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NON-CONVENTIONAL USES AND PROCESSING TECHNIQUES FOR COCONUT PRODUCTS

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At present the products of the coconut palm that are of commercial significance are copra, coconut oil, desiccated coconut and coir fibre. Some recent trends in coconut technology are reviewed and certain claims for the non-conventional utilization of products derived from the husk, the shell and the kernel are discussed. The possibilities of up-grading coconut oil by the preparation of oleo-chemicals are considered. Reference is made to the application of research findings for the improvement of the fermentation industries based on coconut toddy with a brief annotation on certain clinical uses for tender coconut water.

Tropical agriculture organized on a plantation basis is almost entirely a response to the industrial stimulus of modern civilization.

Coconut is one of the oldest known tropical crops, the proceeds of which constitute the means of sustenance for millions of people in this world. Of the three major plantation industries of Ceylon, coconut occupies by far the largest acreage and is vitally linked up with both the export and domestic economies of the country.

With the impetus from the activities of research in recent years, coconut production is no longer considered a mere agricultural process. It is actually a highly ramified Agri-Industry, embracing the technology of all known and potential raw materials from the palm to their end-products. In other words, the harvest of coconuts has ceased to be reckoned the end of one's labours, but regarded instead as a starting point and source of raw materials for a series of manufacturing processes.

Though the products of the coconut palm are legion, at present only copra, coconut oil, desiccated coconut and coir fibre are of significance in the world markets. Within the compass of this paper it is my intention to briefly review some recent trends in coconut technology in conjunction with possibilities, and claims that have been made for the non-conventional utilization of certain coconut products. I hasten to mention however that whilst coverage of the subject in depth is not possible in a short paper, it is certainly not delimited to these aspects that are economically viable, knowing that members of a learned society would have interests wider than those of industrialists, extending even to propositions of a speculative nature that are subject to research.

Structurally the coconut consists of an *exocarp* (husk) which is attached to the *endocarp* (shell), which in turn is firmly united to a hollow kernel (*endosperm*) on the inside. The cavity of this kernel contains the *liquid endosperm* (known locally as 'coconut water') which varies in volume depending on the maturity of the fruit. Perhaps it would be appropriate to consider each of these fruit components in turn *vis-a-vis* the subject of my paper.

THE EXOCARP

The coconut husk consists of strands of fibro-vascular bundles or 'coir' embedded in a non-fibrous parenchymatous 'corky' connective tissue or pith. Coir is the most important product that can be obtained by decortication of the husk. It is an industrial 'hard fibre' of a uniform gold colour. It offers immense possibilities of profitable utilization on account of its natural resilience, durability, resistance to dampness and other properties. By suitable processing, coir can be extracted and converted into a variety of products including bristle fibre, mattress fibre, matting, rugs, carpets, brushes, brooms and other coir manufactures. The fibre can also be spun into yarn for the manufacture of cordage. A versatile product of relatively recent origin is "rubberised coir". Owing to its astonishing resiliency and springiness its application in the domestic and industrial fields, as a cushioning material appears to be almost limitless. In Europe, where pioneering research on this product has been carried out, it is now employed widely in the automobile industry, air-conditioning industries, acoustic installation industries, railways, hospitals and the upholstery trade. With continued research there is every possibility that the scope for the specialized uses of this product would be widened.

Extraction of Coir

Coir extraction is essentially a cottage industry in all its phases and rests on very old traditions. After the husks are retted, the fibre is separated from them either manually by crushing and beating with mallets or by means of 'fibre-drums'. Even though recovery is reasonably satisfactory the methods are crude.

In the new process of Dry Decortication the fibre is recovered from unretted husks. It is based on principles of desintegration by impact. The actual technique involves the application of continuous rapid processing by purely physical means—a process consisting of mechanical crushing, beating and winnowing in continuous production lines. The decorticating process consists essentially of a husk bursting operation followed by a sifting operation. Segments of the husk are fed into a *Husk Bursting Mill* where they are exploded by impact and instantly discharged through a top opening into a connecting duct along which they pass on the air blast into a sifter where they are further screened. Fibre is discharged at the end of the sifter and dust through the screen forming the undershield of the machine. The disadvantage of this process is that it produces only mattress fibre. The fibre however is eminently suited for 'curling' prior to impregnation with rubber latex in the manufacture of 'rubberised coir'.

Since unretted husks are used the coir dust that is separated has a certain amount of manurial value.

The literature contains reference to a new mechano-chemical process for the recovery of white coir fibre (Builder 1954). The unretted husk segments after disintegration by impact in a husk burster are conveyed automatically into a sifter for the separation of dust. The fibre thus recovered is then fed into a wooden boiling vat containing a solution of tannin extracting chemicals. After lixiviation with the hot liquor, the fibre is washed and then cleaned by impact in a turbo-screen and dried in a steam oven.

Since the plant for chemical treatment is intermittent, a number of boiling vats are generally operated in parallel. The good spinning and dyeing properties (in light shades) of the white fibre produced by this method, are claimed to be some of its special virtues.

Coir Dust

The fibrous elements in the coconut husk account for only about 40 per cent of its weight. The pithy residue—"coir dust", would make up the balance 60 per cent or more. Except for a small proportion used agriculturally as a mulch or soil additive, this refuse remains an industrial waste despite diverse attempts to explore avenues for economic utilization.

I have had occasion to review elsewhere the work that has been done on coir dust (Nathanael 1965). In my opinion among these, the most promising lines for utilization are based on very recent work carried out at the Tropical Products Institute, Ministry of Overseas Development, London (Tropical Products Institute 1968). The reports are favourable in respect of the use of coir dust both in the making of building slabs ("Precast Concrete Blocks") and as an aggregate in the preparation of resin bonded hardboard. It is gratifying that the former possibility is already being pursued by the State Engineering Corporation.

THE ENDOCARP

The uses to which coconut shells can be put to are partly ornamental, partly domestic and partly industrial. I have had occasion to review its status as a potentially valuable industrial raw material elsewhere (Nathanael 1964).

Of the enormous quantities of shells produced annually in coconut growing countries, doubtless the bulk is used as fuel. In those regions where a well developed plantation industry exists shells are largely used for firing copra kilns. In fact, shells constitute economically useful and relatively smoke-free fuel eminently suited for this purpose, and about 60-65 per cent may normally be reckoned to be used this way.

Apart from their direct use as fuel, the manufacture of charcoal represents the most important direction in which coconut shells are utilised at the present time. Furthermore, shell charcoal which was a relatively minor product in the past has now developed into an important commodity commercially owing to its intrinsic value as a raw material for the manufacture of 'Active Carbon'.

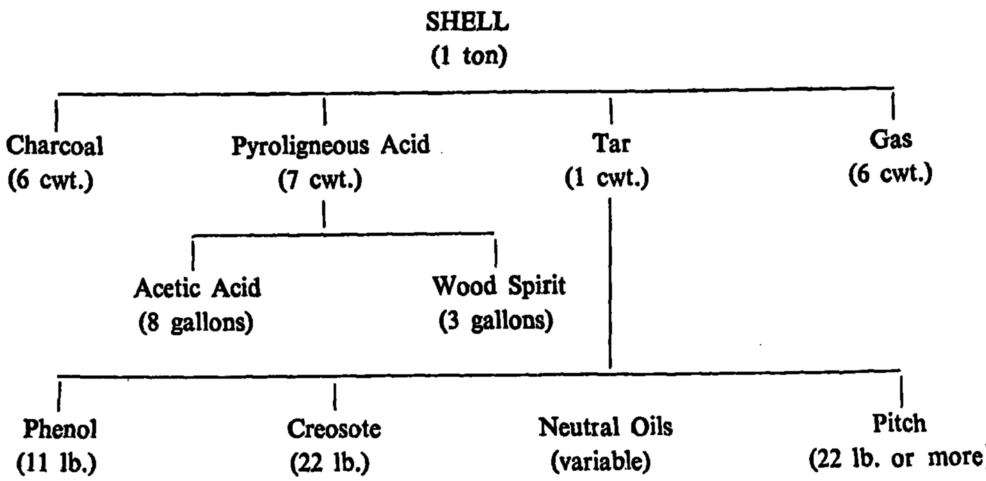
Destructive Distillation

The normal process of carbonizing coconut shells for the recovery of charcoal is extremely wasteful of some of the commercially remunerative thermal decomposition products. When the shells are subjected to Destructive Distillation the primary products include *retort charcoal* which remains in the carbonizing apparatus, *pyroligneous liquor and settled tar* that distil over and *uncondensable gases.*

The pyroligneous liquor may be regarded as an impure dilute acetic acid contaminated with other compounds. It is a dark, reddish coloured aqueous liquid with a strong empyreumatic odour. During re-distillation of this liquor, a low boiling fraction (of commercial importance)—"wood naphtha" could be recovered. This is actually a mixture of methanol and acetone. If the distilled pyroligneous acid is neutralized with lime and evaporated to dryness, acetate of lime known commercially as 'grey acetate' can be recovered. From this acetic acid may be obtained by treatment with sulphuric acid.

The settled tar is a very complex mixture and also more variable in composition than the pyroligneous acid. By sample fractional distillation of the tar—phenol, creosote and pitch could be recovered.

On the basis of pilot plant research conducted in Ceylon, one ton of shells on dry distillation may be reckoned to yield the following quantities of the aforementioned products:—



Coconut Shell Flour

As a result of intensive practical research during the past few decades, an entirely new commercial use has been found for coconut shell. This is the preparation of *Coconut Shell Flour*.

Early research on the applications of shell flour established its value in the plastics and allied industries, and now it is extensively used as a compound filler for synthetic resin glues and as a filler and extender for phenolic moulding powders. This filler is also being used successfully with specialized surface finishes, liquid products (as an absorbent), mastic adhesives, resin casting, mild abrasive products, hand cleaners, poly-ester type laminates, bituminous products and as a diluent with insecticides. Coconut shell flour is reckoned to give a smooth and lustrous finish to moulded articles and also improve their resistance to moisture and heat.

There are certain important uses to which coconut shells can be put to, which can scarcely be described as industrial. As the shell is hard and takes on a polish, it can be carved, decorated with lacquer, inlaid with silver or other metals and generally used with great ornamental effect. Coconut shells are also put to innumerable domestic uses in producing countries, even though the quantities that could be utilized for such purposes would constitute a negligible fraction of the potential supplies.

THE KERNEL

The kernel of the mature coconut is the most valuable part of the fruit, as it provides important articles of food. Besides the direct use of the raw kernel, grated meat and milk for culinary purposes, the principal products of the kernel are copra, oil, poonac and desiccated coconut.

Commercial copra has only one use namely in the manufacture of oil and its single by-product —poonac.

Refined coconut oil has been sold in Europe under a wide variety of proprietary names, such as Cocolardo, Cocoline, Lactine, Laureol, Nucoline, Nutrox, Palmine and Vegetaline. With the introduction of hydrogenated fats, coconut oil has really lost its pre-eminence as a solid vegetable fat. The oil however still finds use in specialised products such as 'coconut stearin' employed as a substitute for cocoa-butter in chocolate manufacture. Commercially, coconut oil is mainly used in the manufacture of soap and margarine. Increasing quantities are also being used in biscuits and confectionery.

Unlike some other fruits, almost all the oil of the coconut is present in the kernel. For a long time copra has remained the exclusive raw material for the industrial production of coconut oil. As the commonest culinary fat of the tropics, it is apt to be prepared in the household from the freshly grated meat by the traditional process of heat rendering. On the bigger scale however, it is expressed from copra in bullock-driven mills ("Chekkus") power driven rotaries ("Ghanis"), hydraulic presses or in expellers.

Wet-Processing of Coconut Kernel

In order to obviate some of the inherent practical shortcomings associated with dry-processing methods, technologists and chemical engineers have been at work to evolve a suitable method for extracting coconut oil directly from the fresh kernel. Some degree of success has been achieved in this direction in recent years, though the economics yet remain to be resolved. Perhaps we could consider very briefly the principles underlying three methods that have been used for the extraction of coconut oil directly from the wet meat.

The Krauss-Maffei Process (Evolved by a firm in Munich).

The operational sequence in this process is as follows :—

The mature de-husked nuts are steamed in an autoclave for 10 minutes, under a pressure of three atmospheres. During this operation the kernel gets more or less detached from the shell. The nuts are split open and the partly dislodged kernel is prised out of the shell with a suitable lever. Since most of the brown integument tends to adhere to the shell, a fairly good separation of the white meat is achieved. The separated white meat is first chipped in a mechanical cutter and then ground into a fine pulp in a roller mill. The ground material is next fed into a filter press, which retains a solid residue which still contains some oil, and spews out an emulsion ("milk") consisting mainly of water, oil and protein. The residue is dried in a dehydrator and ground to give *Flour*. The "milk" is put through a centrifugal separator from which an oil-poor/protein rich *water phase* and a water and protein poor *oil phase* are obtained. These two streams are next subjected to centrifugal treatment and the oil recovered this way is filtered, but needs no further refining as it is practically free from water and is low in F.F.A. The protein of the water phase is recovered by dehydration on a roller drier. The aqueous phase which has been stripped of proteins, contains a mixture of sugar, mineral matter and other water solubles. This is concentrated to produce a 'syrup', claimed to possess an attractive flavour and taste. The successful utilization of the three by-products—flour, protein and syrup would doubtless influence the economics of the process.

The Robledano-Luzuriaga Process

The process and patents are now controlled by Coconut Process Inc., Manila. The operational sequence involved is as follows :—

The nuts are halved and the kernels removed manually, grated in a comminuter and pre-pressed. This yields about even proportions of coconut emulsion ("milk") and a semi-cake. This cake is flaked and pressed again to yield additional milk, which is processed together with that obtained from the original grated meat.

Centrifugal separation of the milk yields a cream—'Skim milk' and a small amount of protein. The cream is pumped into maturing tanks where it is subjected to enzymatic action under close temperature and pH control, and thereafter chilled in a continuous freezing machine. Chilling is followed immediately by melting. The cream is now ready for centrifugal separation which removes most of the oil.

The balance of the cream is again chilled and melted and sent through a centrifugal classifier, which removes the remaining oil and separates that which is left into water and proteins. Additional protein is obtained by heating and centrifuging the skim milk.

In the meantime, the process continues in a branch production line on the flaked and pressed semi-cake. It is dehydrated in a drying unit, and an expeller then strips it of the remaining oil. In terms of the overall oil recovery rate from the fresh meat, this is reported to be 10% higher than by the copra method.

Though the RL-process is in some ways similar to the KM-process, the physico-chemical principles involved are novel. In this process the breaking up of the intractable protein envelope, enclosing the oil globules is accomplished by controlled enzymatic action followed by chilling. In the KM-process this is achieved by high temperature treatment.

The Chayen Process

Owing to the vision and industry of the Development team of British Glues and Chemicals Ltd., a new chemical engineering technique has been evolved for the separation of not only fatty materials but also proteins from cellular tissue. It is called the Impulse Rendering Process or the Chayen Process. This is based on the new principle that if any oil bearing cellular material is suspended in a fluid such as water, and then subjected to a series of high speed impulses or shock waves of sufficient intensity and frequency, the membranes of the fat containing cells are ruptured. The cellular contents (including fat and protein) that spill into the water (as a result of the shattering action), preserve their quality and can be recovered by suitable methods of separation. The material to be rendered is fed into the mill with the liquid to be used, and is removed continuously from the mill by the liquid in violent movement. The efficiency of impulse rendering does not appear to be affected by the condition of the fat i.e. whether it is solid or liquid.

The application of the impulse rendering technique to coconut has so far been carried out only on a laboratory scale and unquestionably offers a fruitful field for research.

Oleo-Chemicals

Proposals have been made for chemically up-grading the value of coconut oil by the preparation of chemical derivatives (oleo-chemicals) which could compete at higher price levels in the world markets. The strong point that has been adduced in this connection is that (without affecting the traditional exports) lauric acid which constitutes 46 per cent of the fatty acids of coconut oil should be exploited to a maximum and the high values attached to the component Fatty Acids of coconut oil and their derivatives should be earned in the form of increased foreign exchange.

Coconut oil fatty acids can be produced by the hydrolysis of coconut oil, which is a very simple and inexpensive process. We are no doubt aware that since the Fatty Acid Complex at the Oils and Fats Corporation, Seeduwa was commissioned in 1968, quantities of distilled fatty acids and crude glycerine (derived therefrom) are being exported. To keep abreast of modern technology in this field, and to identify new end-use areas for coconut oil and its derivatives, it is the intention of the Corporation to establish a Research and Development Laboratory. There are no real technical difficulties regarding the numerous interesting possibilities in this field. For example coconut oil fatty acids can be readily fractionated to isolate component fatty acids such as capric/caprylic, lauric, myristic, oleic/linoleic and palmitic/stearic. It is correct that coconut fatty alcohols would fetch higher prices than the corresponding acids, in overseas markets. In this connection, lauric acid can be reduced to lauryl alcohol by catalytic high pressure hydrogenation, and the latter sulphonated with sulphur trioxide to yield sodium lauryl sulphate for conversion into detergents. Similarly capric acid (which constitutes 8% of the coconut oil fatty acids) can be converted into capryl alcohol which is used in vinyl plastics. The point to remember, however is that the various possibilities regarding the preparation of coconut oil based oleo-chemicals for use in the cosmetic and pharmaceutical industries would be contingent on the techno-economics of the processes involved and of course export markets.

Coconut Water

Large volumes of coconut water from ripe nuts are run off as a waste product of copra and desiccated coconut manufacture. As against 5% of total sugars in the tender coconut, the water from ripe nuts contains only about 2 per cent. Obviously this cannot be regarded as an economic source of sugar or alcohol. The possibility of using these effluents for the propagation of yeast and bacteria which are employed in the manufacture of antibiotics is an interesting speculation which appears to warrant investigation.

According to a recent publication (Shivanandiah 1966), the use of tender coconut water as a remedy for gastro-enteritis is receiving increasing attention by clinicians. It is now reckoned a good substitute for glucose, saline or plasma to combat the dehydration of patients suffering from severe diarrhoea and vomiting.

Tender coconut water contains not only glucose but also other nutrient elements such as P, S, Na, Cu, Fe, K, fat, sugars, amino acids and vitamins, which vary in proportions according to the maturity of the nut. The calorie value of tender coconut water is of the order of 17 per 100 gms. of water.

THE SAP

Any discussion on the products of the coconut would be incomplete without reference to coconut sap or "toddy". I have had occasion to present some papers to Section (E) of our Association in the past, on certain aspects of the work that has been done on this product.

In its fresh state coconut toddy is a liquid containing as its essential constituent about 12 to 15% of cane sugar. On fermentation the sugar rapidly disappears and its place is taken by 5 to 8% of alcohol. Fermented toddy, on further keeping undergoes as process of acetic fermentation, the alcohol being converted into acetic acid. All of the main constituents—sugar, alcohol and acetic acid can by suitable means be separated in a relatively pure state. Partial separation is indeed effected in some industria and semi-industrial processes whereby products like treacle, jaggery, arrack and vinegar are produced For paucity of time, in the present context I will make fleeting reference to only two products.

Arrack

Between 1939 and 1942 an extensive and successful series of experiments were carried out conjointly by the Coconut Research Institute, the Excise Department and the Government Analyst on the production of an improved grade of arrack by double distillation. Though this grade of arrack is yet being produced and marketed, I would mention that there is much scope not only for improving its quality but also for increasing the all-round efficiency of the fermentation industries based on coconut toddy.

As long as tapping costs have remained high, economic arguments have always loomed large against attempts to use coconut toddy as a base for the production of power alcohol.

Vinegar

Successful laboratory experiments followed by pilot plant trials have proved the possibility of using the continuous 'Generator' process for the manufacture of high grade coconut toddy vinegar. This process has shown promise of removing the principal disabilities of the existing industry by combining speed of action and economy of labour with simplicity and ease of operation. As the process is continuous and takes place in a closed acetifier it is more hygienic than the old 'Vat' process. At present two factories in the Island are producing vinegar by the 'Generator' process.

CONCLUSION

The coconut palm with its innumerable uses as an economic plant and food crop, is doubtless a boon to millions. In spite of the work that has already been done there is yet much to be learned about the chemistry and technology of coconut products. The coconut industry has a great wealth of raw materials which provide a unique opportunity for improvement and utilization in directions hitherto untried. With further applied research the prospects for development and better utilization of coconut products seem good.

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