COCOS (1998-99), 13, 08 – 20
Printed in Sri Lanka

BIOMEDICAL AND ENVIRONMENTAL ASPECTS OF SOME COCONUT-DERIVED PRODUCTS AND THEIR PRODUCTION PROCESSES IN SRI LANKA

Rohan H. Wickramasinghe

Institute for Tropical Environmental Studies, Colombo, Sri Lanka

ABSTRACT

The coconut palm is said to have been introduced to Sri Lanka over 2300 years ago. Several industries have grown up to process products from this tree. Many of these production units have traditionally been located in rural areas and any adverse environmental impacts have in the past been considered negligible or not very serious. However, with the development of these industries and the increasing density of population more concern is being taken to identify and mitigate any adverse environmental effects and biomedical effects on workers in these industries as well as the general public. The industries examined in this article relate to the production of 1) coconut oil, 2) desiccated coconut, 3) charcoal and activated carbon and 4) husk fibre and coir pith. Biomedical aspects of some of these products are also noted as well as articles which can serve as guides to the literature in each area.

INTRODUCTION

The coconut palm (Cocos nucifera L.) is believed to have been introduced to Sri Lanka by at least 300 B.C. Every part of the palm finds some use by individuals or in major industries (Wickramasinghe, 1989). The annual crop of nuts in Sri Lanka fluctuates between around 1900 and 3000 (average 2500) million nuts (Central Bank, 1995; Department of Census and Statistics, 1996) depending on the weather, use of fertilizer etc. Of these, domestic consumption per capita per annum is estimated at 90 fresh nuts and 30 nuts equivalent as oil (Liyanage, 1998). Thus, assuming a population of 18 million, around 450 million nuts may be available annually for industrial uses, other than for the manufacture of coconut oil.

Some major products derived from the coconut palm are 1) coconut oil and copra, 2) desiccated coconut, 3) charcoal and activated carbon and 4) coir (husk) fibre and pith (i.e. coir dust). The relative export values of kernel products from Sri Lanka in 1995 were desiccated coconut (77%), coconut oil

(10%), copra (8%), coconut milk powder (3.5%), coconut cream (1%), defatted coconut (< 1%) and copra cake (< 1%) (Coconut Development Authority, 1995; Liyanage, 1998). Internationally, Sri Lanka is the second largest exporter of desiccated coconut (d.c.) and activated carbon and the biggest exporter of brown fibre. Liyanage (1998) has reported recently on the current status of the coconut industry in Sri Lanka, presenting statistics which demonstrate that insufficient raw material (i.e. coconuts) precludes many of these sectors from expanding.

While there has been extensive research reported on various aspects of the coconut industry (Liyanage, 1996; Mahindapala and Pinto, 1991), insufficient information appears to have been reported in the scientific literature on biomedical and environmental aspects of these products and their production processes in Sri Lanka. While the benefits of the industry far outweigh the problems, the latter cannot be ignored. The present article reviews some of these aspects and presents references from which more detailed information regarding the sometimes voluminous literature can be obtained.

Coconut Oil

Coconut oil is expressed from copra, the dried kernel of the coconut. It is also (to a much lesser extent) recovered by skimming the surface layer which forms when coconut water (which has 2% oil) is allowed to stand in settling tanks.

Little environmental pollution occurs while coconut oil is expressed from copra, the dried kernel of the coconut. In Sri Lanka, little "edible copra" is produced; most being "milling copra" which is used for the production of coconut oil. Coconut oil is used for culinary purposes and in industry.

Questions have been raised as to whether consumption of coconut oil leads to health problems. However, epidemiological data suggests that heart disease is not significantly increased in populations which habitually consume coconut oil (Asian and Pacific Coconut Community, 1996; Wickremasinghe, 1994) and the view has been expressed that coconut oil is, at worst, neutral with respect to atherogenicity of fats and oils. A large volume of literature exists on the subject but this is not the occasion to review this evidence. References to articles presenting opposing views on the controversy are found in a recent publication (Asian and Pacific Coconut Community, 1996).

While aflatoxin contamination of improperly dried and handled copra may occur, this carcinogen does not pass to coconut oil when copra is crushed but remains in the meal (United Coconut Association of the Philippines, 1988).

In 1995, there were in the formal sector in Sri Lanka, 402 units producing copra to a capacity of 10,000 MT and 130 units producing coconut oil to a capacity of 9000 MT per year (Liyanage, 1998).

Desiccated Coconut (d.c.)

The initial experiments on the industrial manufacture of desiccated coconut (d.c.) from coconut kernel meat were undertaken in Colombo in 1888 and the first exports (of 189 MT from Ceylon to London) was undertaken in 1891 (Perera, 1996). The entrepreneurs were successful and four mills were established by the company in Ceylon, which was essentially the only exporter until 1927 when the Philippines came into the picture. At present, Sri Lanka produces and exports over 50,000 tons per year (i.e almost 40% of the world's production), while in 1995 the operating capacity was 66,000 MT (Liyanage, 1998).

Of the 58 d.c. mills presently in operation in Sri Lanka (Liyanage, 1998), 48 process less than 50,000 nuts per day while the five largest process over 100,000 nuts per day and of these at least two have the capacity to process 200,000 nuts per day. (1 M.T. of d.c. is calculated as being equivalent to approximately 6800 nuts) (Central Bank of Sri Lanka, 1995; Coconut Development Authority, 1995).

The manufacturing process results in two types of pollution.

a) emissions into the air resulting from burning firewood to provide heat and
b) release of coconut water and of "washings".

Consideration of the production process is necessary in order to gain an appreciation of the problems (see Central Environmental Authority, 1992 for further details):

Coconut are dehusked on the plantations and transported to the d.c. factory, where the shells are cut manually. They separate readily from the kernels, since the coconuts have been kept for several days after picking. (The shells are used for the production of charcoal and activated carbon).

The brown outer layer or testa covering the while kernel is next sliced off manually using a "paring knife". The sliced off pieces or "parings" are rich in oil and are kept aside for the manufacture of copra.

The white kernel is next cut open and the meat sliced into pieces. At this step, the coconut water is released.

The pieces of coconut meat are washed in a solution of calcium hypochlorite (200 mg/l) and subsequent manufacturing operations are performed under strictly hygienic conditions to prevent contamination with salmonella and other microbial infections. The washings which contain chlorine are another polluting effluent. The only other chemical which may be used during the manufacture of d.c. is sodium metabisulphite which is added to maintain the whiteness of the product; this is, however, only added on specific demand of buyers and at the concentrations requested.

The pieces of kernel meat may next be sterilized by boiling for 1-2 minutes in water. Following this, the pieces are fragmented into small particles. In an alternative process, the pieces of kernel are first fragmented into small particles and then steam sterilized for 1-2 minutes. This latter process results in less waste water generation.

The sterile "meal" of kernel meat is dried at 90-95°C to bring the moisture content down from 55% to 3-3.5%. The last production step is sieving the d.c. particles and bagging the fine and medium grades. The large particles are re-cut before bagging. Microbiological testing of the product is performed before shipping.

Pollution

The gaseous emissions due to the burning of firewood in the factory furnaces are not peculiar to this industry nor especially significant and will not be discussed further at the present time (n.b. But see the discussion below on charcoal manufacture).

The pollution caused by the release of large quantities of coconut water (liquid endosperm) and the kernel washings is a characteristic of the desiccated coconut industry and a serious problem.

A coconut may be assumed to contain, on average, 200 ml of coconut water (nut water) so that a d.c. factory processing 50,000 nuts per day releases 10,000 liters per day. To this effluent may be added around 40-45,000 liters per day of chlorine-containing waste water and around a further 2700 liters per day if boiling water is used for sterilizing the pieces of kernel.

The coconut water has coconut oil (2%) and is rich in organic chemicals. The pH may be around 4.8, the chemical oxygen demand (C.O.D) around 40 g/L and the biological oxygen demand (B.O.D) around 10 g/L. As d.c. factories are customarily sited in coconut producing rural areas, the effluent has usually been released into streams, paddy fields etc. The combined effect of low pH and high oxygen demand etc. causes damage to water courses, paddy fields etc. and the release of offensive odious. With the increasing production of d.c. and the increasing density of population in the country, this problem is of growing importance.

Pollution Control

A relatively small amount of coconut water is utilized for vinegar making (Fernendez, 1968) and for the manufacture of the dessert "nata de coco" (Anon, 1994), while a variety of investigations have been performed to examine the possible use of coconut water in such diverse applications as use as an intravenous fluid (Anzaldo, 1985) or as oral rehydration fluid (Chavalittamrong et al., 1982), for the cultivation of microorganisms (Vichien, 1978) and of orchid seedlings (Pages, 1971) and the nutrition of ducklings (Constante, 1976).

However, the bulk of the coconut wastewater needs to be disposed of after treatment to reduce its polluting properties. This takes place in several steps. Techniques suitable for use under Sri Lankan conditions have been described by the Central Environmental Authority (1992) and the outlines of the procedures given in the Guidelines are, with permission, presented here. Further details are given in the source publication.

a) Pretreatment

The coconut water has good quality coconut oil (2%) and this is recovered to a large extent by allowing the water to stand and skimming off the surface oil layer which forms. (The oil present in the "majang" or sediment, the remaining coconut water and the "washings" is similarly recovered after settling and is used in small-scale soap factories, etc.). Around 200 liters of oil may be recovered from a factory processing 50,000 nuts per day. The pH of the coconut water after pretreatment is about 4.8, the C.O.D. 28 g/l and the B.O.D. 6 g/l.

b) Anaerobic Treatment

The coconut water may next be treated anaerobically in, for example, an Upflow Anaerobic Sludge Blanket (UASB) reactor or in anaerobic ponds.

After either of these two treatments the average pH may is around 7.5, the C.O.D. around 7 g/l and the B.O.D. around 0.6 g/l.

c) Aerobic Treatment

The coconut water, which has been pretreated and treated anaerobically, is then mixed with washing and sterilizing waters. Where the coconut water has been treated thus before combination with washing and sterilizing waters, the combined waste water may, on average, have a pH of 6.5-7.5, a C.O.D. of 1 g/l and a B.O.D. of 0.15 g/l. The oil content may be 50 mg/l at this point.

The Guidelines advise that this combined waste water may be applied on coconut and other lands (but not discharged into water courses) or may be further treated aerobically. Four alternative aerobic treatment techniques which have been developed are; a) Facultative ponds, b) Mechanically aerated ponds, c) Use of an activated sludge and d) The rotating biological contact system. Detailed descriptions of these techniques are given in the Guidelines (Central Environmental Authority, 1992) which may be referred to. The B.O.D. removal efficiency of the various systems ranges from 80 to 98%.

The choice of treatment facility for any given d.c. factory depends on a number of variables. These include the number of nuts processed per day, availability of land for construction of ponds etc., cost of plant and availability of finance, availability of lands on which waste waters and sludge may be applied, ability of a receiving water course to dilute treated waste water sufficiently throughout the year etc.

It is proposed that the quality of the effluent for discharge into inland surface waters includes a pH of 6.5 to 8 and maximum allowable values of C.O.D. 300 mg/l, B.O.D. 30 mg/l and oil 10 mg/l.

Charcoal and Activated Carbon

Coconut shell charcoal is an important item of the coconut industry and it, in turn, is a raw material for the manufacture of activated carbon.

The manufacture of charcoal is traditionally carried out by controlled combustion of coconut shells in pits, which typically contain 2.5 tons per charge (or 50,000 shells per day). Problems have been experienced in mechanizing the process, as the gases are highly corrosive.

The following products result from the destructive distillation of charcoal from coconut shell at 550°C (see Banzon and Velasco, 1982 for review).

Charcoal	-	32.5%
Pyroligneous acid	-	41.3%
Settled tar	-	6.9%
Distilled tars	-	3.2%
Non-condensable gases	-	16.2%

Pyroligneous acid is composed of a mixture of chemicals such as acetic acid and methanol. Another estimate gives the following figures for the products resulting from destructive distillation of coconut shell at 400°C.

Charcoal - 32.96%

Non-condensable gases - 19.40% (composed of carbon dioxide, 40.70%, ethane, 1.80%, carbon monoxide, 27.83%, and hydrogen and methane, 27.70%).

Pyroligneous distillate - 47.64% (which includes tars, 12.21%, acetic acid, 5.86%, formic acid, 0.37%, phenol, 1.44%, methanol, 10.86%, water upto 19.50%).

The large volumes of smoke and irritant gases presently resulting daily from charcoal burning operations give rise to numerous and vehement complaints from those residing and working in the locality. These reasons and the loss of heat during traditional charcoal burning in pits have led to attempts to design coconut shell carbonization units with waste heat recovery, which can be used in the production of coconut oil bypassing copra manufacture (see Breag *et al.*, 1991). The recovery of fine chemicals is not economic but a major Sri Lankan producer of activated carbon is currently developing a process to use the gases to generate electricity. Once the process is mechanized the gases released will be carbon dioxide and steam.

Activated carbon is produced from the charcoal at temperatures in excess of 800°C in controlled atmospheres. (Increasing the final temperature at which carbonization is performed decreases the yield and increases the pore size, see Shi *et al.*, 1986) The charcoal is crushed prior to activation and after activation and graded in size (Uragoda, 1989). In the overall process some dust may be generated and emitted; this, however, is minimized with well-designed and operated dust extractors. One major manufacturer of activated carbon in Sri Lanka uses bag filters with reversed jet pulses of air for cleaning them.

Activated carbon produced from coconut shell charcoal has a variety of environment-related uses. It is, for example, used in some applications of water purification, gas masks, solvent recovery, odour control (e.g. hydrogen sulphide absorption in sewage plants), air purification in closed rooms (e.g. removal of cigarette smoke), waste water treatment plants and dechlorination. It also has numerous other industrial uses such as the recovery of gold from tailings. It has been incorporated in media for the tissue culture of immature embryos of the coconut (Karunaratne *et al.*, 1989).

In 1995, there were in the formal sector in Sri Lanka 200 units with a production capacity of 8000 MT of coconut shell charcoal and 04 units with a production capacity of 15,000 MT of activated carbon (Liyanage, 1998).

Coir (Husk) Fibre and Pith (Coir Dust)

Husks removed from coconuts have traditionally been used for fuel, used for extraction of fibre or buried on coconut plantations in order to improve moisture retention. In Sri Lanka about 35 to 40% of the total crop of husks go into the fibre industry and the rest is burned or buried. Coir pith has, however, been found to be preferable to husks for burial in pits for moisture conservation on plantations although both are beneficial (Liyanage *et al.*, 1991-1993); it has also been noted that, since the pith contains 30 to 40% lignin, it takes 8 to 10 years after burial to decompose (Liyanage, 1988). Husks contain relatively elevated amounts of sodium and potassium salts which enter the soil when they are buried without prior treatment.

Husks may be used for the production of white fibre or brown fibre. Traditionally, husks have mostly been steeped in pits containing non-brackish water for about 4 to 9 weeks and the brown fibre extracted manually. The colour of the fibre increases on aging. Steeping or "retting" husks in coastal lagoons or backwaters for 6 to 9 months for the production of white fibre have been shown in India to have a markedly adverse effect on fish, crustaceans etc due to the liberation of organic matter and a variety of chemicals, including hydrogen sulphide, into the water (Devi *et al.*, 1990; Remani *et al*, 1989).

Husks contain 30% fibre and 70% coir dust (i.e. pith) on a dry basis. With the extraction of fibre, mounds of pith build up and, since pith decays very slowly, causes an extensive pollution problem. About 60 to 70,000 tons of dry coir dust may presently be generated each year as a by-product of the fibre extraction industry. In 1986, the accumulated mounds of coir dust in Sri Lanka were estimated to amount to four million tons and some of these were 30 years old (Wickramasinghe, 1986). Leaching of salts from these mounds could affect ground water and wells; notably in areas where the density of housing is high.

In 1995, the operating capacity in the formal sector in Sri Lanka was 450 units for 6000 MT of brown fibre and 10 units for 3500 MT of white fibre (Liyanage, 1998).

In recent years, attempts were made to briquette coir dust for use as fuel both to reduce the accumulated mounds of material as well as to provide a substitute for fuel wood consumption. However, the process developed was deemed to be not economically viable for a company in the private sector to undertake. More success has been achieved in recent years with using coir dust to develop a medium referred to as coconut pith peat for use in horticulture. The coir dust is allowed to weather in the open for two monsoons (i.e. one to two years) to allow salts to leach out and prepared in brick form for export. This commercial success has reduced an environmental problem of pollution with large amounts of coir dust (and uncontrolled leaching of associated salts) as well as reducing the demand worldwide for the extraction of traditional peat for horticultural purposes.

Occupational Health

Few studies have been published in recent years relevant to occupational health in Sri Lankan workers in coconut-related industrial activities. Three such studies are briefly discussed below.

a) Production of Activated Carbon

A clinical and radiographic study of workers directly engaged in the production of activated carbon has been reported (Uragoda, 1989). It was noted that, while the coconut shell charcoal was activated in the process studied by passing steam through it and that the carbon did not contain free silica, the workers concerned did not exhibit an elevated incidence of respiratory symptoms nor was there radiological evidence of pneumoconiosis. The period of exposure of these sixty six workers ranged from one to eleven (mean 7.2) years.

b) Production of Coir Fibre

A clinical and radiographic study of 779 workers in the coir industry has also been reported by Uragoda (1975). Coir fibre is obtained from coconut husk and has a variety of uses. The fibres are bound together by the light pith which is released as particulate matter during the processing of husks for fibre.

The coir industry in Sri Lanka probably dates back to the thirteenth or fourteenth century and in around 1972 exported over 94 million-kg or 90 to 95 per cent of the world export trade. Since this provided employment to some 75,000 persons in Sri Lanka, it was important to examine occupational health aspects relating to possible respiratory disorders.

In a detailed account, which included a description of the processing techniques and consideration of respiratory diseases associated with working with other vegetable fibres such as cotton, flax, hemp, sisal, jute and manilla, Uragoda (1975) reported no definite relationship between coir dust and respiratory diseases such as asthma, chronic bronchitis, byssinosis and pulmonary tuberculosis. While the 779 workers studied had been engaged in coir processing and been exposed to the dust for between 0 to 35 (average 11.2) years, 235 had had over 14 years service. The staff histories of the factory studied (which was established in 1901) also did not support the possibility of such relationships.

These findings are of added interest and significance in view of the development in recent years of the processing and utilization of coconut pith for horticultural purposes (see above).

c) Bleaching of Coir Fibre

Coir fibre to be used for the manufacture of brushes is bleached with sulphur dioxide gas to give it a golden colour with enhanced brightness. Uragoda (1981) studied a small group (15 males) who have been engaged in this work for 6 to 20 (average of 11.3) years. While they did not present any long standing respiratory symptoms attributable to the gas, the incidence of tuberculosis among them (3 cases) was statistically significant (= 28.8). All the workers had stomatological problems with around 80 per cent a) having carious teeth or having had several dental extractions since joining the factory and b) having recession of gums over the incisors and canines.

ACKNOWLEDGEMENTS

I am grateful to Dr. M de S. Liyanage, Director, Coconut Research Institute of Sri Lanka, for helpful comments and criticisms. However, all views expressed and errors in this article remain the responsibility of the author. I would also like to thank Mrs. Sunethra Perera, who is in charge of the extensive specialist library of the Coconut Research Institute and the staff of the library of the Ceylon Institute for Scientific and Industrial Research for their help.

REFERENCES

Anon. (1994). Nata de coco production. Cocoinfo International 1, 29-31.

Anzaldo, F.E. (1985). Coconut water as an intravenous fluid. Philippine J. Coconut Studies 10, 31-43.

Asian and Pacific Coconut Community (1966). Facts about Coconut Oil, pp. 76. APCC, Jakarta, Indonesia.

Banzon, J.A., and Velasco, J.R. (1982). Coconut Production and Utilization. pp. 349. Philippine Coconut Research and Development Foundation, Manila.

Breag, G.R. Drew, P. and Joseph, P.G. (1991). Production of coconut oil directly from fresh coconut meat using waste heat recovery technology: a "new oil process". *Cord* 7, 35-48.

Central Bank of Sri Lanka (1995). *Annual Report* Part 1, p. 27. Government of Sri Lanka.

Central Environmental Authority (1992). Industrial Pollution Control Guidelines, No. 3 - Desiccated Coconut Industry, pp. 18. Government of Sri Lanka.

Chavalittamrong, B., Pidatcha, P., and Thavisri, U. (1982). Electrolytes, sugar, calories, osmolarity and pH of beverages and coconut water. Southeast Asian J. Tropical Med. Public Health 13, 427-431.

Coconut Development Authority (1995). Sri Lanka Coconut Statistics, pp. 125. Government of Sri Lanka.

Constante, J.M. (1976). The Utilization of Coconut Water in the Drinking Water of Mallard Ducklings. M.Sc. Thesis, Araneta University, Philippines.

Department of Census and Statistics (1996). Statistical Pocket Book, pp. 252. Government of Sri Lanka.

Devi, M.A., and Pillai, N.G. (1990). Effect of pollution due to coconut husk retting on the species diversity of benthic communities of cochin backwaters. Indian J. Fisheries 37,145-149.

Fernendez, W.L. (1968). Coconut water vinegar making in the Philippines. Coconuts Today 6, 92-106.

Karunaratne, S., and Periyapperuma, K. (1989). Culture of immature embryos of coconut, *Cocos nucifera* L.: Callus proliferation and somatic embryogenesis. Plant Science 62, 247-253.

Karunaratne, S. Santha, S. and Kovoor, A. (1991). An in vitro assay for drought-tolerant coconut germplasm. Euphytica 53: 25-30.

Liyanage, M. de S. (1988). Use of coir dust for moisture conservation. Coconut Bulletin 5, 18-19.

Liyanage, M.de S., Jayasekara, K.S., and Fernandopulle, M.N. (1991-1993). Effects of application of coconut husk and coir dust on the yield of coconut. COCOS - J. Coconut Res. Inst. SriLanka 9, 15-22.

Liyanage, M.de.S. (1996). Coconut Research in Sri Lanka, Coconuts for Prosperity (P.K. Thampan Ed.), pp. 221-237. Peekay Tree Crops Development Foundation, Kerala, India.

Liyanage, M.de.S. (1998). The coconut industry in Sri Lanka - Status report. Proceedings, International Cashew and Coconut Conference, Dar es Salaam, Tanzania, 17-21 February 1997. (C.P. Topper, P.D.S. Caligari, A.K. Kullaya et al. Eds.) pp 16-20. Biohybrids International Ltd., Reading, U.K.

Mahindapala, R. and Pinto, J.L.J.G. (1991). Coconut Cultivation, pp. 162. Coconut Research Institute of Sri Lanka, Lunuwila, Sri Lanka.

Pages, P.D. (1971). Banana Homogenate, Coconut Water, Peptone and Auxins as Nutrient Supplements in the In Vitro Culture of Dendrobium and Phalaenopsis Ovules, pp. 202. Ph.D. Thesis, University of the Philippines, Los Banos.

Perera, U.V.H. (1996). Desiccated coconut industry in its pioneering days. Cocoinfo International 3, 10-14 and 38.

Remani, K.N., Nirmala, E., and Nair, S.R. (1989). Pollution due to coir retting and its effect on estuarine flora and fauna. Int. J. Environ. Studies 32, 285-295.

Shi, Yonrui, Tang, Qifeng, and Zhao, Yuming (1986). Manufacture of activated carbon from coconut shells - carbonization of coconut shells, Linchan Huaxue Yu Gongye 6, 23-28.

Thampn, P.K. (1993). Handbook on Coconut Palm, Third Edn., Oxford and IBH Publishing Co. Pvt. Ltd., Bombay.

United Coconut Association of the Philippines Inc. (UCAP) (1988). Aiming for a better quality copra : an industry update. Coconuts Today 6, 8-23.

Uragoda, C.G. (1975). A clinical and radiographic study of coir workers. Br. J. Indust. Med. 32, 66-71.

Uragoda, C.G. (1981). Long term exposure to sulphur dioxide during bleaching of coir. J. Soc. Occup. Med. 31, 76-78.

Uragoda, C.G. (1989). Clinical and radiographic study of activated carbon workers. Thorax 44, 303-304.

Vichien, K. (1978). Factors Affecting Growth and Vitamin B 12 Production by Bacillus Megaterium ATCC 13639 in Ripened Coconut Water. pp. 143, M.Sc. Thesis, Kasetsert University, Bangkok.

Wickramasinghe, R.H. (1986). Utilisation of agricultural residues as a source of energy. Biomass 11, 233-235.

Wickramasinghe, R.H. (1989). Possibilities of non-waste technology in developing countries, "Technology and the Environment: Facing the Future", Proceedings, VTT Symposium on Non-waste Technology, 20-23 June 1988, VTT Technical Research Centre of Finland, Espoo, Finland, (A. Johansson, Ed.), pp. 69-74. The Finnish Academies of Technology, Helsinki.

Wickremasinghe, R.L. (1994). Coconut oil, not the villain. Cocoinfo International 1, 6-7.