Commercial utilization of coconut stem wood and shells: Present scenario and future needs

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There is a need to popularize the newly developed appropriate processing technologies for value addition of coconut by-products such as preservative treated rough sawn kiln dried (RSKD) coconut timber for structural and furniture and panel boards, waste stem wood and shells for charcoal and activated carbon which are suitable for community level operation so as to enable the rural community also to realize the benefit of value addition.

Domestic scenario

Coconut, the versatile tree crop is cultivated in an area of over 1.94 million hectares in India (CDB 2007) with an annual production of 9.4 million tonnes of copra (FAO 2008) from 15 billion nuts and it contributes over 70,000 million rupees to the country's GDP. India accounts for 27.49 per cent of the world's coconut production and is one of the major players in the world's coconut sector (3rd in world) in terms of copra processing and coconut oil extraction. Coconut industry principally depends on the domestic market price of coconut oil which is again highly volatile as it always depends on the price of other vegetable oils. Owing to high cost of production, on account of high labour cost, the domestic price of coconut oil is always higher than the international price. For instance, the domestic price of coconut oil was US$ 1261 per tonne against the international price of US$ 467 during 2005. Though the domestic price of coconut oil is higher than the international price, the farmers are not generally benefited from the market price due to sudden and unprecedented import of large quantities of coconut products to India from other countries. This situation of dwindling domestic price of coconut is adversely affecting the economic viability of many coconut processing units in the country. The coconut sector has to be equipped to face these challenges by evolving ways and means to reduce cost of production and scaling up the production of selective items that India has the advantage. Enterprise diversification, by-product utilization, and value addition are some viable options to assist the sustenance of the coconut processing industry.

About 90 per cent of the total area and production of coconuts in the country is concentrated in the four southern states (Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh). Kerala accounts for the major share, 45% in area and 38% in number of nuts (Table 1) and hence an attempt is made to analyze the by-product utilization.

Major coconut by-product utilization avenues

The coconut by-product industry in India is commercially limited to

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Table 1.State-wise percentage of area under coconut plantation, overall production and coconut shell availability in India

States /Union Territories	Percentage of area under coconut plantation	Total production (Million Nuts)	Shell availability per year (Tonnes)
Andhra Pradesh	5.41	1326	204006.9
Assam	0.98	153	23539.5
Goa	1.31	126.7	19493.8
Gujarat	0.85	138.3	21277.1
Karnataka	20.67	1625	249977.2
Kerala	44.89	6054	931327.1
Maharashtra	1.08	175.1	26938.2
Nagaland	0.05	0.2	30.7
Orissa	2.63	275.8	42432.0
Tamil Nadu	19.31	5429.9	835358.0
Tripura	0.17	7	1076.8
West Bengal	1.29	359.1	55247.0
A& N Islands	1.10	89	13692.7
Lakshadweep	0.14	53	8154.0
Pondicherry	0.11	27.9	4292.4
All India	100.00	15840	2436812.8

(*Source:* CDB 2007)

mainly coir and coir products and very few shell based activated carbon industry; with little development in the stem wood utilization sector. Lack of efficient technologies and unorganised set up of this sector (problems associated with raw material collection, transportation, handling and processing) caused the slow pace of development in these sectors. As far as shell is concerned, as more than 50 per cent of the coconuts are consumed in the household level, equivalent quantity of shells are either ineffectively utilized or wasted at this level resulting in the availability of only 50 per cent of the total available shells for commercial utilization, which is again distributed in scattered form in different coconut growing states where accessibility between the collection and processing centres causes huge transportation costs. Promoting the community based organisation (CBO) or cluster based approach could be the right solution for developing the above sector. Processing technologies needs to be appropriated for implementing the concept of local cluster level processing of the by-products such as stem wood and shells. Even though the establishment of the Coconut Development Board accelerated the development of new technologies through R & D efforts, more emphasis needs to be paid in the establishment of stem wood and shell utilization ventures.

Rationale of community level processing

The concept of community or cluster level processing of coconut received momentum following various women empowerment schemes. Economic viability of community level processing units in the coconut sector is realized from various programmes and schemes implemented by State and Central Government agencies. The efforts under various self help groups (SHGs) formulated under women empowerment schemes for the below poverty line (BPL) groups; "Kudumbasree" of the State Poverty Alleviation Project of Government of Kerala and many similar activities had one or more components of coconut processing in the community based organisation (CBO) level. Technology intervention support for processing by-products such as shells and waste stem wood are identified as the key issues that need to be attended for livelihood improvement.

About 10 million people of the country sustain with coconut related activities. Coconut sector contributes to about Rs. 40 billion total value products and around Rs. 1 billion foreign exchange in the national economy. Any coconut processing industry should have a plan for economic utilization of all by-products, otherwise that will lead to difficulties for storage space and environmental problems. In this regard, the community level processing of coconut assumes importance for easy local level management of by-products and reduced cost of transportation of raw material. CBO level approach for developing coconut by-product utilization industries is important as coconut being essentially small holders' crop in the country and is grown mainly in homestead gardens and small holdings.

Coconut stem wood

It is estimated that about 41% of the bearing palms in the seven southern districts of Kerala are affected by root wilt, a debilitating disease. About 14% of the non-bearing palms are in the advanced stages of the disease. Although the disease occurs in palms of all ages, young palms are more susceptible. The diseased palms may continue to give economic yield for few more years even after the onset of the disease. Once the palm reaches the advanced stage of infection, it is not economical to retain it, as it is a phytosanitary hazard. Cutting and removal of root wilt-diseased palms will help in controlling the disease spread by reducing the inoculum pressure on the existing palms of susceptible nature. Also, clearing the land will facilitate systematic laying out of new seedlings of comparatively disease-tolerant varieties and permits the benefits of simplified inter-cropping. However, experience shows that it is extremely difficult to persuade farmers to cut and remove the wilt-diseased and over-mature palms as long as they continue to yield a few nuts. They will be persuaded if the value of coconut stem wood compensate more than the trouble of maintaining the uneconomic palms and expense of cutting and removal and replanting the area with disease-resistant varieties. It is due to this reason, subsidies are offered by the government for the cutting and removal of diseased palms. This will create an opportunity for massive replantation programmes leading to the increased availability of palm wood requiring steps for better and efficient utilization of stem wood. Effective utilization of stem wood is of great advantage in reducing the overall cost of replanting and also in reducing the pressure on forests or other tropical plantation species for wood requirement and thereby benefit in terms of environmental conservation.

Basic density of merchantable coconut timber (avoiding inner soft core portion; up to middle portion) from mature trees (55-70 years old) varies from 500-600 kg m^3. Palms grown in Kerala have slightly higher density compared to those grown in other parts of the world (Gnanaharan, *et. al.* 1986). In general, only the outer portion from the bottom one-half of the palms are suitable for structural or sawn timber uses. The remaining low-density (200-280 kg/m^3) portions from the top portions of the palms are wasted and this could be considered for conversion into charcoal.

Table 2 gives the average height and volume of trees from different age groups and their respective sawn timber output and recovery (Gnanaharan, *et. al.* 1985 and 1986). It can be seen that the pooled mean sawn timber output from over-aged to mature palm is about 0.5 m^3 with an average density of 550 kg/m^3.

Even though not very popular, the primary and significant utilization potential of mature coconut stem wood is for structural applications and furniture purpose. As the timber falls in the category of 'perishable', only preservative treated timber will last long. Due to the peculiar nature of coconut stem wood, it yield a significant quantity of waste wood (the outer and inner portion of stem wood of senile and mature palms as well as the whole stem wood of juvenile palms) while sawing. One rational way to utilize the portion not suitable for structural applications is to convert it into charcoal. Charcoal, as a domestic fuel, has many advantages over firewood in terms of energy and economy. Stem wood charcoal can also be used as an ingredient in fuel briquettes. At present, the waste stem wood portions of a coconut tree are not being utilized even for charcoal. Hence, there exists scope for utilizing the waste stem wood portions for the production of charcoal for fuel briquettes.

Out of the various coconut products, on a commercial scale, coconut stem wood is the least utilized in the country properly and is the least attended. Much R & D inputs were seldom made in the utilization sector of coconut stem

Table. 2. Height, volume, sawn timber output, sawn timber recovery and basic density of wood of non-diseased senile palms and wilt-diseased palms of different age groups.

Age	Height (m)	Volume (m^3)	Sawn timber Output (m^3)	Sawn Timber recovery (%)	Mean wood density (kg/m^3)*
Non-diseased, over-aged; 70 years	12.7	0.44	0.12	26.5	540
Wilt-diseased matured; 55-65 years	15.8	0.62	0.15	24.5	560
Wilt-diseased; 35-45 years	10.2	0.44	0.07	16.2	510
Wilt-diseased; 15-25 years	7.4	0.43	0.05	11.9	370

n-10; * Mean value of the density values of wood samples from the outer portion of the base and middle height levels of the palm wood, as is evident from the review of coconut research in India by Chadha (2005) who never mentions about stem wood utilization. The present scenario is that some of the existing sawmills saws and sells coconut stem wood and some are engaged in producing limited volume furniture and handicrafts; none being preservative treated. This situation specifically calls for emphasised efforts for developing and popularizing efficient and value-added utilization of coconut stem wood.

The coconut stem wood available from the root-wilt affected palms of different age groups (over-mature palms of age about 55-65 years; mature palms of age 35-45 years; young palms of age 15-25 years) were assessed for their sawn timber recovery, physical properties like wood density and shrinkage, mechanical properties, calorific value, treatability, conversion potential into charcoal and the yield and quality of charcoal and compared with the same from the wood of non-diseased over-mature (senile) palms of age about 70 years (Gnanaharan and Dhamodaran 1988). In general, it has been found that the wilt disease did not have any significant effect on shrinkage, strength properties, yield and quality of charcoal. An average charcoal yield of 27.5% is reported. The charcoal from coconut stem wood was of desired quality suitable for domestic use (Gnanaharan *et. al.* 1988). However, recovery of sawn sizes is significantly higher from non-diseased over-mature palms compared to that of wilt-diseased over-mature palms (26.5% versus 24.5% respectively). Strength properties of stem wood from over-mature palms compare quite well with that of other locally available structural timbers. Stem wood from wilt-diseased palms, of adequate density is suitable for construction purpose (Gnanaharan and Dhamodaran 1989 a). It has been found that coconut timber can be effectively preservative treated to the required retention levels; thereby the possible attack from insect borers and termites can be prevented by making the timber durable (Gnanaharan and Dhamodaran 1989 b). Besides structural use, coconut wood can be converted into other useful and saleable products which could provide additional income to the farmer after helping to underwrite the replanting operation. The average calorific value of coconut stem wood in air-dry condition was found to be about 16.3 MJ/kg and it compares fairly with that of hardwoods. Upper half of the over-mature (senile) and mature palms and full length of disease affected young palms removed for replanting, which has no value for structural applications could be used for fuel wood of adequate heating value or converted into charcoal which can again be used as a direct fuel or as an ingredient for fuel briquettes (Dhamodaran, *et. al.* 1989).

Shells

Considerable amount of shells, the by-product of kernel based (copra) processing units, is not properly utilized or lacking value-addition at present. According to estimates of CDB, it has been calculated that out of a total availability of around 2.5 million tonnes of shells in the country, Kerala accounts for about 38.2 per cent (0.93 million tonnes). One tonne shell is reported to be equivalent to about 6500 whole shells. On oven dry (OD) weight basis, coconut shell has the chemical composition of 33.01% cellulose, 36.51% lignin, 29.29% pentosans (hemicelluloses), and 0.61% ash. The air dry moisture content of shells is around 7%. One kg shell on oven dry basis yields about 5000 kilo calories of heat. Coconut shells offer the best raw material for charcoal production. Shell charcoal is of high value both for domestic and industrial uses and is of great demand. One kg shell charcoal yields around 7200 kilo calories of heat. Shell charcoal forms the best raw material for the production of granular activated carbon, an important product for many industries.

Granulated activated shell charcoal

Value addition to coconut shell charcoal by converting it as activated carbon has enormous export market but production is at present limited to large scale industrial units. Coconut shells abundantly available in copra units, DCP making units and VCO manufacturing units offer scope for value addition by converting it into first charcoal and then activated carbon. World demand for activated carbon is forecast to expand 5.0 per cent per year through 2010 to 1.2 million metric tonnes. Besides the demand from developed countries (accounting for over half of the demand), greater growth opportunities will generally occur in developing markets, primarily the emerging industrial economies of Asia. Haris and Paul (1994) pointed out our comparative inability to earn foreign exchange by exporting shell charcoal and activated carbon till 1990. By designing appropriate carbonization and activation plants with pollution control facilities, it is possible to downsize the production of activated carbon from large scale industries suitable for operation at community level.

Conversion of coconut shells to charcoal and subsequent conversion of the charcoal thus produced into activated carbon opens up an avenue for industrial as well as community level processing for value addition of these by-products. Activated carbon being a high value-added product from charcoal and charcoal being the single raw material required for manufacturing active carbon, rather than selling the charcoal, scope exists for the cluster or producing community to use it for the production of further value-added product, activated carbon, on a collective level in the cluster itself.

Charcoal manufacturing - Issues

Charcoal manufacturing is always a defamed industry due to its inherent issue of smoke production there by polluting the environment. The major quantity of charcoal is still produced in the country by the traditional earth pit and drum methods due to its simplicity necessitating less capital investment and skill. But the great disadvantage of this method is the ground level spread of smoke produced thereby damaging the ambient air quality and associated public health issues. Due to this reason, traditional charcoal production sites are always restricted to remote village areas with less inhabitation which is scarcely available in thickly populated states like Kerala. Industrialization and urbanization limits the future scope for continuing the production of charcoal by the traditional earth pit method. This situation calls for looking into alternative safe and clean methods for charcoal production, preferably suitable to industrial scale operations.

Appropriate technology for cluster or community based organisations and small to medium scale industries

Cluster or community based organisation (CBO) approach is popular now days in the small scale industries. In clusters, charcoal is presently produced in small quantities by earth pit method as well as the drum method employing empty oil drums in homesteads. The charcoal produced in a cluster is pooled together for further marketing or processing. The charcoal production may be changed from the cluster members' homesteads to a community level operated centralized production unit having the small industrial scale alternative safe and clean production facility. This will limit the cluster members' activity to collection of the raw material alone. This will also greatly help to solve the issue of environmental damage. Further, products of desired quality fetching higher prices or enhanced production can also be assured in such controlled systems.

Activated carbon manufacturing industry is presently limited to the large scale industry sector alone. The technology under wider commercial use in large scale industries is limited to rotary kilns. Rotary kilns are commercially available in large sizes only and hence are not appropriate for use in cluster based or small scale industries. Economic down-scaling of the rotary kiln is a challenge due to its inherent limitations of minimum length and diameter associated with the required minimum retention or residence time of charcoal for activation in the kiln and the non-suitability of such a system to process small quantity of charcoal.

R & D inputs of KFRI

In the above circumstances, the Kerala Forest Research Institute (KFRI) with the support of the Coconut Development Board conducted studies to assess and develop appropriate technology for value-added utilization of coconut stem wood (Gnanaharan and Dhamodaran 1988) and shells for community level production of charcoal and activated carbon (Dhamodaran and Gnanaharan 2009). The carbonizing plant developed has little pollution and is suitable for both small/community level as well as for medium to large scale industries. The fluidized bed reactor (FBR) plant developed for activated carbon production is ideal for small/community level or cluster based enterprises and is with little pollution. This will provide the farmers' cluster an opportunity to get enhanced income through local community or cluster level processing for further value-addition. This will help the farmers to sustain and to retain cultivation affordable. Industries will also get benefited in terms of new technology for small scale production and in terms of value-added product, activated carbon.

Since in Kerala, the major utilization of coconut shells is for the production of charcoal, in order to develop an industrial plant with controlled pollution, through the assistance of CDB, Dhamodaran and Gnanaharan (2009) successfully developed a carbonizing plant of 1 tonne input capacity per day for the production of charcoal and a fluidized bed reactor (FBR) of 0.25 tonne input capacity per day for the production of activated carbon. The products, charcoal and activated carbon from the newly developed plants are found conforming to Indian Standards (BIS 1984, 1989, 1992 and 1995). Economic analysis indicated the need for up-scaling the capacity of plants for better sustenance while adopting for industrial production. The technology developed is found successful and appropriate for small to medium scale industries including community level operation in clusters.

There is a need to popularize the newly developed appropriate processing technologies for value addition of coconut by-products such as preservative treated rough sawn kiln dried (RSKD) coconut timber for structural and furniture and panel boards, waste stem wood and shells for charcoal and activated carbon, which are suitable for community level operation so as to enable the rural community also to realize the benefit of value addition. As such activated carbon production from shell charcoal is limited to large-scale industries; no viable processing unit exists in the community level at least for demonstration of the potential. It would be ideal to take up the issue on a technology adoption project mode for further required up-scaling of the successful technology so as to make it suitable for the sustenance of medium scale industries at the first stage.

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