Sell the Shells

Opportunities for coconut shell based industrial products and consumer goods

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1. Introduction

Coconut is always eulogized as 'Tree of Life' for its multifarious uses. The crop is cultivated mainly for the fruit which yields kernel and water based products like copra, coconut oil, desiccated coconut, coconut milk, virgin coconut oil, coconut milk cream, coconut milk powder, tender coconut water and other confectionery and beverage products. The fruit of the coconut palm is not a real nut but a fibrous drupe, wherein the kernel with water (endosperm) is covered with a hard shell (3 and 6 mm endocarp) and thick outer fibrous husk (1 to 5 cm epicarp and mesocarp). Shell thickness varies based on the variety and depends on the management practices adopted for cultivation. In general, the average shell weight in a matured coconut in Tall variety is 100-120 grams.

> Coconut shells which were once used for fuel purposes only, is now being used for several industrial purposes. The shell is similar to hard woods in chemical composition, though lignin content is higher & cellulose content is lower. The coconut shell for industrial use is processed into three major forms viz., coconut shell powder, shell charcoal and activated carbon. Coconut shell oil also finds use in several medicinal preparations and industrial products.

Since coconuts are shelled at the factory, in the process of making the above products, shells are collected in large quantities. However, in general the husk and shells are normally used as fuel in the coconut processing units itself for generation of heat at various stages of processing operations and also in the rural households as fuel for cooking.

2. Forms of coconut shell based products and their uses:

The world is full of creators who make innumerous products for countless and fascinating uses. Coconut shells which were once used for fuel purposes only, are now being used for several industrial purposes. The shell is similar to hard woods in chemical composition, though lignin content is higher & cellulose content is lower. The coconut shell for industrial use is processed into three major forms viz., coconut shell powder, shell charcoal and activated carbon. Coconut shell oil also finds use in several medicinal preparations and industrial products. Designer handicrafts and utility items are also made from raw coconut shells.

i. Industrial products:

a) Shell chips:

Coconut shell is made into pieces of various sizes and shapes for compact packing to facilitate convenience in transports. The chips are used for making shell powder and charcoal by the handicraft industry. Coconut shell chips are also being used as mulching material in protected vegetable cultivation in European countries instead of wood chips used earlier. Shell chips last for about three years while wooden chips last for a year, due to constant contact with moisture.

b) Shell powder (flour):

The manufacturing process for coconut shell powder (flour) is not very complicated and resultant product is of high value both as filler and extender for phenolic mulching powder. Shells of matured coconuts, free from contamination of coir pith, kernel testa and other impurities are broken in to small pieces and fed through a pulverizer and cyclone to obtain shell powder. Shells of about 12000 coconuts may be required for manufacturing one tonne of coconut shell powder.

According to the requirements of various end uses, the shell powder is sieved through various mesh sizes to get a powder which is homogeneous in its size and quality. It has good durability characteristics, high toughness and abrasion resistant properties and is suitable for long standing use.

It is extensively used as compound filler in the manufacture of Phenolic moulding powder (Bakelite plastic) as a filler & extender to reduce `ageing'. The product finds extensive use in plywood and laminated boards as a phenolic extruder, as filler in synthetic resin glues and as a flux coating for electric welding rods. Coconut shell powder is considered to be suitable and cheap filler compared to others. Though other alternate materials available in the market such as bark powder, furfural and peanut shell powder, coconut shell powder is preferred to because of its uniformity in quality and chemical composition, better properties in respect of water absorption and resistance to fungal attack.

Coconut shell powder is used successfully with specialized surface finishing liquid products (as an absorbent), mastic adhesives, resin casting and bituminous products. It is also used in manufacturing weather-resistant outdoor emulsion paints. It is used as a mild abrasive in heavy duty hand cleaner pastes, in shot blasting of delicate objects and of historic buildings. It can give a smooth and lustrous finish to moulded articles, and also improve their resistance to moisture and heat. The coconut shell granules are used as a Lost Circulation Material in oil well drilling.

It is widely used as a critical organic additive for the manufacture of insect repellent in the form of mosquito coils and also in Agarbathis (incense sticks) and dhoops (incense extrudes), for its improved

qualities of long and uniform burning. The hollow portions of the gold ornaments are used to be filled with coconut shell powder for firmness.

Keeping in view of the vast industrial uses, the demand for coconut shell powder appears to be promising.

c) Coconut Shell Charcoal

Shell charcoal is obtained by carbonizing the shells of fully matured coconuts with limited supply of air, which is usually carried out in mud-pits, brick kilns and metallic portable kilns. Good quality and yield of charcoal can be obtained by experience and skill. Over-carbonizing results in over-burnt pieces and reduced yield, whereas unburnt brown pieces due to under-carbonizing are undesirable. Good quality charcoal should be uniformly black in colour and should be free from unburnt & over-burnt pieces, dust & dirt, husk and other contaminants. Broken edges should show a shiny black surface and a characteristic sharp fracture. When dropped on a cement floor, well carbonized charcoal lumps give a clear ring.

The yield of charcoal is 25 - 33% of the mass of raw shell. The number of shells required for production of one tonne of charcoal depends on the size of shell. In general, 35 kg of charcoal can be obtained from 1000 whole shells or about 30,000 whole shells yield 1 tonne of charcoal.

Further, shell charcoal powder is a waste product obtained during the processing of charcoal. The powder is bonded with the help of binding materials and moulded in the form of briquettes using moulding machine.

Shell charcoal is one of the purest forms of charcoal, as hardwood charcoal and coal have much higher ash contents. Coconut shell charcoal is of two types, viz., coconut shell charcoal pieces and granulated shell charcoal.

Shell charcoal has been used for blacksmith and goldsmith furnaces, smoothing irons in non-electric areas, bakeries, barbecues, etc.. It is used as reductant in smelting furnaces and for carbon electrodes in dry cells. In Sri Lanka, a limited quantity of 'edible white copra' is made for export as a very high premium product. In this case, coconut shell charcoal is used as fuel in the manufacturing process, which produces an even cleaner direct heat.

From the minor uses, the coconut shell charcoal has become a commercial commodity due to its intrinsic value as a raw material for the manufacture of activated carbon, which is having wider uses.

d) Activated shell charcoal (Activated Carbon)

The coconut shell charcoal is activated by reaction with steam at high temperature under controlled atmosphere in a rotary kiln. The reaction between steam and charcoal takes place at the internal surface area, creating more sites for adsorption. The temperature factor (900°C - 1100°C), in the process of activation is very important. If it is below, the reaction becomes too slow and uneconomical. If it is above, the reaction takes place on the outer surface of the charcoal resulting in loss of charcoal. The different lots of activated carbon manufactured are tested for activity levels and blended as desired, and then sieved for size grading. Each lot is identified by its activity level and particle size range. About 90,000 shells of whole coconut or say three tonnes of shell charcoal are required for production of one tonne of coconut shell activated carbon.

Two types of activated carbon are distinguished. One refers to granular (made of shell charcoal, anthracite etc) activated carbon, mainly far gaseous phase adsorption applications, and the other is powdered activated charcoal (made of wood charcoal) for liquid phase applications.

The sources of activated carbon are mostly coal (anthracite, bituminous, lignite), petroleum based residues and agricultural by products. Production of activated carbon from agricultural by products is preferable since it is more cost effective. There are numerous studies regarding the production of activated carbon from agricultural by products such as coconut shell, oil palm kernel shell, pistachio nut shell, sugar cane bagasse, olive stones, macadamia nut-shell, watermelon peel, banana peel, orange peel, lemon peel, tea, waste tire rubber, durian shell, rambutan, pine cone, grapes, papaya seed, mango stone under physical or chemical activation process.

Coconut shell activated carbon is preferred as it has pores mainly on a micropore scale. Almost 85-90% of the coconut shell surface is made up of these micropores. However, the peat, wood and other activated charcoals are predominantly macro-sized pores that match the size of larger molecules. The superiority of micropores in coconut carbon gives it a denser and more durable structure that provides good mechanical strength and hardness as well as greater resistance to friction wear.

The coconut shell charcoal activated carbon finds many applications in manufacturing military and

Table- 1: India: Export of Major Coconut Products

Item of export from India	2015-16		2016-17		2017-18		2018-19		2019-20		Total		% share of value
	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	
Total coconut and coconut products (other than coir and coir products)		1450.24		2061.70		1764.30		2045.36		1762.17		9083.77	100.00
Activated Carbon	0.72	747.56	0.85	811.17	0.93	951.27	0.97	1344.11	1.03	1184.60	4.51	5038.72	55.47
Shell Charcoal	0.17	40.39	0.39	87.88	0.27	79.28	0.55	54.14	0.10	34.62	1.47	296.31	3.26
Shell products total	0.89	787.95	1.24	899.05	1.20	1030.55	1.52	1398.25	1.13	1219.22	5.98	5335.02	58.73
% of shell products to total coconut products		**54.33**		**43.61**		**58.41**		**68.36**		**69.19**		**58.73**	**58.73**

Q- Quantity in lakh MT, V- value in INR crores, Source: Directorate General of Commercial Intelligence and Statistics, Kolkata

industrial gas masks, solvent recovery plant, recovery of petroleum gas, purifying recycled air in central air-conditioning, air pollution control, cigarette filters, tertiary treatment of water used in the brewery, liquor and pharmaceutical industry for the removal of flavours and odours, dechlorination of municipal water, and gold dust recovery. This could also be used to develop electrodes for super capacitor. The liquid phase applications of powdered grades include decolorizing edible oils and sugar refining.

Coconut shell activated carbon is preferred to remove volatile organic compounds (VOCs) from drinking water purification systems because it is more economical than bituminous coal-based activated carbon. It has higher hardness, less dust, lower ash and is more environmental friendly.

Some of the main features that the drinking water purification industries see as a big advantage in favor of coconut carbon are it adsorbs disinfection by-products, VOCs, pesticides and herbicides; removes halogens from water; improves the appearance and taste of drinking water.

e) Coconut shell oil

Pyrolysis of coconut shells yields coconut shell oil. Traditionally coconut shell oil has been used for the treatment of skin infections.

ii. Consumer goods

a) Cosmetics & toiletries

From the above facts, we cannot come to a

Table - 2: World exports of Coconut Shell Charcoal and Activated Carbon by Selected Countries, 2012 - 2017 (in Lakh MT)

	Country	2012	2013	2014	2015	2016	2017
A	**Shell Charcoal**	**2.62**	**3.09**	**3.61**	**2.51**	**3.20**	**4.00**
	Philippines	0.48	0.93	0.77	0.60	0.25	0.40
	Sri Lanka	0.07	0.06	0.09	0.09	0.05	0.09
	Indonesia	1.81	1.79	2.50	1.06	2.73	3.11
	India	0.26	0.32	0.25	0.76	0.17	0.39
B	**Activated Carbon**	**2.44**	**2.09**	**2.39**	**1.90**	**2.13**	**2.42**
	Philippines	1.28	0.62	0.60	0.55	0.62	0.70
	Sri Lanka	0.30	0.37	0.37	0.32	0.35	0.40
	Indonesia*	0.25	0.20	0.22	0.26	0.23	0.20
	Malaysia	0.16	0.16	0.15	0.15	0.13	0.16
	Thailand	0.05	0.06	0.08	0.08	0.09	0.11
	India	0.39	0.68	0.97	0.54	0.72	0.85
	Total**	**5.06**	**5.18**	**6.00**	**4.41**	**5.33**	**6.41**

* Includes wood/coal based activated carbon
** Aggregate of coconut shell charcoal and activated carbon in shell charcoal basis
Source: ICC Coconut Statistical Yearbook 2017

conclusion that the coconut shell products have confined only for industrial purposes. There are several products now available in retail market for day to day use by the common consumers.

The charcoal and activated carbon based mud packs, face masks, etc. have arrived in market attributing to its cleansing properties. Branded activated coconut charcoal teeth whitening powder/ polish and coconut charcoal whitening toothpaste also claim to whiten the teeth and also strengthen the gums, remove toxins from the mouth and absorb bacteria. Tooth brushes infused with softer charcoal bristles also try to maximize the effectiveness of the charcoal toothpaste.

Due to its amazing moisturizer and purification qualities, coconut charcoal is also used to create soaps, body scrubs, etc. and it is said that these types are sensitive and good for skin also. Coconut shell activated carbon refreshers/ air purifiers/ deodorizers for households/ hotel rooms and cars, etc. are also available in the market.

b) Use in household grills and barbeques

Due to the high heating capacity, it is widely used for barbeque as an alternative for normal

coal. Because of its pleasant smell, most of the food producers in the food industry are now tend to use coconut charcoal to prepare traditional foods and barbeques.

As many people are now trying the restaurant dishes in their kitchens with the mini household appliances including grills and barbeques, the coconut shell charcoal in different shapes and sizes is also now made available in small consumer packs.

c) Food, feed and medicinal uses

The primary health uses of activated coconut charcoal are to treat acute poisoning in people and for gastrointestinal problems. Ayurvedic medicine used this black powder for thousands of years. Food grade charcoal are also manufactured in various parts of the world. Studies for using charcoal in animal feeds are also being undertaken.

d) Clothings

Bed sheets, kitchen towels, dish cloths, etc. with charcoal (not only of coconut) blended with other fabric are now available in the market for their greater cleansing properties.

e) Shell based utility items and handicrafts

For centuries, coconut shells have traditionally been used in producing countries as utility items like spoons and cups for various purposes. The coconut shells are polished, cut, carved and painted and attached to other accessories to make several artifacts. Bowls, tumblers, bird's nests, ice cream cups, etc. are also made. In the rubber plantations, coconut shell cups have been used for several decades to collect latex from tapped rubber trees.

As coconut shells are biodegradable, these can also be used for planting saplings temporarily before they settle in the soil for good rooting. Shell bowls are used in culturing orchids as they resist the fungal growth.

Hair pins, ear rings, necklaces, spice boxes with lids, coin collecting tills, buttons, ladies' handbags, etc. are also made from coconut shells which attract the customer and especially the tourists, as part of the souvenir.

3. Shell trade

The newly emerging products from this byproduct, coconut shell, encourage future commercial applications to increase income from coconut through trade in modern, value-added products. These products from the shell (charcoal, activated carbon, flour) enter international trade.

During the past 5 years, export of coconut shell based activated carbon and shell charcoal from India has increased (Table-1). About 5.98 lakh MT of activated carbon and charcoal valued at Rs. 5335.02 cr. has been exported during the period. It is also pertinent that these two products alone contributed to 68-69 % of export value of coconut and coconut products (other than coir and coir products) during the last couple of years.

The country exported 1,03,071 tonnes of activated carbon made from coconut shell (valued at Rs.1,184 crore) in 2019-20. The export of activated carbon from the country was at 97,050 tonnes (valued at Rs.1,344 crore) during 2018-19. US is the major importer of coconut shell-based activated carbon from India, followed by Japan and the United Kingdom. Nearly 95 per cent of Indian product is exported to different destinations.

It may be observed during the above period the the Indian export of shell charcoal is in the diminishing trend, but the activated carbon export is increasing. This can be considered as higher domestic value addition to activated carbon from shell charcoal.

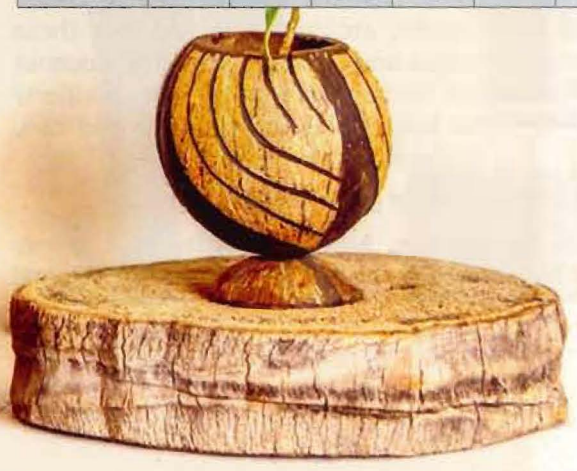
India's share in global activated carbon and shell charcoal exports has peaked to 29.48 % in 2015 from 12.85 % in 2012, which is now regaining (Table-2).

Coconut shell charcoal (ITC HS Code 44089010) is eligible for 5 % incentive under Merchandise Export from India scheme (MEIS). The few other related ITC HS Codes are 38021000 (activated carbon), 44029090 (Coconut Shell Charcoal Other), 96062910 (Button of coconut shell/ wood), 08011210 (Fresh Endocarp), 08011220 (dried Endocarp) and 08011290 (Other Endocarp).

The global data on import of activated carbon for the years 2012-2017 show an increasing trend, with major buyers in European, American countries (Table - 3).

Table- 3: World imports of Activated Carbon, 2012 - 2017 (in Lakh MT)

Country	2012	2013	2014	2015	2016	2017
European countries	2.41	3.29	3.33	3.46	3.48	3.55
American countries	1.38	1.43	1.53	1.68	1.53	1.93
African countries	0.30	0.26	0.23	0.20	0.25	0.31



Asian countries	2.59	2.89	2.86	2.70	2.68	3.20
India	0.09	0.10	0.11	0.13	0.12	0.16
Pacific countries	0.08	0.11	0.09	0.09	0.09	0.09
Total	**6.76**	**7.98**	**8.04**	**8.13**	**8.03**	**9.08**

Source: ICC Coconut Statistical Yearbook 2017

It is estimated that the global activated carbon market size reached a value of almost USD 3.93 billion in 2019. The market is expected to reach a value of nearly USD 6.24 billion by 2025, growing at a CAGR of 8% in the forecast period of 2020-2025. The growing demand for water filtration as well as air purification as a measure to improve water and air quality are the leading market trends in the activated carbon industry.

4. Project cost

For setting up of a coconut shell powder unit with a capacity of 10 tonnes per day, about Rs. 150.00 lakh (excluding land and buildings) would be required. Likewise Rs. 100 lakh is the average project cost estimated for a unit producing 5 tonnes shell charcoal per day. For the high end product of activated carbon, an investment of Rs. 700 lakh except land and buildings is required for an output of 3 tonnes per day.

5. Technical and financial support from Coconut Development Board

There are already around 30 such units in the country. Since India being the highest producer of coconut in the world, there will not be any dearth of raw material in the country. There is good scope for setting up more activated carbon units in India in view of the ever-increasing worldwide demand for activated carbon. This is also substantiated by the import of activated carbon to a tune of 70953 MT during 2012-2017.

The Coconut Development Board encourages value addition and extends technical and financial assistance for setting up of processing units for coconut based value added products.

a) Researches, demonstration and setting up of processing units

Under the 'Technology Mission on Coconut', the Coconut Development Board extends technical and financial assistance upto Rs. 75 lakh for 'Development, Demonstration and Adoption of technologies for processing and product diversification' by individuals and various institutions and groups, as below:

Development of technologies

- 100% of the project cost limited to Rs.75 lakh for Govt. institutions & societies.
- 75% of the project cost limited to Rs.35 lakh for NGO's, Individual entrepreneurs and other research organizations

Demonstration of technologies

- 100% of the cost to all the Govt. institutions and cooperative societies.
- 50% of the cost for the NGO's, Individual entrepreneurs and other organizations.

Adoption of technologies

- Back-ended credit capital subsidy limited to 25% of the project cost
- For SC/ST Women farmers, 33.3% of project cost, 50% for HVA in A&N islands & Lakshadweep, not exceeding Rs.50 lakh

Several units for manufacturing coconut shell powder, charcoal and activated carbon are assisted under the TMoC. The interested persons may submit the project proposals to the Coconut Development Board. The application format and other details are available at https://coconutboard.gov.in/TechnologyMission.aspx# AnnexuresAndApplication.

b) Marketing support

The Board organizes buyer seller meets and exhibitions for popularization of coconut products among the targeted groups. For the manufacturers, the Board extends financial support for brand building, domestic/ international market promotion, setting up of sales outlets/ kiosks, etc.

At the capacity of Export Promotion Council for coconut and coconut products (other than coir and

coir products), the Coconut Development Board issues RCMC to the exporters to facilitate export of coconut products. The Board facilitates availing various benefits under the Foreign Trade Policy and duty neutralization schemes of the Department of Revenue, to the exporters registered with CDB.

6. Future thrust

These coconut shell based products provide opportunities for substantial value addition as normally shells are either thrown away or used as a fuel. Activated carbon being a high value added product from charcoal and charcoal being the single raw material required for manufacturing activated carbon, rather than selling the charcoal, scope exists to use it for the production of further value added products.

The aggregation of the shells can be undertaken by the FPOs in coconut sector facilitated by the Coconut Development Board, other farmers' collectives and SHGs in rural area and in urban area can facilitate produce aggregation. From the units making copra and other matured coconut based products, the shells can be collected and supplied to the required industries. The households and hotel/ catering sector who procure raw dehusked coconuts with shells for varied uses may also be tied up for regular collection of coconut shells. Conversion of coconut shells into charcoal and subsequent conversion of the charcoal thus produced into activated carbon opens up avenue for community level processing for value addition of these by-products. Primary processing of cleaning, breaking and upto shell powder can also be taken up by the FPOs. This will benefit the members of the collectives giving them a marginal gross profit from coconut.

More R&D activities can be taken up for exploring the medicinal properties of the shell based products.

ICAR-CPCRI Vision 2050 (2015) estimated that just over 10% of global demand for activated carbon is met from coconut shell. Hence, the uses for which the charcoal and activated carbon from sources other than coconut shell and still to be tested/ applied to this valuable product also have to be attended. The use of nanotechnology in the production of nano-fibres from coconut shell need to be envisaged for its application in food packaging and other related fields to develop nutritive and marketable products. The biofuel production from coconut shell oil may be standardized for commercial utilisation.

Higher awareness about these products is to be created among the chemical industries and the FMCG sector, to boost the trade. Though considerable costs on energy is reduced by the use of coconut shells in the coconut processing units, these alternate options for value addition to high end products expand the opportunities for generating high income for the entrepreneurs and farmers apart from creating employment opportunities, especially in the rural sector.

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