COCONUT SHELL MADE PRODUCTS

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INTRODUCTION

Coconut is probably the only tropical crop commercially cultivated extensively in about 86 countries especially on the small and marginal holdings over an area of 11.1 million hectares and produces about 51.3 billion nuts per year. The endocarp of the coconut is known as shell. It is estimated that in India over 1.7 million tonnes of shell is theoretically available per year. Much of this is lost in the form of tender nut shell and shell of coconut is used for culinary purpose.

Major portion of the shells are used as fuel, for domestic and for copra production. Much of the available coconut shells is scattered in small quantities on individual farms through out the coconut growing area. Under these circumstances, setting up of a viable industry based on coconut shells is unlikely. Such a venture is likely to succeed only where large quantities of shells are available at one point as in the concentrated coconut growing area or large plantation or desiccated coconut factory or centralized copra processing plant etc.

The commercial utilisation of coconut shells for the production of shell charcoal, activated carbon, shell flour, etc., is now gaining importance in the producing areas with an expanding market demand. The shell charcoal is already in demand in the world market. Coconut shells are not favoured as boiler fuel due to the corrosive effect of the combustion vapour that are intensified by high temperatures.

COMPOSITION OF SHELL

Coconut shells are similar in composition to the hardwoods, but have a higher lignin and a lower cellulose content. The composition of coconut shell as reported by a number of workers is given in Table 1.

Table 1 : Composition of coconut shell

Constituent	Percent		
	a	b	c
Moisture	10.15	-	8.0
Extractives	2.72	-	4.2
Nitrogen	0.23	-	0.11
Cellulose	26.41	33.61	26.6
Lignin	57.77	36.51	29.4
Pentosans	20.49	29.27	27.7
Ash	2.59	0.61	0.6
Uronic anhydride	-	-	3.5
Methoxyl	-	-	5.6

[a] Serrano, D. J. et al. (1975)
[b] Woodroof, J. G (1970).
[c] Child, R. (1974)

The methoxyl content does not differ much from that of hardwoods. The moisture content varies according to environment, variety and maturity of the nut. Under average conditions, air-dried mature shells contain 6-9 per cent moisture. The heat value of the shell is 7500-7600 cal/g (d.b).

COCONUT SHELL CHARCOAL

The most important produce derived from shell is charcoal. The yield of shell charcoal is about 30 per cent of the weight of the shells used, and it is generally reckoned that about 17000-24000 whole shells makes one metric ton of charcoal. In India, production of shell charcoal is still a very primitive industry. To obtain charcoal, the shell of fully matured nuts are burned in a limited supply of air, so that they do not burn away to ash as in open fire but are only carbonized. Several methods are in vogue for the production of charcoal.

The shells are often burned in pits in the ground. A simple pit suitable for producing a charcoal for copra drying can be described as follows: A hole 1 m deep, 75 cm long, and 75 cm wide is dug in the soil. Some dry shells, clean and free from adhering fibres of the husk, are placed at the bottom and set on fire. When the shells emit flames, they are slowly piled together, and more and more shells added until the whole pit is filled. The pit is then covered with a zinc or iron plate, and the hole is made airtight by packing earth around the edges. It is preferable to use fire-resistant bricks for the lining, but ordinary locally made bricks will stand up for a considerable time. Mud mortar is found to be more satisfactory than cement. Regarding the shape of the pit, circular pits, narrower at the top than at bottom or bottle-shaped are preferable, as the firing is more easily controlled.

In Indonesia, a simple technology for producing coconut-shell charcoal is developed. The conversion efficiency is about 25percent, which is high as compared to traditional methods. The production time per batch is 20 hrs. The technique involves the use of a 200 l drum as a kiln. The coconut shells are put into the drum through a 30 cm hole in the top. Small holes in the bottom part of the drum allow air to enter. A little kerosene is used to allow the shells to catch fire. After 5 minutes, the lid is put on the drum to put out the fire. Shells are added to the drum when white smoke is emitted. More shells are added to the drum when black smoke is emitted. This process is repeated until the drum is filled with charcoal. The drum is sealed and kept overnight, and in the next day the charcoal can be taken from the drum.

Success in operating these types of kiln greatly depends on the experience of the operator. Some practice is required to attain exactly the right conditions. If the combustion is smothered too much and carbonization is complete, a mass of woody half-burned charcoal results. If, on the other hand, the burning is not smothered enough, there is a poor yield of charcoal, which is brittle, thin, and dusty. When the pit is full, the slow burning proceeds, while much acidic smoke is given off. During this process the pit is covered as described above, leaving only sufficient space for a smoke outlet. It is not usually possible to open the pit until the third day. When it is opened, the mass of charcoal may catch fire, and it is therefore sometimes necessary to sprinkle it with water until it cools off.

There are many modern kiln available for the manufacture of coconut-shell charcoal, and most kilns suitable for wood charcoal can be used for this purpose. Where a large supply of shells is regularly available at one spot, the carbonisation can be done in kiln, in which the heat energy producing at the time of carbonisation is effectively used. An advanced coconut shell carbonization unit, otherwise called as waste heat recovery unit, has been developed by National Research Institute, United Kingdom. This unit carbonizes shell whilst simultaneously producing a combustible gas which is used to provide process heat. In the traditional methods of carbonization to produce charcoal, this heat is lost to the surroundings and large volume of obnoxious smokes are evolved. This smoke problem is virtually eliminated by using the waste heat recovery unit. During carbonisation of coconut shell using traditional pit methods, approximately 65 per cent of the heat in the feed stock is wasted. The charcoal produced in the waste heat recovery unit, contain approximately 40 per cent of the original heat content of the shells and approximately 75 per cent of the remaining heat, which would normally lost to the surroundings, could be used for processing, this heat being approximately equivalent to 235 liters of fuel oil, when one tonne of shell is carbonised. This technology has been commercialized in Sri Lanka.

Good shell charcoal is uniformly dark and snaps with a clean shining fracture and produces a metallic sound, when dropped on hard ground. Under-burnt shells do not give a metallic sound and a clean fracture, while the over-burnt ones are friable and the surface of the fracture sounds dull when dropped and easily crumbles. Shell charcoal contains the highest percentage of fixed carbon of all the ligneous charcoals. Better quality charcoal can be obtained from more matured coconut shell. The dead ripe matured shells and turning brown matured shells can be mixed during carbonisation without reduction in charcoal quality.

Other than the traditional uses of shell charcoal such as culinary fuel, dentifrice, etc., it has other important uses as base material for activated carbon. The charcoal has a high absorption capacity for gases and colouring matter and can be used as a refining agent, both as a deodourizer and a decolouriser. The shell charcoal also finds way to laundries, smitheries, etc. The ash obtained from the shell, at the time of carbonization, is found as a useful substitute for potassium fertilizer.

ACTIVATED CARBON

Coconut shell charcoal, is a material with a very limited surface area. The absorption capacity for gases and colouring matter is, therefore very less. This can be increased by activation with chemicals. On activation, it is transformed into a product with the ability to absorb effectively even trace quantities of either unwanted or valuable liquids and gases. Activated carbon plays a very important role in solvent recovery processes, water and effluent treatment, and in treatment of flue gas before discharge into the atmosphere.

In the activation process, shell charcoal is fed continuously into a retort. The normal activation process involves the use of steam at selected temperatures for the selective oxidation of material, resulting in production of carbon with pores of molecular dimensions. Shell carbon, having a cellulose base, produces a material with a finer pore structure than obtained from coals. Approximately three tons of shell charcoal are needed to produce one ton of activated carbon. Retorts designed to produce activated carbon usually operate in one of the three ways-vertically, horizontally, or by means of a series of hearths. In a vertical retort, utilizing steam, activation is controlled by the rate at which the material is withdrawn from the discharge hopper. Activation can be carried out with a variety of gases, including oxides of carbon, chlorine, and mixtures of steam and air. After withdrawal from the retorts, the material is cooled and passed through a series of granulators and screens, thereby attaining carbon of a known quality, available in variety of grade sizes to suit many applications.

For certain specific purpose, different process is used to prepare the activated carbon. This process consists of the treatment of crushed coconut shells with surface active chemicals followed by drying and subjecting the material to carbonisation. The carbonised material is activated with steam followed by air to facilitate oxidation. The activated material is subjected to steam quenching to reduce the bed temperature and is then discharged in a receptacle. The material is subsequently subjected to acid treatment to adjust the pH value. The acid treated activated material is then washed with water, dried and stored.

Granular activated carbon produced from shell charcoal is an important industrial material, and the prospects for the intermediate charcoal appear to be good as long as quality is maintained. In general, activated carbon is used where the compound to be absorbed has a small molecular diameter or, if it is a gas, when a boiling point is below 100°C. The use of this type of carbon is also specially indicated where the concentration of the absorbate is very low.

While the shell based activated carbon is considered superior to those obtained from other sources because it is generally dense, very hard, and highly retentive. They have a very fine pore structure, and their rate of absorption is generally faster than that of coal carbons.

DESTRUCTIVE DISTILLATION

In ordinary methods of charcoal making, the recovery rate is less than 30 per cent of the weight of shells. By subjecting shell to destructive distillation, charcoal of excellent quality constituting about 35 per cent of the original quantity of shells used and a variety of other useful products are obtained. The shell charcoal obtained in the process is of the best quality and has a good demand for the manufacture of activated carbon. When coconut shells are heated in a retort to a sufficiently high temperature, they are broken down in the absence of air into a number of produce. The yield and the composition of the products are likely to vary considerably with the maturity of coconuts from which the shells are derived and even more, with the conditions under which the destructive distillation is carried out. The products generally obtained are charcoal, pyroligneous liquor, settled tar and incondensable gases.

The settled tar is a complex mixture of products. By fractional distillation, it yields phenol and neutral oils, pitch, settled tar, methyl alcohol, crude creosote oil and acetic acid. The acetic acid is a good substitute for the coagulation of rubber latex.

SHELL FLOUR

A second important product derived from shell is shell flour. It is prepared by grinding clean coconut shells to a fine powder, the particle size depending on the end use. Typical grades are 100, 200, and 300 mesh.

The shells are first precrushed in a beater type disintegrator into, 5 cm pieces which are then conveyed to the first hammer mill. Suction in the conveying system draws the particles of flour into a cyclone, where they are separated into coarse and fine particles. Ultrafine particles are drawn away and collected separately. From the cyclone the coarser particles pass to the second hammer mill, and the ground products are subjected to the same air separation as the particles from the first grinding. The fine particles from the cyclone are fed into a vibrator sieving unit and graded into the required mesh size.

It is used mainly as a filler, replacing wood flour either partially or wholly in the manufacture of phenolic moulding powders by the thermoplastics sector of that industry. The inclusion of shell flour results in an improvement in the surface finish of the mouldings, and because of its higher resinous content and lower absorption properties, it can be used in higher concentrations than wood flour. Shell flour has a variety of other uses. It is used as a filler in phenolic glues for plywood and laminated sheets manufactures, filler for mosquito incense coils and filler in specialised surface finishes, resin castings, etc. As a mild abrasive it is used as a soft blast to clean piston engines. It has been incorporated into hand cleaners and used as a diluent for potent insecticides.

OTHER USES

Shell has a variety of other uses. It is used for the manufacture of hookah shells, various domestic utensils, curios, fancy items, souvenirs, etc. It is also used for the collection of rubber latex from rubber estates.

EXPORT POTENTIAL FOR COCONUT SHELL PRODUCTS

There is a good demand for activated carbon world wide, not only from buying countries such as Japan, South Korea, France and United Kingdom, but also from the producing countries such as the Philippines, Indonesia, Malaysia and other countries. Export of shell charcoal and activated carbon by selected countries during 1992-1997 is given in Table - 2. The combined exports of coconut shell charcoal and activated carbon increased from 2,24,251 MT in 1996 to 2,47,900 MT (expressed in coconut shell charcoal basis) in 1997 exhibiting about 10 per cent increase. This increase will be more if the supply increases from emerging countries such as Malaysia, Thailand and India. There is an increased desire to set up more activated carbon processing facilities in a number of coconut producing countries. As a result, few countries such as Malaysia, Thailand and India have emerged as regular supplier of activated carbon in recent past.

In the importing countries, the main usage is said to be the gold mines which use the C-I-P (Carbon In Pulp) process. The increased demand for activated carbon is also increasing in Indonesia, Malaysia and Philippines. This is to meet the growing demand from the increasing vegetable oils and oleochemicals industries and from water treatment plants.

Table 2 : Exports of shell charcoal and activated carbon by selected countries (in MT)

Destination	1992	1993	1994	1995	1996	1997
Shell charcoal	65640	67332	60761	52332	66861	73000
Philippines	43423	51975	39645	34235	41065	46000
Sri Lanka	8081	2995	6729	3820	9941	10000
Indonesia	14136	12362	14387	14277	15885	17000
Activated Carbon	35869	40226	36753	34361	47694	53000
Philippines	15785	19458	15806	9489	19490	20000
Sri Lanka	14363	13605	13302	16422	15879	17500
Indonesia	5721	7163	7645	8450	12325	15500
Total*	184008	200078	182046	165723	224251	247900

* aggregate of coconut shell charcoal and activated carbon in shell charcoal basis

CONCLUSION

Shell is a very important raw material for the manufacture of many useful products of commercial importance. Among the various shell products, shell charcoal is having more demand in the international market and Sri Lanka meets 90 per cent of the demand, the rest being met by the Philippines. In India, effective utilization of coconut shell is not popular because, the availability of shell at a place may not be adequate for further processing and the processing margins may not justify transportation cost of the shell. Shell or waste heat recovery technology offers coconut processors the opportunity to take one small step towards reducing CO_2 emission to the atmosphere. It is through a combination of many such steps, the present damaging impact of combustion on the environment will be eliminated.

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