COCONUT PRODUCTS

AND

THEIR UTILIZATION

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D.T.A. Report

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I am grateful for the information given by the managers and owners of the various coconut estates and oil factories.
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USES OF THE COCONUT (CHART)
INTRODUCTION

In the wet tropics the coconut palm (Cocos nucifera L.) is the most important member of the Palmaceae family. The coconut palm is, perhaps, the most important plant grown in rural humid tropical economy, supplying the staple food of the people. It yields, not only, edible fruits, oils and sugary saps, but also, thatching, fuel, construction and building material, fibers and waxes. (FAO 1958)

There is hardly any other plant in the tropics or the temperate areas that has so many uses and of which every part of the plant from the roots to the very tip of the leaves can be used to make life more pleasant. In many atolls the coconut palm is life, and life is the coconut palm.

For centuries the coconut palm has given life to thousands of people on atolls of the Pacific and Indian Oceans. These people have utilized the palm and its by-products to the fullest extent that they knew how.

Before the era of industrialization and a cash economy, the palm had been exploited for domestic purposes. It can be stated that nearly all possible uses of the coconut had been investigated and tried through empirical methods by the various peoples of the world that live in association with the coconut. Since industrialization coconut products and their utilization has been investigated by research workers. To quote S. Balce (1953) in a paper given at the Eighth Pacific Science Congress, "The salient characteristics of the coconut as a potential source of new industrial products are its lignin in the husk; protein in the meat; glutamic acid in the protein, besides arginine, valine and histidine; potash and lime in the ashes of the husk; meat and water; and growth factors for micro-organisms in the water."

The aim of this report is to review available literature on the products of the coconut and their utilization. For greater clarification, the use of diagrams, tables, schematic flow sheets, and graphs are interspersed throughout the report. Where applicable, reference is made to local instances of manufacturing of by-products. Reference is also made to the use of the coconut as food and the use of shells and husks.
Copra is the dried kernal or "meat" of the mature coconut and as such is the most important single product of the coconut industry. However, this has been changing in recent years because of the making of oil at the source of the raw material -- the coconut plantation. Most of the producers of coconuts sell their product as copra, whether the buyer be a trader or an oil crushing plant.

The manufacture of copra varies from country to country and from island to island. The objective is to dry the kernel to approximately 6% moisture while keeping the kernel clean and free from any contaminating agents.

Since human beings are not infallible, good quality copra is rather the exception than the rule. The reasons for poor quality copra according to Cooke (1932) and Pieris (1955) are:

1. Use of germinated nuts
2. Use of under-ripe nuts
3. Presence of harmful foreign material in the cut kernels
4. Under-drying
5. Scorching
6. Delayed drying
7. Too rapid drying
8. Smoked copra
9. Wetting of kernels during or after drying.
10. Poor storage

When well-dried copra of good quality is stored in a properly ventilated building, there is practically no loss during storage, and molds, if any, are only superficial. When wet copra is stored, the losses are heavy due to development of penetrating molds such as Aspergillus niger (black), Aspergillus flavus (yellow-green), and Aspergillus tamarii (yellow-brown). The superficial molds, that attack the surface of the copra, do not appreciably decrease the quality of the copra. The "copra bug", Carpophilus dimidiatius is the only insect which does any great harm to stored copra. (Patel, 1938)

Generally, the copra of Trinidad has a high percentage of moisture, up to 11%, when delivered to the factory. It is also infested with the common molds and contaminated with foreign matter. The factories are becoming more stringent as to the amount of moisture they will accept; one
factory is penalizing the producer if the moisture content is above 8%.

The improvement of quality of copra is only attractive if the superior quality commands higher prices proportionate to higher processing costs, or inversely, if the price of poorer quality copra is lower thus discouraging the producer from making poor copra. The price differential between top quality copra and poor quality copra should be great enough to induce producers to make only top quality copra. (Le fort, 1956)

Copra grading should become standardized. A beginning in this direction was made by the South Pacific Commission in 1951 by use of the following table:

<table>
<thead>
<tr>
<th>Copra Grading Table</th>
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<tbody>
<tr>
<td><strong>I. Color</strong></td>
</tr>
<tr>
<td>1. White</td>
</tr>
<tr>
<td>2. Grey or pale brown</td>
</tr>
<tr>
<td>3. Dark brown</td>
</tr>
<tr>
<td>4. Reddish, black</td>
</tr>
<tr>
<td><strong>II. Cleanliness</strong></td>
</tr>
<tr>
<td>1. Very clean</td>
</tr>
<tr>
<td>2. Slightly dirty, smoked</td>
</tr>
<tr>
<td>3. Dirty, moldy, smoked</td>
</tr>
<tr>
<td>4. Very dirty</td>
</tr>
<tr>
<td>5. Rotten, charred</td>
</tr>
<tr>
<td><strong>III. Condition</strong></td>
</tr>
<tr>
<td>1. Large, round, thick, smooth</td>
</tr>
<tr>
<td>2. Small, irregular, thin</td>
</tr>
<tr>
<td>3. Very small, irregular, thin dusty</td>
</tr>
<tr>
<td>4. Rubbery, torn, distorted, shapeless</td>
</tr>
<tr>
<td><strong>IV. Smell</strong></td>
</tr>
<tr>
<td>1. Sweet</td>
</tr>
<tr>
<td>2. Slightly smoked, rancid</td>
</tr>
<tr>
<td>3. Smoked, rancid, smell of green copra</td>
</tr>
<tr>
<td>4. Very smoky and rancid</td>
</tr>
<tr>
<td>5. Very rancid, burnt</td>
</tr>
<tr>
<td><strong>V. Dryness</strong></td>
</tr>
<tr>
<td>1. Pearl luster, biscuit hardness, moisture content less than 6%</td>
</tr>
<tr>
<td>2. Breaks with dull snaps, dark pearly luster, moisture content 6 to 7%</td>
</tr>
<tr>
<td>3. Bends in breaking with dull thud, faint waterline, moisture content 7 to 8%</td>
</tr>
</tbody>
</table>
4. Soft rubbery, distinct waterline, breaks with dull thud, moisture content 8 to 9%

5. Soft spongy, rubbery, meat showing white break, moisture content 9 to 10%

FAO Copra Processing in Rural Industries (1958)

After SPC November 1951

The above table is recommended by Cooke, and is being used in some areas of the South Pacific. It may prove useful, at least as a guiding principle to follow and is a start toward a more realistic approach to the grading of copra.

The stabilization of copra prices is an encouragement to making of good quality copra as well as assuring a steady supply of copra. The principle is to accumulate funds during high prices which are distributed during low prices to assure a stable income to producers. The method normally employed is to set up an organization that will buy and sell all copra within a given area. The monopoly fixes its purchasing price and sometimes its selling price, however, the selling price cannot usually be set because in most areas the production is not large enough to affect world price. (Lefort, 1956)

Copra Exports of the Main Producing Areas of the World 1956

<table>
<thead>
<tr>
<th>Area</th>
<th>Metric Tons (Thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philippines</td>
<td>966.3</td>
</tr>
<tr>
<td>Indonesia</td>
<td>291.4</td>
</tr>
<tr>
<td>Ceylon</td>
<td>58.7</td>
</tr>
<tr>
<td>Pacific Region</td>
<td>222.0</td>
</tr>
<tr>
<td>India</td>
<td>(All consumed locally)</td>
</tr>
<tr>
<td>Caribbean &amp; Central America</td>
<td>4.0</td>
</tr>
<tr>
<td>Africa</td>
<td>80.0</td>
</tr>
<tr>
<td><strong>TOTAL EXPORT</strong></td>
<td><strong>1622.4</strong></td>
</tr>
</tbody>
</table>

FAO Yearbook of Agricultural Statistics 1957
COCONUT OIL

Up to the present, most of the coconut oil has been produced from copra. Copra at various times and places has been reported to have an oil content of 57% to 75%. The Coconut Growers Association, Ltd., Trinidad report that their copra yields 68% oil. According to Child (1937) Ceylon copra yields 68.3% oil, South Seas 67% and the Philippines 66%. The above figures are on the dry basis, the actual oil percentage is lower, due to the moisture content of the copra at the time of crushing. For example, Ceylon copra produced 68.3% oil on the dry basis, the actual oil percentage is approximately 63.7%. (Child, 1937)

The Constance Estate, Trinidad, has an oil mill in which they crush part of their copra. The oil and copra meal are sold locally. This estate, from 100 pounds of sun-dried copra, extracts six gallons of oil, and from 100 pounds of artificially dried copra, only 1 2/3 gallons is extracted.

According to Cooke, (1932) the oil content on the dry basis is determined by the method of drying: the slower the drying of the copra, the greater the oil content. The oil content is greater from small nuts, and dwarf nuts. It is not possible to detect any regular variation of oil content or composition due to time of plucking or to the location of the estate. (Child, 1937)

Copra is being increasingly processed in the countries of production and it is quite probable that in the future it will be produced on the estates. When oil is being produced in the country of origin, the by-products are fully utilized and labor is furnished by the local people.

There are two known methods of extracting oil from the coconut. (1) Drying the endosperm or kernel, yields copra, then crushing the copra and expelling the oil. (2) The use of the fresh coconut meat by extracting the cream from the endosperm, the oil is then extracted from the cream. This method has been known by the natives of coconut growing areas from time immemorial. The second method is variously known in commercial circles as the "Lava" Process, the "Gata" Method, or the R. L. Process.
In Trinidad the extraction of oil from copra at the Coconut Growers' Association mill in Port-of-Spain follows the general pattern of most coconut oil mills. The essentials of the factory are as follows: The sorting table, shaker and magnets dispose of the foreign material. The copra is then conveyed to the hammer-mill where it is ground. The ground copra is then brought to the steam-jacketed kettle, where moisture is either added or taken out depending on the moisture content, (optimum 6%), of the ground copra. From here the ground copra is conveyed to a steam-jacketed cylinder and heated to the desired temperature. From here it enters the expeller. The oil flows out at the bottom and into under-ground tanks. The copra cake is discharged from the end of the expeller, carried by conveyors to a pulverizer and the meal is then put into bags.

The oil from the under-ground tanks is pumped into kettles and heated, then, this heated oil is filtered. The raw filtered oil can now be used for making soap or refined to make edible products.

In the refinery the raw oil is first treated with a solution of caustic soda, this neutralizes the free fatty acids, precipitates the mucilaginous matter and bleaches the oil. The neutralized oil is then further bleached with Fuller's earth and activated carbon under vacuum. After cooling, the oil is again filtered.

The last phase is deodorization, the oil is heated to 190 degrees Centigrade. At this temperature, super-heated steam of about 250 degrees Centigrade is blown through it. Again it is filtered. The oil is now ready for table use.

The simple cottage industry type oil mill usually consists of a hammer-mill and a rotary crusher or expeller, also a hand pump or power pump and storage tanks.

The second method of extracting oil from the fresh coconut has become a commercial possibility in the last decade. The advantages of this method are: (1) production of an edible oil (2) reduction in cost of producing oil (3) eliminating the intermediate product, copra (4) elimination of the refining of oil (5) the oil recovery rate in terms of fresh nut meat is greater (6) recovery of protein (7) use of copra cake as human food.
SCHEMATIC FLOW SHEET OF A COCONUT OIL FACTORY

COPRA
  \| /
  \| /
SHAKER  MAGNETS
  |  |
  |  |
GRINDING  COOKING
  |  |  |
  |  |  |
EXPELLING

COPRA CAKE

GRINDING

COPRA MEAL

USED DIRECTLY  FEED COMPOUNDERS

FILTERING

OIL

NEUTRALIZING

BLEACHING

DEODORIZING

FILTERING

SOAP MANUFACTURE

TOILET SOAP  HOUSEHOLD  CRUDE
SOAP  SOAP  GLYCERINE

ADDITIVES

COMPOUNDING

EMULSIFYING

COOKING

CRYSTALLIZING

PACKING

MARGARINES

LARD COMPOUND  SHORTENING
(8) requires simple, light and less expensive machinery. (9) negligible quantity of free fatty acids in the oil (10) no loss of oil, sugars and other carbohydrates and proteins through the action of molds and bacteria (11) greater use of by-products for home and industrial uses. (Anon. 1952)

The essentials of the new process are as follows: breaking, washing, comminuting, pressing, separation of the oil and processing the by-product. (Lava, 1941)

A fuller explanation of the new process is as follows: A breaking machine which consists of a series of knives which cut the meat into small pieces. The washing operation consists of passing the broken pieces of meat under a spray of water to take away any foreign material. The comminuting operation prepares the washed meat for the pressing operation. The best type of machine in use for the comminuting operation is a disk grinder. (Lava, 1941)

The pressing operation is done by feeding the ground 'meat' into a series of roller presses to express the "coconut milk" or "gata" from the 'meat'. This operation is very exact and to get the maximum possible percentage of oil extracted the following factors must be considered:

(1) Method of feeding ground meat into rollers. (2) Water of dilution
(3) Pressure between rollers (4) Successive order of pressing. (5) Speed of the rollers. (6) Particle size. (Lava, 1941)

The separation of oil is done by passing the "coconut milk" through a suitable centrifuge; this separates the "coconut milk" into cream, "skim milk", and small amounts of protein. The cream is pumped into maturing tanks and subjected to enzymatic action under close temperature and pH control, then chilled under a continuous freezing machine. Chilling is followed immediately by melting. The cream is then ready for the second centrifugal separation which removes the remaining oil and separates the water and proteins. (Anon. 1952)

The manufactured by-products of the "Lava" Process are highly remunerative. The coconut cake goes to a drier, after this, it is ground in a pulverizer to reduce it to flour. The flour can then be packaged in cloth or polyethylene bags and sold as a flour substitute. This flour can be
SCHEMATIC FLOWSHEET OF THE LAVA PROCESS

SHOWING

MACHINERY AND EQUIPMENT

1. The protein content of milk contains all the amino acids necessary for normal growth.

2. It contains plenty of carbohydrates which can be readily used by the organism.

3. The nature and composition of the milk proteins are such that they readily become the isotropic proteins and enter into proteins and milk powders as a normal, physical and physiological process.

(Torres, P. E. 1941, New Guinea Agric. Gazette, Vol 7, p. 29.)
incorporated with wheat flour to make bread and cakes. (Anon. 1952)

The "skimmed milk" or maceration water is probably potentially the most important by-product of the process for the following reasons:

1. Its protein constituent contains all the amino acids necessary for normal growth.
2. It contains plenty of carbohydrates, mostly in the form of sugars, and a fat content which can be varied as desired.
3. Its nature and composition permits its processing into different products which can replace milk and milk products.

(Lava, 1941)

Some other possible by-products are: coconut syrup, spray-dried milk, protein, coconut meal used as a cereal, pharmaceutical products and vinegar. (Lava, 1941)

According to an experiment conducted in the Philippines in 1941 by Lava, Tordes and Sanvictores, it was found that the cost of processing oil from the fresh coconut ("Lava Process") is no greater than from copra. The advantages of selling the by-products from the "Lava Process" were not taken into consideration, consequently, this method is definitely a commercial possibility in areas of high coconut production. It must be noted that the "Lava Process" plants must be set up on an estate or near coconut producing areas. In the Philippines it is planned that ten ton-a-day capacity plants will be installed in great numbers within easy reach of the coconut supplying plantations, thus transportation costs and spoilage will be minimized. (Lava, 1941)

In Trinidad products made from the coconut oil are: colored cooking oil, lard compound, table margarine, cooking margarine, ghee, toilet soap, flaked soap and three grades of bar soap for washing clothes.

Numerous products are made from coconut oil. It is a constituent of most soaps and many cooking oils and fats.

A list of products made from coconut oil is as follows:
1. Glycerin
2. Soaps
3. Lubricants
4. Fuel
5. Illuminates
6. Disinfectants
7. Margarine
8. Shortenings
9. Frying oil
10. Cheese
11. Vegetable lards
12. Shampoo
13. Medicine
14. Cooking butter
15. Toilet articles
16. Ingredient in the manufacture of synthetic rubber
17. Used as a plasticizer
18. Confectionary & bakery Products
19. Emulsion

Minor Sources of Oil

From the desiccated coconut industry by-products are paring oil and sediment oil. The paring oil is retrieved from the brown testa that have been shaved from the kernel. This oil is, generally, darker in color and has a larger content of free fatty acids, so is used in soap making. The sediment oil is collected from the water after the coconut meat has been washed. This oil is of poor quality and used for soaps and lubricants. The residue is used for manure after extracting the oil from the water.

A laboratory experiment conducted by Carangal and Banzon (1949) in the Philippines on the practicability of extracting coconut oil by the solvent method with ethyl alcohol, showed that they could extract the oil on a laboratory scale; the percentage of extraction being 93.4. This method uses copra as the initial product. It needs further development on a larger scale before it is likely to become a commercial possibility.
Copra meal, an important and valuable by-product of the oil mills, is the residue left after extracting the oil from the copra. It is a valuable stock feed and it is being used for human food and for the production of plastics.

The meal absorbs water readily; consequently, its keeping qualities are not as good as other meals, as for instance those of cottonseed or ground-nuts. Unless stored in a very dry atmosphere copra meal will rapidly become rancid and moldy. These characteristics limit its use as a stock feed.

The composition of an average good sample of copra meal is given in the table below.

<table>
<thead>
<tr>
<th>Total Dry Matter</th>
<th>( \text{Total Dig. Prot.} )</th>
<th>( \text{Total Dig. Nutri.} )</th>
<th>Protein</th>
<th>Fat</th>
<th>Fiber</th>
<th>N. Free</th>
<th>Mineral</th>
</tr>
</thead>
<tbody>
<tr>
<td>93.0</td>
<td>13.0</td>
<td>77.1</td>
<td>21.2</td>
<td>6.7</td>
<td>11.2</td>
<td>147.4</td>
<td>6.5</td>
</tr>
</tbody>
</table>

(Harrisson, 1956 Table I.)

Copra Meal Analysis - Trinidad

1. Protein \( \text{-}23.0\% \)
2. Fat \( \text{-}6.0\% \)
3. Fiber \( \text{-}15.4\% \)
4. Carbohydrate \( \text{-}39.6\% \)
5. Ash \( \text{-}6.0\% \)
6. Water \( \text{-}11.0\% \)

The oil left in the copra meal is termed "hard" oil. The butter from cows fed on copra meal will be firm in consistancy as will also the fat from pigs fed largely on coconut meal. Crawford (1940) states that copra meal's composition has an excellent ratio of protein to carbohydrate and fat. This ratio is one to four which is generally accepted as the correct ratio for a balanced ration for milk production, for young growing pigs, and for egg production.

However, there are certain points to be remembered in feeding copra meal to livestock. Copra meal has very little calcium; therefore, it can not be the only concentrate fed to cows for milk production. For pigs
there is also an insufficient amount of calcium in the copra meal, so limestone must be added to their ration. For poultry, copra meal, alone, is too fattening and should comprise only about ten to fifteen percent of the ration. (Crawford, 1940)

In Ceylon there is an over-supply of copra meal for stock feed; for this reason, the meal is sometimes used as a fertilizer on coconut, tea, and rubber plantations. The NPK content of copra meal is N - 3%, P - 1.5% K - 1.3%. Although, it has a high C/N ratio, this is immaterial when used on perennial crops. (Salgado, 1940)

There have been preliminary studies in the Philippines by Tampla (1953) to ascertain the possibility of using copra meal as a plastic. These studies confirmed that if water absorption and high flexural strength are of minor consideration, copra meal plastic has potentialities.

Some of the commercial coconut is prepared in Europe and the United States from fresh coconut imported into these areas. However, most of it is exported to the commercial coconut growing regions, Ceylon in the largest measure. The Philippines and India, however, have begun production during recent years. (Sineva 1939)

The dehusked coconut is largely used in the making of wafers, cakes, pastries, chocolates and other confections. In 1939 the Ceylon Coconut Board held a competition for the best confectionary in which dehusked coconut had been used. In this competition a total of 120 variations of wafers, cakes, and biscuits were displayed. This duly demonstrates the large number of possibilities for the use of dehusked coconut.
DESICCATED COCONUT

For the preparation of desiccated coconut only well-matured (1½-2 months after harvest) nuts are selected. (Belfort and Hoyer, 1914). The shell is chipped from the nut with a sharp hatchet and the brown testa is shaved from the kernel. The latter is washed clean, shredded and then dried in hot-air ovens. It is then graded for size of the grain and packed in tins or boxes. The following seven grades of desiccated coconut are listed in order of fineness:

1. Macaroon
2. Fine
3. Medium
4. Coarse
5. Chips
6. Tapes
7. Shreds

Some of the desiccated coconut is prepared in Europe and the United States from fresh coconuts imported into those areas. However, most of it is prepared in the commercial coconut growing regions. Ceylon is the largest producer. The Philippines and India, however, have begun production during recent years. (Moore 1952)

The desiccated coconut is largely used in the making of sweets, cakes, pastries, chocolates and other confections. In 1939 the Ceylon Coconut Board held a competition for the best confectionary in which desiccated coconut had been used. In this competition a total of 130 varieties of sweets, cakes and biscuits were displayed. This amply demonstrates the large number of possibilities for the use of desiccated coconut.
BALL COPRA

Ball copra is produced under the most sterile conditions. Generally, fully ripe nuts of twelve to fourteen months old are harvested. The smaller sized nuts are best suited for the manufacture of ball copra, as they take less time to dry and for this reason, spoilage is negligible. (Verghese, Thomas and Ramanandon, 1955)

According to Pieris (1936) for home consumption the fully ripe whole coconut is dried on a rack over the kitchen fire. In this manner they dry in 3-6 months. The commercial methods of producing ball copra require a regular dryer with fire pits. During the period of storage the nuts are smoked three to four days per week. In some areas, however, no fire is used for the drying of the nuts. The nuts will be dry and the resultant ball copra made after eight to twelve months storage. The nuts are ready when they begin to rattle, they are then husked, the shells broken with a knife and the copra ball removed. (Verghese, Thomas and Ramanandon, 1955). It may then be cut open and stuffed with dates, nuts and sweet meats. Prepared in this manner it is a very popular confection in Ceylon (Pieris, 1936). If the balls are not sufficiently dry, they are cut in half, dried in the sun, then sold as cup copra.

On the tenth day the date will be sufficient to collect ore gulate, and a meal to bear unto the end of the month to catch the sap. The sap is collected eight and morning, after such collection the bark surface of the tree is scored with a knife to prevent the wound from healing.

If fermentation is prevented in the collecting vessels, the sap is known as "toddy", and the fermented sap is known as "haka". The spirit obtained from distillation of toddy is known as "arumuk". The sap of the coconut palm as a crude material is well appreciated in the Far East, also the food value is acknowledged by many to be of great importance. Considering the composition of the sap, it compares favorably with the same made in sugar content, sugar cane has 16.8% sugar and coconut sap has 21% sugar content (Pieris, 1937). Besides sugar, coconut sap also contains proteins, minerals, vitamins and the 8-essential vitamins in the toddy.
PRODUCTS FROM TAPPING OF THE COCONUT PALM

Production of Sap

Tapping is the process of artificial extraction of sap from the unopened spadix. The spathe is beaten and the cells are ruptured thus the stalk is stimulated to produce a flow of juice.

According to Sampson (1923) the simplest form of tapping is as follows: The spathe to be tapped is not fully developed and the right stage of development is roughly judged by the state of the older spathe. If this is ready to burst, then the one younger than this is approximately ready for tapping. The spathe to be tapped is then tied very tightly at intervals of 1½ to 2 inches all along its length. On the following day the end of the spathe is cut off far enough down to cut off the end of the inflorescence which is within. The cut end is then pounded with wood or stone. The end is then tied with a piece of stipule of the coconut leaf. This operation is repeated for three days, morning and evening. During the next three days the cut surface is scraped with a knife to remove the bruised portions on the cut surface. If all the operations were successful the sap will begin to flow on the seventh or eighth day after the operation started.

On the tenth day the flow will be sufficient to collect the juice, and a vessel is hung onto the end of the spathe to catch the sap. The sap is collected night and morning, after each collection the cut surface of the spathe is scraped with a knife to prevent the wound from healing.

If fermentation is prevented in the collecting vessel, the sap is known as "sweet toddy", and the fermented sap is known as "toddy" or "tuba". The spirit obtained from distillation of toddy is known as "arrack".

The sap of the coconut palm as a raw material is well appreciated in the Far East, also its food value is considered by many to be of great importance. Considering the composition of the sap, it compares favorably with the sugar cane in sugar content, sugar cane has 16.5% sugar and coconut sap has 15% sugar content (Nathanael, 1955). Besides sugar, coconut sap also contains proteins, minerals, vitamin C and the B-complex vitamins in the toddy.
Nathanael (1955) reports from Ceylon that the tall variety of palm of about thirty to forty years of age produces the highest yield of sap. The tall variety produced 1¾ quarts daily whereas the dwarf produced less than ½ quart daily. This changed into acreage production is 22.3 gallons of sap per day and 6.7 gallons, respectively.

Nathanael (1955) also states that an eight month tapping period and four month rest period is recommended for economical production of toddy. There is also interaction of certain physical environmental variables associated with weather and climate which influence the production of sap. Some of these factors are day and night flow of sap, cloudy or sunny weather, seasonal variations, day length, and relative humidity. (Nathanael, 1955)

**Alcohol**

The easiest method of making alcohol from the coconut sap is to just let it ferment for a day, this produces a 1.3% alcohol by volume. If a stronger alcohol is required, then the toddy can be distilled and arrack produced. Many countries have regulations restricting the making and selling of this product. (Nathanael, 1955)

**Vinegar**

Coconut toddy vinegar, when well made, is reported to be of good strength and color, of the highest keeping qualities and has a very superior flavor. However, in areas of the East, until recently, vinegar made from coconut toddy has been of poor quality because the vinegar makers were unable to get proper acetic fermentation of their toddy. (Nathanael, 1955)

The principles involved in vinegar manufacture are as follows: In general, vinegar is made from watery solutions of sugar or starchy materials containing yeast and bacteria by alcoholic and subsequent acetic fermentations. Essentially, the finished product is dilute solution of acetic acid containing salts and extracted matter from the source material. (Nathanael, 1955)

According to Nathanael (1955) the sap from the coconut is ideal for making a superior vinegar, because its composition is such that it needs no fortification with adventitious sugar or salts, and it possesses the
over-riding advantage of being a well-balanced medium containing sufficient
nutrients for the growth and activity of yeast and bacteria.

A new continuous "Generator" process has been evolved in Ceylon for
the commercial production of good quality vinegar. The vinegar generator
is designed to provide the maximum surface exposure for a volume of vinegar
stock in order to supply enough air for the acetic acid bacteria to effi-
ciently and quickly oxidize the alcohol to acetic acid.

The old method of making vinegar in acetifying vats was not only
wasteful but time consuming. Taking three to six months to complete aceti-
fication and it produced a maximum of 4.5% acetic acid, whereas the contin-
uous "Generator" process takes six days and produces vinegar with 7.2%
acetic acid content. (Nathanael, 1955)

Yeast

Until recently the yeast, which is a by-product of distilling and
brewing and is present in toddy, has been a wasted product.

The most efficient method of recovering this yeast from the alcohol
and vinegar factories is by continuous centrifugal separation, followed
by vacuum drying.

The Ceylon Coconut Research Institute (1956) reports yeast that can
be recovered from the toddy is a valuable stock feed. They have found
that from 100 gallons of toddy can be produced one pound of dried yeast
which contains over 50% protein and over 5% on the dry basis. Yeast
recovered in the crude form of "fodder yeast" provides a valuable source
of protein which when mixed with other concentrates provides food for
livestock.

Sugar

If the coconut sap is collected for the purpose of making honey-sugar
or jaggery, the collecting vessel is well washed and the sides are limed,
this will prevent fermentation of the sap (Sampson, 1923).

The sap is then collected, placed in a pan and boiled until it is the
consistency of syrup. The process can stop here or the syrup can be boiled
a little more, stirred until it begins to crystallize, and then poured into
molds, the result is "jaggery." Brown sugar can be obtained through the
adoption of the centrifugal process. (Patel, 1938)
COCONUT WATER

Coconut industries give as a by-product large volumes of coconut water, about thirty gallons for every thousand nuts. This water is nearly always wasted, however, the chemical analysis of the water verifies that it has small quantities of useful products. (Child & Nathanael, 1917)

Analysis of Water of Mature Coconuts

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids</td>
<td>4.71 gms./100 cc</td>
</tr>
<tr>
<td>Total sugars</td>
<td>2.08 &quot; &quot; &quot;</td>
</tr>
<tr>
<td>Ash</td>
<td>.62 &quot; &quot; &quot;</td>
</tr>
<tr>
<td>Organic solids not identified</td>
<td>2.01 &quot; &quot; &quot;</td>
</tr>
</tbody>
</table>

(After Child & Nathanael, 1917)

It has been suggested that alcohol could be fermented from the sugars that are present in the water. This would be practicable if sufficient coconut water could be produced in one area. The water quickly becomes inoculated with micro-organisms and spontaneous fermentation and acetication is rapid; for this reason, it could not be collected and sent to a central factory. (Child & Nathanael, 1917)

In times of shortage of acetic and formic acids due to war emergencies, acid from the fermentation of coconut water was used for rubber coagulation. (Child & Nathanael, 1917)

On some Ceylon estates the fresh coconut water is given to cattle instead of water. Coconut water has some value as a fertilizer, 1000 nuts contain about $\frac{1}{2}$ pound of K$_2$O and where the nuts are cracked in the field the palms get the benefit of the fertilizer. Another possibility is to use the coconut water for sprinkling over compost heaps, which would thereby become enriched with potash. (Child & Nathanael, 1917)

Coconut water has been used as a culture media under field conditions, and is in the laboratory as a culture media in experiments with the growth of cells and tissues.

According to Balce (1953) growth factors and minerals in the coconut water provide a medium in which yeast and dextron can be manufactured in large quantities.
The fibrous husk of the coconut, which is commercially known as coir, provides many products of commerce. Most coir products are manufactured in India and Ceylon. There is room for expansion of this industry in other coconut growing regions where there is a demand for this product. The industry lends itself to be either a cottage or a commercial scale production, depending on the situation and conditions of the region. The production of coir fiber, yarn and ropes is primarily a cottage industry; whereas, coir mats, mattings, rugs, carpets, and bags are made in factories.

There are two types of husks used in the manufacture of coir; the highest quality fiber is from the green husk of the harvested mature nut; the second type is the dry husks from the dropped mature nut. According to Gopolon (1951), dry husks are very little used in India in the manufacture of coir.

**Retting**

The husk can be either retted or be sent straight through the decortication machine. Retting means to soak the husk in brackish water or fresh water. This process of retting softens the husk so that the fiber and the interconnective tissues can be separated. The process can be hastened by first passing the husk through a machine which crushes the exocarp without damaging the fibrous material.

It has been established that the disintegration of the tissues during retting is brought about by the action of certain micro-organisms present in the husk. This activity is only possible in water; normally warm water seems to quicken the retting process. In most areas of India and Ceylon retting is done in the backwaters of rivers and swamps or man made pits, ponds or low depressions. In recent times concrete tanks have been built by some modern mills, retting in these tanks has the advantage of taking less time. In tanks, retting of husks previously crushed is complete in from three to seven days and if husks have not had prior treatment --seven to ten days. In pits, ponds, and rivers the period is much longer, ranging between three weeks and six months. The reason for the difference in retting time between pits and tanks is that the husks usually float on the
surface in pits; whereas, in tanks, weight is applied evenly over the whole surface thus submerging all the husks at one time. The fiber from the husk rotted in the tanks is of better color and the general quality is superior. (Hudson, 1951)

On an average the husks obtained from 1000 coconuts will yield about 180 pounds of fiber. The actual yield of fiber from the husk depends on the method employed for separating the fiber, the season in which it is done, and the quality of the fiber produced. (Gopalan, 1951)

Decorticating - Mechanical Extraction of Coir Fiber

In Trinidad and Tobago there are two decorticating machines, which utilize the mature, dry husk for the making of coir fiber. The fallen nuts are gathered and brought into the factory area where they are cracked into three portions by laborers with cutlasses. The endosperm is taken out and delivered to the copra dryer, and the husk with shell attached is sent to the decorticating machine. The husk is then hand-fed into the machine. The decorticating machine, powered by a 100 horsepower electric motor, smashes the husks, separates the fibers from the coir dust and shell, and blows the latter into a large pile behind the factory or into a large wooden tank, as at the Friendship Estate in Tobago.

The fiber drops from the machine onto the floor where it is picked up, taken to a baler, and pressed into 50 or 100 pound bales. The decorticating machine at Cocal Estate produces 10,000 pounds of fiber in twenty-four hours. All of the coir fiber produced in Trinidad and Tobago is sold locally to furniture manufacturers who make cushions and mattresses. The supply and demand of the coir fiber in Trinidad and Tobago seems to have reached an equilibrium.

Manufacture of Coir Products

According to Gopalan (1951) there are two principal types of coir fibers, bristle (curled) fiber and mat fiber.

In India and Ceylon the bristle fiber is prepared from unrettled husk and is of inferior quality. It is sold to factories which produce the finished article; such as, brushes, brooms; the stiffer fibers being used for nail brushes, and scrubbing brushes.
In the Far East the mat fiber is spun into yarn, this is usually a cottage industry. Spinning is done by the palm of the hand or front of the thigh and by the use of spinning wheels. The yarn is used for multifarious purposes, much of it in the manufacture of mats, netting, rugs, carpets, ropes, and bags. The coir yarn is much esteemed for the making of fishing nets and hawsers as it is resistant to the action of salt water. Netting made from coir can very cheaply and effectively be made fire-proof by treating it with sodium silicate and lime. (FAO, 1958)

Lefort (1956) states that fiber products from the coconut husk has ever increasing possibilities, especially the new products produced from mechanically spun thread, which is made into various canvases whose rot-resistant character suits them for many uses in the building industry. These canvases have an unequalled resistance to alkaline and micro-biological action, and a coefficient of stretch and elasticity six or seven times higher than other products of the same type. They are, also, completely non-inflammable.

The coir fiber is thus utilized today in manufacturing the following articles for which there is considerable demand (Lefort, 1956).

1. Lacking strips coated with pitch
2. Pitch-coated waterproof coverings
3. Canvas for rubber mats
4. Nets and canvases for military camouflage
5. Sacks for chemical products.

Average Mineral Composition of Fresh Rotted Coir Dust

\[
\begin{array}{cccc}
\text{C} & \text{O} & \text{N} & \text{P} \\
44.8 & 68.3 & 5.6 & 0.3 \\
\end{array}
\]

(Drake, 1919; After H. Fernández, 1929)

This analysis was made on coir dust taken from rotten husks. It would seem that the husk from cleanly decoricated husks would have a larger mineral composition as it would not have been leached during the process of rotting; however, there is no information available on the mineral of fresh coir dust.
COIR PITH OR DUST

Coconut pith or dust is the light fluffy material left over after extracting the fiber from the husk. For years this by-product of the coir industry has been piling up near factories or being dumped or burned. In recent years new uses of the pith have been found and it is just beginning to be utilized.

Agricultural Uses

Coconut pith has been used in small quantities for many years for horticultural purposes by incorporating it into the soil to increase the organic matter content, to improve the water holding capacity and to increase the general tilth of the soil. It can be used as a bedding for livestock and is used as a rooting medium for cocoa propagation in Trinidad. The pith can be used as a mulch and in Puerto Rico was found to be excellent for the purpose. (Hume, 1949)

At the Cocal Estate, Trinidad, the coir dust is blown into a large pile from whence it is taken and used as bedding for livestock, or sold to cocoa propagators and nurserymen.

In Tobago the coir dust is returned to the land by being spread between every other row of palms to a depth of eight to twelve inches. The manager claims that by conserving moisture during the dry season it has increased his coconut yields substantially.

Coir dust has very little manurial value as is shown by the following table:

<table>
<thead>
<tr>
<th>Average Mineral Composition of Fresh Rotted Coir Dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Ash</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>2.44</td>
</tr>
</tbody>
</table>

(Hume, 1949 After R. Fernandez, 1949)

This analysis was made on coir dust taken from retted husks. It would seem that the dust from freshly decorticated husks would have a larger mineral composition as it would not have been leached during the process of retting; however, there is no information available on the analysis of fresh coir dust.
Industrial Uses

The Ceylon Coconut Research Institute and the Rubber Research Scheme carried out experiments on the possibilities of using coconut shell and coir dust in combination with rubber to form composition flooring, ceiling boards and similar products. Although the results of these experiments were promising, up to 1950 no commercial enterprise was engaged in the manufacture of these items. (Cooke, 1950)

In India it has been found by experiments that coir dust has greater insulating power than many other common insulation materials now on the market. Rubber latex is used to bind the coir dust into insulating blocks. Fish stored with ice can be shipped long distances in boxes which are lined with these blocks without much loss through evaporation. (Pillay and Warrier, 1953)

Experiments have been performed in Japan which show that it is feasible to make press board such as "masonite" from the coir dust.

In this method a mix of dust and latex with the correct adhesive added is placed around the base of the palm. In this method, besides conserving water, in that weed growth is prevented around the base of the palm and valuable minerals from the dust are carried into the root zone.

(1) Broadcastirig of dust to the soil. The broadcasting of dust is the least expensive method of disposing of the dust and is not generally recommended, however, it may prove beneficial on lateritic or gravelly soils which suffer from drought. The dust prevents complete drying out of the soil. (Ceylon Leaflet No. 1, 1939)

On all the estates and pleasant farms in Trinidad and Tobago, except the two estates which use coir fiber, the husk with the shell is left in the field in boxes or broadcast in the vicinity where they were cracked.

The ideal method of utilizing the husks is burying them. However, this may be too costly as an adequate labor supply may not be available. According to the Ceylon Coconut Institute there are a number of plans for burying the husks. They are summarized as follows:

1. Burying husks in the center of four palms.
If there are no fiber mills near at hand, then the husk can be profitably used for manuring the estate. The main manurial constituent in husks is potash which forms nearly 30 to 35% of the ash. On an average, about 100,000 husks contain potash equivalent to one ton of muriate of potash. The phosphoric acid content is low, being only 2% of the ash. (Ceylon Leaflet No. 5, 1939)

The potash is present in husks in a soluble form, so that if the husks are buried in the soil, the potash is easily available. An added good feature when the husks are buried in the soil is their moisture holding properties which are extremely valuable in times of drought. Their spongy structure also provides a good medium for root development. (Ceylon Coconut Leaflet No. 5, 1939)

The coconut husks can be used as a mulch. There are two methods in which this may be done: (1) Mulching around the base of the palms. In this method a six foot band of husks with the convex sides facing upwards is placed around the base of the palm. The advantage of this method, besides conserving water, is that weed growth is prevented around the base of the palm and soluble minerals from the husks are washed into the root zone.

(2) Broadcasting husks between palms. The broadcasting of husks is the lazy man's method of disposing of the husks and is not normally recommended. However, it may prove beneficial on lateritic or gravelly soils which suffer from drought, the husks prevent complete drying out of the soil. (Ceylon Leaflet No. 5, 1939)

On all the estates and peasant farms in Trinidad and Tobago, except the two estates which make coir fiber, the husk with the shell is left in the field in heaps or broadcast in the vicinity where they were cracked.

The ideal method of utilizing the husks is burying them. However, this may be too costly or an adequate labor supply may not be available. According to the Ceylon Coconut Institute there are a number of plans for burying the husks. They are enumerated as follows:

1. Burying husks in the center of four palms.
2. Burying husks between the rows of palms.


The ash of the burnt husk is a good fertilizer; however, certain husks contain more valuable ash than other husks. The type of soil on which the coconut has grown will make a difference in the ash content of the husk (Croucher, 1936). In order to produce ash with high potash content the husks must be fresh and should not have been exposed to prolonged leaching. According to Croucher (1936), in Jamaica the amount of potash lost by exposure to leaching is about six pounds for each 1000 husks. Also, he states that husks should be burnt slowly at as low a temperature as possible to reduce loss of potash. The ash usually contains about twenty to twenty-five percent potash (Ceylon Leaflet No. 5, 1939). If the ash is mixed with sulphate of ammonia or ammonias it will result in high loss of ammonia. Husk ash has a high sodium chloride content and should be used sparingly on crops, such as bananas and citrus. (Croucher, 1936)
In India, Menon (1941) has done experimental work on the production of pressboard from the husk of fallen immature nuts. This pressboard has numerous uses, some of which are: suit cases, cardboard and millboard substitute, use in the shoe industry, wallboards, panelboards, insulation boards, veneering, pulleys, and molded and embossed articles.

Hadinoto (1957) explains the production of hardboard from coconut husk in Indonesia, combining fiber and coir dust. He states that one pilot plant started producing hardboard in 1955 in East Java. This plant is capable of producing 3,500 tons of board annually. The smallest plant, which produces five tons of board daily, needs to be in an area that has at least 50,000 coconut palms. On the average it takes 1,900 tons of husk to produce 3,500 tons of hardboard, this will give seventy percent efficiency. (Hadinoto, 1957)

Hadinoto (1957) states that hardboard has a promising future in Indonesia, especially in house construction for flooring, walling, roofing, ceiling; and also for furniture, fixtures, bus bodies, railroad cars, shipbuilding, structure and containers.

From information available on the subject, hardboard from husks is a feasible enterprise in areas of intense coconut cultivation. Capital is needed for the machinery; husks must be near at hand; and there must be a market for the hardboard. The hardboard must be able to compete with similar products in regards to quality, price and suitability.
DOMESTIC USES OF COCONUT SHELLS

The shell of the coconut has been used domestically for ornamental and other purposes for many years in the coconut growing regions of the world. In places where the coconut grew the half of the shell, without the eyes was probably the first cup or drinking vessel. In the past the shell has been used as a resonant backing for musical instruments. In Madras, shells were made into elegantly carved ornamental vases, lamps, spoons, sugar-pots and tea-pots. (Child, 1944)

Many interesting rites have been performed down through the ages with the coconut shell. To this day, in some of the Pacific Islands, traditional ceremony requires that Kava, which is the juice of the root of Piper Methysticum, be drunk from a half coconut shell.

Items that are made from the shell are numerous and vary from country to country and from one locality to another. According to Child (1944) and Pieris, (1936) the following items are made from the shell: combs, ladles, bowls, stands, water-dippers, bangles, buttons, cuff-links, ash-trays, trinket dishes, paper weights, buckles, cups and spoons. In reference to buttons, this has become a small scale industry in Hawaii. The making of handicraft from the shell is profitable if good quality products are made and if markets are established in tourist centers.
SHELL AS A FUEL

According to Child (1944) the shells are similar in composition to hard wood, though the lignin content is higher and cellulose content lower. The following are typical figures after Child (1944):

- Moisture .................. 8.0 %
- Ash ....................... 0.6 %
- Solvent extractives ...... 1.2 %
- Lignin ..................... 29.4 %
- Pentosans ................ 27.7 %
- Uranic Anhydrides ....... 3.5 %
- Cellulose .................. 26.6 %

The bulk of the coconut shells are used for fuel. In most instances it is an excellent fuel, however, it has its disadvantages as a boiler fuel in that creosote is deposited on vital parts having a corrosive effect.

Normally sixty percent of the shells are used on the estates for the firing of copra-drying kilns. In many areas the balance of the shell is used as domestic fuel. In Ceylon, much of the surplus shell is sold to laundrys, bakeries, lime kilns and brickyards. (Child, 1944)
COCONUT SHELL CHARCOAL

The process of making charcoal is merely the burning of shells in a limited supply of air, so that they do not burn away to ash. The object is to burn the shells so they are carbonized to just the right degree. The kiln in which the shells are burned may be anything from a simple hole in the ground to elaborate brickwork structures. (Child, 1940)

The procedure in burning the shell is to fire some shells at the bottom of the pit; more shells are added and burned, continuing until the pit is full and the whole mass of shells is burning. Then, the fire may be dampened down by sprinkling with water. The glowing mass is then covered to exclude air, but space left to allow the smoke to escape. The pit is left covered for three days, then it is opened; the shells are ready for sorting and drying. Normally, thirty pounds of charcoal will be made from 100 pounds of shell. (Child, 1940)

Coconut shell charcoal has at times been a valuable by-product, because it is one of the best absorbents for gases. It has been extensively used in the manufacture of gas masks and at all times has a limited use in certain industrial operations. (Child, 1940)

The manufacture of charcoal is well adapted to being a home industry; consequently, any surplus shells on an estate can be very readily made into charcoal.

According to Child (1947) charcoal is used in the following industrial operations:

1. Purifying carbon dioxide from fermentation processes
2. Purifying air
3. Recovery of gasoline from natural gas and benzene from coal gas
4. In vacuum work as in the manufacture of radio and x-ray tubes.
5. Water purification
6. Refining of edible oils
7. The purification of such materials as glycerine and pharmaceutical chemicals
8. Sugar refining
DESTRUCTIVE DISTILLATION OF COCONUT SHELL

Only thirty percent of the coconut shell is recovered as charcoal, which means that seventy percent of the shell was lost during the process. However, if the shells are fired in ovens or retorts heated from the outside, and the vapors are condensed, there can be obtained from 100 pounds of shell, besides the charcoal, some thirty-five or forty pounds of pyroligneous acid and five pounds of settled tar. (Child, 1918)

Child (1918) has laid out in the following diagram, the quantities of primary products obtained by the dry distillation of one ton of shells.

**SHELL, ONE TON**

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charcoal</td>
<td>6 cwt</td>
</tr>
<tr>
<td>Pyroligneous acid</td>
<td>7 cwt</td>
</tr>
<tr>
<td>Tar</td>
<td>1 cwt</td>
</tr>
<tr>
<td>Acetic Acid</td>
<td>8 gals</td>
</tr>
<tr>
<td>Wood Spirit</td>
<td>3 gals</td>
</tr>
<tr>
<td>Phenol</td>
<td>11 pounds</td>
</tr>
<tr>
<td>Creosote</td>
<td>22 pounds</td>
</tr>
<tr>
<td>Neutral Oils</td>
<td>Variable</td>
</tr>
<tr>
<td>Pitch</td>
<td>22 pounds, plus</td>
</tr>
</tbody>
</table>

The dry distillation of coconut shell is an industrial potential in areas of large concentrations of coconut shells, however, the manufacture of this material would not be a home industry, because of capital investment in machinery and buildings.
MINOR USES OF COCONUT SHELL

The finely ground coconut shells have become a commercial product. They are used as a filler in thermoplastic. The ground shells give a smooth and lustrous finish to molded articles, and improve resistance to moisture and heat. (FAO, 1958)

In Trinidad the finely ground shell is used in the oil industry. The ash of the shells which are used in copra drying are rich in potash and phosphoric compounds and so will serve as a good fertilizer.

Although these logs were used in heat building (FAO, 1953). Although the logs are no longer used for this purpose, some, which in made from the fiber of the back, to this day is preferred to anything else in the country. The various pieces of the coconut shell are used together.

A certain amount of paraffine wood used nowadays in commerce for calico and buttons is obtained from the coconut palm. The logs have at times been used in making temporary docks. (FAO, 1953)

The greatest use has been made of the coconut palm leaves. They are the basic material for the making of matting and for the sides and partitions of buildings, and to a lesser extent woven handicraft. Many items are not being used into articles from the leaves, these items are becoming of secondary importance in order next to use in certain areas where a market has developed and where there is a tourist attraction. These made from the leaves are:

1. Baskets
2. Handbags
3. Mats
4. Curtains
5. Fans
6. Reels
7. Cigarette cases
8. Wallets
9. Fans
10. Baskets

The petioles and affilix are used to make coco paste, brooms and sandals.
COCONUT PALM AS BUILDING MATERIAL

In some atoll islands of the Pacific, the coconut palm is indispensable for the building of houses. The stem is used for the frame and rafters. Not only, the dwelling houses, but large community or council houses are built from the coconut palm.

The coconut log is an item in bridge building — one or two logs bridging two banks of a stream, sufficing as a foot path, is very common. Coconut logs are also used for more elaborate bridges. (FAO, 1958)

In ancient times the logs were used in boat building (FAO, 1958). Although the logs are no longer used for this purpose, semnit, which is made from the fiber of the husk, to this day is preferred to anything else in the securing the various pieces of the outrigger canoe together.

A certain amount of porcupine wood used nowadays in commerce for cabinets and buttons is obtained from the coconut palm. The logs have at times been used in making temporary docks. (FAO, 1958)

The greatest use has been made of the coconut palm leaves. They are the basic material for the making of thatching and for the sides and partitions of buildings, and to a lesser extent woven handicraft. Many items are now being hand made into curios from the leaves, these items are becoming of secondary importance in value next to copra in certain areas where a market has developed and where there is a tourist attraction. Items made from the leaves are:

1. Baskets
2. Hand-bags
3. Mats
4. Curtains
5. Hats
6. Belts
7. Cigarette cases
8. Billfolds
9. Fans

The petioles and midribs are used to make fence posts, brooms and needles.
USES OF THE COCONUT PALM FOR FOOD

Food Value of the Coconut Palm

In the domestic economy of the inhabitants of the humid tropical countries, every part of the coconut palm is utilized in some manner or other. For this reason the coconut palm has been referred to as the "Tree of Life", and "Tree of Abundance" by writers acclaiming the value of the coconut palm. (FAO, 1958) To quote Pieris (1955), "Human life in the Pacific would become intolerable if there were no coconut palms. On atolls, it would become impossible. Nothing has been found to take its place, and nothing is likely to be found in the foreseeable future." There are very few plants in the world today that have a greater variety of uses. Ancient writers referred to 360 uses for the coconut palm in the domestic economy. (FAO, 1958)

The coconut furnishes nearly all of the nutrients required by the human body; although some are present only in small quantities. The nutrients are in the six categories, proteins, carbohydrates, fats, minerals, vitamins, and water. The coconut is not a good source of vitamins; it has only traces of vitamins A, B, C, D and E. (Barrau & Nassal, 1956)

Main Analytical Data of Various Coconut Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Moisture</th>
<th>Fat</th>
<th>Protein</th>
<th>Carbohydrates</th>
<th>Mineral</th>
<th>Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut Water</td>
<td>93</td>
<td>1</td>
<td>-1</td>
<td>5</td>
<td>-1</td>
<td>---</td>
</tr>
<tr>
<td>Green Soft Pulp</td>
<td>93</td>
<td>1</td>
<td>-1</td>
<td>3</td>
<td>-1</td>
<td>---</td>
</tr>
<tr>
<td>Green Firm Pulp</td>
<td>82</td>
<td>2-3</td>
<td>-1</td>
<td>2-3</td>
<td>-1</td>
<td>---</td>
</tr>
<tr>
<td>Coconut Milk</td>
<td>52</td>
<td>27</td>
<td>4</td>
<td>16-18</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sweet Toddy</td>
<td>84</td>
<td>-1</td>
<td>-1</td>
<td>15</td>
<td>-1</td>
<td>---</td>
</tr>
<tr>
<td>Kernel, Wet</td>
<td>42-48</td>
<td>36</td>
<td>4</td>
<td>7-20</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Copra No. 1</td>
<td>6-7</td>
<td>63-64</td>
<td>7-8</td>
<td>16</td>
<td>2</td>
<td>3-4</td>
</tr>
<tr>
<td>Coconut flour</td>
<td>5-6</td>
<td>7</td>
<td>20</td>
<td>52</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Desiccated Coconut</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Poonac (Cake)</td>
<td>9-13</td>
<td>8</td>
<td>21</td>
<td>45</td>
<td>4-6</td>
<td>10-11</td>
</tr>
<tr>
<td>Coconuts, Mature</td>
<td>18</td>
<td></td>
<td></td>
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<tr>
<td>Coconuts, Immature</td>
<td>70</td>
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</tbody>
</table>

(From FAO Copra Processing in Rural Industries, 1958)
According to Barrau and Nassal (1936) the present importance of the coconut in the subsistence economies of the Indo-Pacific area should not be under-estimated. The number of coconuts eaten per head per day varies considerably from one locality to another. In some areas the daily consumption is five to six nuts while in others only one or two nuts are eaten per head of population per day.

**Food Obtained From the Nut**

The liquid called "coconut water" is in the central sphere of the nut, and is enclosed by the endosperm. Green nuts of the age of six to seven months provide the sweetest and most palatable drink, but both younger or older nuts are also used.

The endosperm or albumen is the "meat" which covers the inner wall of the endocarp or nut shell. The meat is eaten by people at various successive stages of its development and prepared in different ways. The thin gelatinous layer covering the inner surface of the young nut is called "spooning" coconut meat and is frequently used as a food for infants. The older green nuts, the endosperm provides the most common sustenance between meals.

The coconut "milk" or "cream" is derived from the endosperm. The process of making this involves the grating of the coconut endosperm in the half shell, the grated meat may be moistened with water then using a petiole sheath of the coconut or cloth as a strainer, the grated coconut is pressed to extract the milk. The milk is widely used as a condiment and is mixed with starches and edible leaves before cooking.

The mature nut when grated is also used in baking and mixed with other foods such as grated banana, yams, breadfruit and taros.

The coconut "apple" which develops inside the nut during germination is commonly used for food. It may be eaten directly from the bisected nut or the nut with husk removed can be baked then the apple eaten hot.

"Hand oil" is coconut oil domestically made from the milk of the grated fresh nuts, expressed by hand and boiled until a transparent oil is produced. This is a very high grade oil used for dietary purposes. (Pieris, 1936)
The soft young endocarp of the green nut is relished by some people and eaten in conjunction with the tender endosperm.

The sweet husk of some varieties of coconut grouped by Miquel under the botanical variety saccharina is used as a source of sugar. This is chewed in a manner similar to sugar cane. (Barrau and Massal, 1956)

**Food Obtained From the Palm**

The "bud" or "heart" of palm which is the terminal growing point is eaten in salads or cooked. It contains about three per cent starch and about five to six per cent of sugars, mainly saccharose. The heart of palm is taken from only the very old palms or the very young plants during the process of thinning because the coconut palm is too valuable to be destroyed for this purpose. (FAO, 1958)
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