficult, but must be planned in terms of cost and of design of the hardware involved.

DOOTSON, J.; P. NAKA, M. RATTANAPRUK, and M. NGANGORANATIGAR. 1989. *The Production and Properties of Coconut Stem Charcoal in Thailand. CORD. v. 5(1) p. 14-31.*

A programme of experimentation and training on the production of charcoal from coconut stems in transportable metal kilns was carried out. Comparisons were made among different timber densities, preparation methods and kiln loading systems. Other timber sources and traditional kilns were used. The highest density coconut wood produced the best charcoal and extensive preparation was found to be necessary. Local clay kilns produced excellent charcoal, but were slow and needed considerable fuel. Coconut stem charcoal production was markedly different from carbonization of wood from dicotyledonous trees. The charcoal produced had similar calorific value as that from other woods, but was faster-burning and easier to ignite. Content of volatile matter was low and little ash was produced. The charcoal was often rather wet. The main complaint was the speed of burning.

FREISE, F. W. 1932. *Use of Coconut Shells as Boiler Fuels (in Brazil). Chem Abstr 26(21):5726.* [7]

Typical analysis and details of operation are given. The very basic ash required suitable refractories.

GEORGIA, C. D.V. and T. A. BUCKLEY. 1930. *Destructive Distillation of Coconut Shells and Oil Palm Nut Shells. Chem Abstr 24 (5): 208.* [4] *Also in Malay Agric J 17:398-402.*

Coconut and oil palm shells distilled in an iron retort gave 49% and 33.4 % charcoal production, respectively. Charcoal from coconut shell was hard and brittle with a density of 1.17-1.21; that from oil palm shell was similar but more glossy and density was 1.47. Oil palm shell is unlikely to be available for distillation, but coconut shell is a valuable source of HOAc, creosote oil and MeOH, as well as producing charcoal which can compete with those from hardwoods.

NATHANAEL, W. R. N. 1966. *Coconut Husks as Industrial Raw Material Coir Q. J. 10(3): 13-27 (NIST).*

The paper discusses the nature and composition of the husk, its utilization and retting, extraction and processing of coir (the fibre drum method, the dry decorticator, mechano-chemical methods), special uses of coir (the use of green husks from tender nuts and green immature coconuts naturally falling from the palm as a raw material for the manufacture of artificial leather or "coconite" and the utilization of dry mature husks for the manufacture of paper), and coir waste.

SUMARDJAN, H. *Coconut Stem Utilization in Indonesia. CORD. (1989) v. 5(1) P. 32-38.*

The article elaborates on coconut wood utilization in Indonesia. The uses ranged from household furniture, ornaments of artistic value to medium size construction of foot bridges, etc. Commercialization of this wood has encountered several problems. Coco wood fetched very low price compared to regular wood. Qualities of coco wood brought from different provinces were inferior. Supply potential and sawing technology are also discussed.

URATSUJI, K. and M. MATSUSHIMA. 1971. *Solid Fuels with Good Mechanical Strength. Chem Abst 74 (26):149. Also in Jpn Pat 7,032,535, Oct 20, 1970. 2p.*

A solid fuel containing coconut husks, 3.0; coal powder, 54.0; charcoal powder, 10.0; petroleum, 8.0; an oxidizing agent, 8.0 (polyvinyl alcohol); binder, 15.0; and Fe_2O_3 catalyst, 2.0 had crack strength and rupture strength of 47.5 and 57.0 kg/cm^2, respectively. The mechanical strengths increased with increasing husk content (0.3 percent).

WILSON, S. H. J. 1930. *Calorific Value of Coconut Husks. Chem Abstr 24(19):4914.*[8] *Also in N Z J Sci Tech 12:14-15.*

The average calorific value of coconut husk was 4.192 cal/g. Determinations were made using Darroch bomb calorimeter.