Coconut Oil and Its Byproducts

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ABSTRACT

Byproducts of processing coconut fruit include coconut water usable as a carbohydrate beverage or fermentable substance; the husk, as a source of fibers, charcoal and chemicals; and the shell, usable primarily as a source of carbon. Coconut-shell activated carbon is discussed in detail. This effective adsorbent has increasing applications in industrial and environmental processes.

INTRODUCTION

The coconut tree is a very versatile plant, every part of which has its own use or application. The leaves can be used as roofing materials for the construction of sheds and can also be made into exportable accessories such as baskets. When dried, these leaves can be used as fuel. The midribs of the leaves are also used as brooms. Its trunk is extensively used as firewood or timber, a common building material for houses in the rural areas. The inner trunk gives rise to a very delicious native dish, while the roots can be used in the production of dyes. Its flowers are also used extensively. The sap of the coconut flower, when extracted, serves as the primary ingredient in the making of a native alcoholic drink, and further fermentation of this alcoholic drink produces vinegar.

However, the most used part of the coconut is the fruit, which has an outer fibrous covering called the husk. Under it is the hard protective shell. Lining the shell is the white coconut meat, while the inner cavity is filled with coconut water.

Here I will concentrate only on three of the four constituents of the coconut fruit: the coconut water, coconut husk, and coconut shell.

COCONUT WATER

Coconut water from the tender young fruit is a delicious and nutritious beverage which can be sipped straight from the fruit, or as a cool, exotic concoction. It is the water from the mature coconut which is considered the waste product, especially of factories producing copra, dessicated coconut, and other coconut meat products. It is a very active pollutant because of its high biological oxygen demand, or BOD. The pollution problem has increased the interest in coconut water and motivated researchers to find ways to use it fully. Its high sugar content makes it readily fermentable to yield both coconut vinegar, which is now commercially produced, and coconut wine. Its potential medicinal value is also being investigated. One possibility is that coconut water can replace dextrose as an intravenous fluid when taken straight from the unopened fruit in its uncontaminated state. Coconut water can also serve as the raw material for producing industrial alcohol. Research is underway with regard to its possible use in protein food production. There is also a plan to process, package and sell coconut water in tetra paks. On a smaller scale, coconut water is used to produce "nata de coco," a sweet dessert dish popular in the Philippines.

COCONUT HUSK

In the past, driving around the countryside of the Asian-Pacific region, one could see many coconut husks simply scattered around. This was because of the wrong notion that a coconut husk was nothing but waste material. But now, realizing its true value, resulting from its fibrous structure and resilience, people are able to find many uses and applications for coconut husks. Its coir fibers are extensively used as raw materials for making mattresses, rugs, doormats, and ropes. Coconut husk is also a good potential energy source because of the high heating values of its three main components (lignin, cellulose and hemicellulose). It is better used as a fuel in indirectly-fired kilns than in directly-fired kilns, for it produces quite a large amount of smoke.

Research is also directed towards making coconut husk briquettes or charcoal briquettes, as well as the production of pyrolytic oil from the coconut husk. There is also an interest in the high lignin content of the husk for the manufacture of plastic sheets and the production of metalloligno-sulfonates, which have possible uses as adhesives and emulsifiers.

COCONUT SHELL

The coconut shell is fast gaining importance in the coconut industry in the Asian-Pacific region. Cottage industries can produce exportable home decorative items such as lampshades and frames from shells. In its finely pulverized form, otherwise referred to as coconut shell flour, shells are regularly used as a primary ingredient in the manufacture of glue with applications in the plywood industry.

Coconut shell is also used as fuel. Aside from its extensive usage in the household for cooking, ironing, production of copra, dried fish, and meat, coconut shell is fast becoming a good and popular substitute for bunker oil in boiler operations.

Charcoal can be produced from coconut shell. Carbonization or pyrolysis of the shell to produce charcoal is usually conducted in the absence of air and at a temperature of around 600 C. After this carbonization process, the residual charcoal is further processed to decrease the ash content. Charcoal making is principally a small-scale industry. In rural communities, pits are dug from the earth and often lined with bricks to serve as charcoal pyrolyzers. A fire is lit at the bottom of the pit, which is then filled with coconut shells. The recovery of the charcoal from coconut shell is about 20-25%. Due to the large transportation costs and problems brought about by the bulky nature of the coconut shell, large-scale production of coconut shell charcoal is uneconomical.

Activated Carbon from Coconut Shells

An important application of coconut-shell charcoal would be in the manufacture of activated carbon. Further processing of charcoal in the presence of oxidizing agents, such as steam and carbon dioxide, will yield a product known as *activated carbon.* This product has a high adsorptive capacity due primarily to the large surface area available for adsorption – around 500 to 1500 square meters per gram of activated carbon. This results from the large number of internal pores produced during processing.

Activated carbon from coconut shells is currently being produced in the U.S.A., Europe, Japan, Sri Lanka and the Philippines. Malaysia also manufactures activated carbon, but the raw material being used is palm kernel and wood charcoal from rubber trees.

The Manufacture of Activated Carbon

As in most industrial operations, the first step in the manufacture of activated carbon involves preparing raw materials. Screening is employed to remove the powder and other foreign matter so as to improve charcoal quality. The charcoal then goes through the heart of the manufacturing process, the activation. This is done in a rotary kiln. One type of activation involves the use of steam as an oxidizing agent at a temperature of around 1000 C. Under this operating condition, the oxidizing action of steam selectively erodes the surface to increase the surface area, develop greater porosity, and leave the remaining atoms arranged in configurations with specific affinities. The steam is made to flow cocurrent with the flow of the carbon. Thus the gaseous byproducts join the flue gas in leaving the system. The activated carbon is then recovered and further crushed and screened to the desired size, dictated by the market specifications. In certain applications, the product is washed and then dried in a rotary drier, after which it is again screened through a rotary sifter, then packaged. All this occurs in a continuous operation.

In other processes, carbon dioxide can be used instead of steam, at activating temperature of 800-900 C. Alternative equipment to rotary kilns is available for activation purposes. The Herreschoff furnace, for example, is a multiple-hearth furnace equipped with stirrers to constantly change the carbon particles on the surface exposed to the activating gases. These stirrers also lead the carbon particles to the next chamber until the activation process has been completed.

Another method makes use of a fluidized bed whereby the activating gases are passed upward through the bed of carbon particles at a sufficient velocity that these particles are kept in a suspended state. In this way, the temperature distribution is uniform and all particles are in contact with the gas stream. Product recovery for operations using the fluidized bed also makes use of a different scheme. As carbon particles become activated and reach a certain lower density that corresponds to the desired activity, the activated carbon is carried away by the effluent gases into collectors for separation purposes.

All the above procedures use *physical* activation. Another way of processing would be the *chemical* activation of carbonaceous materials such as wood, wood chips and saw dust. This method involves adding chemicals that influence the course of pyrolysis such that tar formation is prevented during carbonization. One good example of this is the method developed independently in America and in Europe that makes use of the dehydrating power of phosporic acid to provide the oxidation environment. This process usually occurs during heating in the temperature range of 400 to 600 C. Other strong dehydrating agents which may be used include zinc chloride, magnesium chloride, potassium sulfide, potassium thiocyanate and ammonium chloride.

Product quality is usually measured by the amount of carbon tetrachloride adsorbed by the activated carbon, which is usually expressed in terms of %CCl_4 adsorbed. The higher the percentage adsorbed, the higher the product quality is. However, the manufacture of higher quality products usually entails higher operating costs, and a different set of such parameters as higher temperatures and longer residence times are required.

Possible Energy Conservation Steps in the Manufacturing Process

The manufacture of activated carbon is an energy-intensive process because of the high temperatures and the steam generation needed. Finding ways to reduce energy utilization would not only minimize operating costs, but would conserve vital energy resources as well.

The flue gas produced during activation contains a considerable amount of sensible heat. This heat can be tapped to produce steam, the most common activating agent, or can even be used to bring about the drying of both the raw materials and the finished products.

Nonpetroleum energy sources such as coconut shells, charcoal, charcoal briquettes and coal are all good fuel substitutes. These fuel sources can adequately supplement, if not totally eliminate, the utilization of petroleum products for heating the kilns or for other applications. Other options to conserve energy include using efficient insulators to minimize heat losses, as well as constantly checking equipment for steam and/or air leaks.

Applications

Coconut-shell activated carbon is of high quality for gas adsorption because of its small pore structure (below 20 angstroms) and its high mechanical strength. In fact, activated carbon figured prominently during World War I as an important component of gas masks. It usually occurs in the form of hard granules which are relatively dense and resistant to breakage and "dusting". It can also serve as protection against substantially all organic vapors or even in the recovery of solvent vapors from the air.

Coconut-shell activated carbon also has a place in the mining industry, where preferential adsorption plays an important role in ore purification. In sugar refining, activated carbon provides a vital and effective way of decolorizing. Coconut-shell activated carbon is not appropriate to this use because of its small pore size. Weak-structured substances like coal, wood and sawdust are preferred sources.

Activated carbon also has a bright future in pollution control. The coexistence of industrialization and environmental protection has always been a subject for debate. I believe that industrialization can coexist with preservation of the ecological balance so long as means are employed to control solid, liquid and gaseous wastes. Ignoring the grav-

TABLE I.

Chemical Compositions of Coconut Byproducts (%)

I.	Coconut Water (From *Coconuts Today*, Vol. 2, No. 1)			
	Sugars	2.56		
	Chlorides	0.17		
	Protein	0.55		
	Oil	0.74		
	Total Solids	4.71		
	Ash	0.46		
II.	Coir Fiber (Data from UCAP)			
		Old Nut	Young Nut	Very Young Nut
	H_2O – Solubles	5.25	16.00	15.00
	Pectin & Other Solubles	3.00	2.75	4.00
	Hemicellulose	0.25	0.15	0.25
	Lignin	45.84	40.52	40.02
	Cellulose	43.00	32.86	36.11
III.	Coconut Shell (from *Coconut Palm Products*, FAO, 1975)			
	Ash	0.55		
	Lignin	27.26		
	Crude Cellulose	33.52		
	Pentosans	5.26		
	True Cellulose	28.26		
	Methoxyl	5.84		
IV.	Coco Shell Charcoal			
	Fixed Carbon	75		
	Volatile Matter	14		
	Ash	3		
	Moisture	8		
V.	Activated Carbon			
	Fixed Carbon	90		
	Volatile Matter	3		
	Ash	4		
	Moisture	3		

TABLE II.

Typical Specifications of Activated Carbon

	Min	Max
Iodine number	1200	
Carbon tetrachloride (wt%)	60	
Ash (%)		4.0
Moisture (%)		3.0
Hardness Number	98	
Apparent Density	0.44	
Magnetics		0.6
Sulfur		0.05

ity of air and water pollution problem would be an enormous mistake, for these ecological problems generated by modern technological advances are expected to increase in the years to come, probably reaching several times the present level by the end of this century. If serious research and development in the downstream application could be undertaken, however, solutions to these ecological problems might lie in the usage of activated carbon.

Most industrialized countries are continually seeking effective means to control environmental pollution. Merging private enterprise's research and development with governmental control planning has already been effected to preserve the harmony between man and nature. Ecologists have expressed their fears and doubts of the continual survival of humankind if air and water pollution continue to be left unchecked.

Now that the world is at the threshold of developing efficient pollution control devices, the Asian-Pacific region, as the primary producer of coconut products, should take advantage of this golden opportunity by further nurturing the activated carbon industry in which it has a comparative advantage. The region undoubtedly has the raw material; what is needed is the technical knowledge to maximize its utility. This can be done through research and development in the areas of solvent recovery in industrial applications, ore purification and the improvement of current devices to counteract both air and water pollution.

CONCLUSION

It can be noted that the unwelcome side effects of modern technology can provide lucrative economic opportunities to the once ignored coconut byproduct, shell. Coconut-shell charcoal has aptly demonstrated its unrivalled position as the best source of raw material for activated carbon in certain applications, specifically in the gas/vapor phase pollution-control devices.

With this development, one can readily assume that the world-wide market for coconut-shell activated carbon will grow along with the industrial growth of the countries of the world who are concerned with pollution and its ill effects. I hope that the Asian-Pacific Region will be ready to service this increasing demand and will not forego the bright opportunities brought about by world-wide industrial proliferation.

Pollution Control in Palm Oil Mills in Malaysia

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ABSTRACT

Pollution prevention approaches are being adopted by more and more mills. Digested POME increasingly is being used successfully as a fertilizer/soil conditioner, resulting in significant savings in imported fertilizers. Studies also have shown that energy can be obtained from biogas generated from anaerobic digestion of POME; in fact, electricity from POME has become a reality. These technological developments and the increasing awareness of the economic value of POME have made it a valuable, renewable resource.

INTRODUCTION

In Malaysia, with a land area of about 14 million hectares, there are more than 1.2 million hectares in oil palm cultivation. Presently, there are 210 palm oil mills which are capable of processing a total of 6743 tons of fresh fruit bunches (FFB) per hour. There are another 47 mills under planning or construction which could process another 1134 tons of FFB/hr. In 1983, Malaysia produced 3.01 million tons of crude palm oil, making it the world's largest palm oil producer with more than 60% of the world's total output.

Over the last decade, the palm oil industry has become one of the largest revenue earners and has contributed much toward Malaysia's development and improved standard of living. However, the palm oil mills also have generated enormous amounts of highly polluting effluent (Table I), which amounted to more than 7.5 million M^3 in 1983. It has been singled out as the chief contributor to Malaysia's environmental pollution.

TABLE I

Characteristics of Palm Oil Effluent and Department of Environmental Standards

Parameters[a]	POME	Doe standards
pH	4.5	5.0-9.0
BOD	25,000	100 (50)[b]
Suspended solids	19,000	400
Total nitrogen	770	200[c]
Ammoniacal nitrogen	35	100[c]
Oil and grease	8,000	50
Temperature (C)	80-90	45 C

[a]All parameters in mg/l except pH and temperature.
[b]This additional limit is the arithmetic mean value determined on the basis of a minimum of 4 samples taken at least once a week for 4 consecutive weeks.
[c]Value on filtered sample.

The palm oil mills traditionally have discharged their effluents into rivers leading to the seas. They relied solely on nature to absorb large quantities of waste products. With the rapid expansion of the industry and the public's increased awareness of environmental pollution, the industry is obliged both socially and aesthetically to treat its effluent before it is discharged. The Government also has responded by enacting the environmental laws in 1976 to control the