UNN-385

Coconut Handbook

Commodity Studies and Projections Division
Economic Analysis and Projections Department

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	In India	1 ton green husks requires 2,500 husks.
	In India	1,000 husks produce 84 kg retted yarn fiber.
	In Sri Lanka	1 ton dry brown husks requires 2,700 husks.
	In Sri Lanka	1,000 husks produce 50 kg of bristle fiber and 100 kg. of mattress fiber.
8.	Coconut Shell Charcoal	
	In Sri Lanka	1 ton shell requires 5,500 shells.
	In Sri Lanka	1 ton shell charcoal requires 20,000 shells.

/a Very approximate figures only. Actual figures will depend on a variety of factors including the variety of coconut, environmental conditions, past rainfall, etc.

/b 62% extraction rate.

Source: H.M.A.B. Fernando and B.E. Grimwood, Study of the Coconut Industry in the ADB Region, Vol. I, (Manila: Asian Development Bank, 1973).

I. INTRODUCTION

The description of the coconut palm (*Cocos nucifera-L*) as "The Tree of Life" is highly appropriate. It provides millions of people in tropical areas not only with many of the basic necessities of life in the form of food, drink, fuel and shelter, but also cash income. Few plants have a greater variety of uses (see Figures I-1 and I-2).

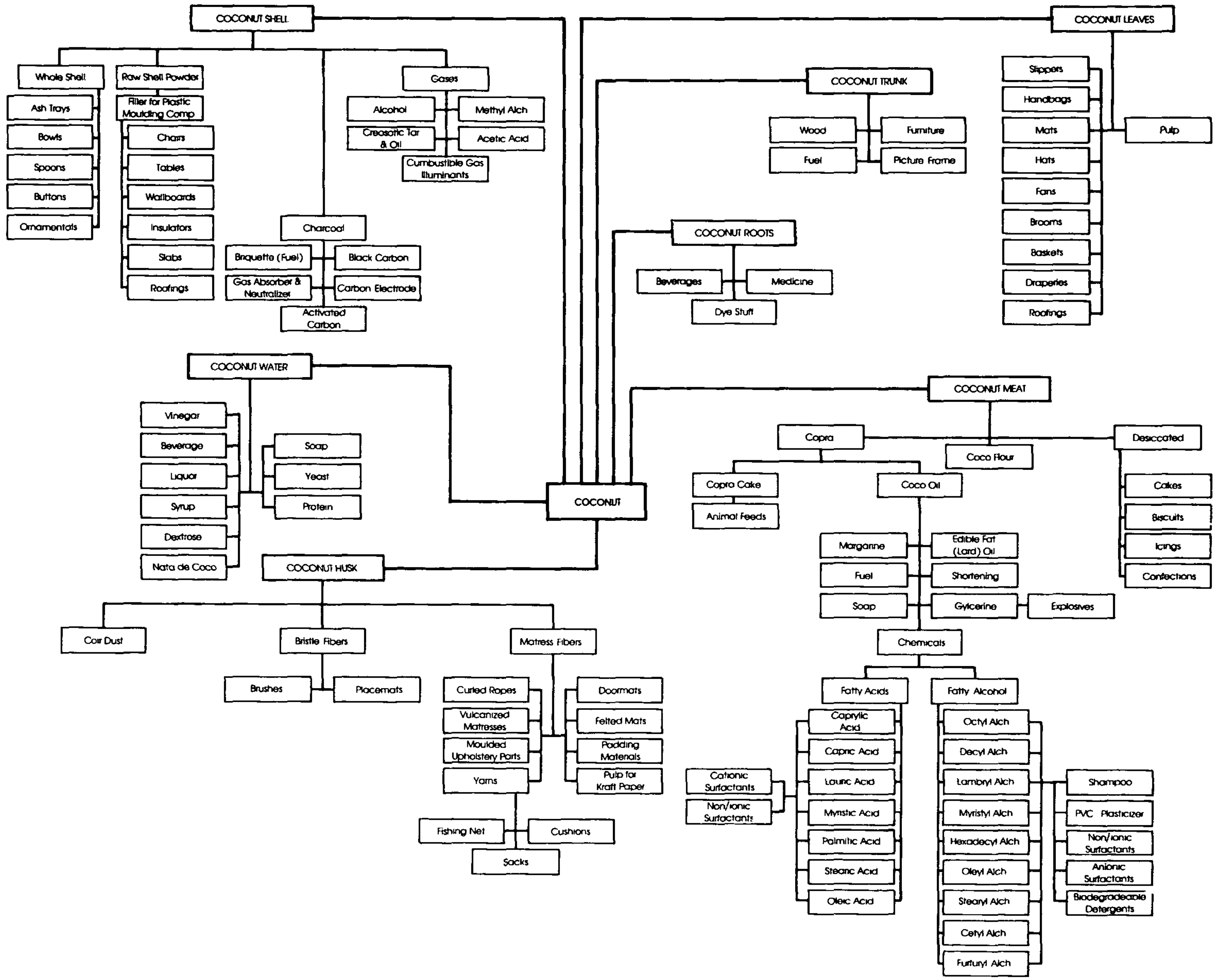
In all producing countries, fresh coconuts form an important part of the diet. It has been estimated that, world-wide, just over half the volume of coconuts produced is consumed fresh.

The wood of the trunk is used for construction and decorative purposes, and the roots extracted for a drug recommended against diarrhea. The dried leaves are widely used for thatching and for making baskets and hats. The husk of the nut yields an important fiber. The shell is used as fuel, and finely ground, it is used as a filler in thermoplastics. It is also used in the manufacture of activated carbon, and for making containers and ornaments.

The sap of the tree can be tapped to yield sugar on evaporation and, when fermented, an alcoholic beverage (toddy) is obtained that yields a spirit (arrack) on distillation. Complete fermentation will produce vinegar.

While it is clear from the above that coconuts are extremely important to the rural economy of producing countries both as a source of food and as a source of a number of non-edible products, the principal attention of this handbook will be on copra, coconut oil and coconut cake/meal--the main coconut products entering international trade.

Figure I—1: Economic Uses of the Coconut



Source: United Coconut Association of the Philippines, Coconut Statistics, 1978

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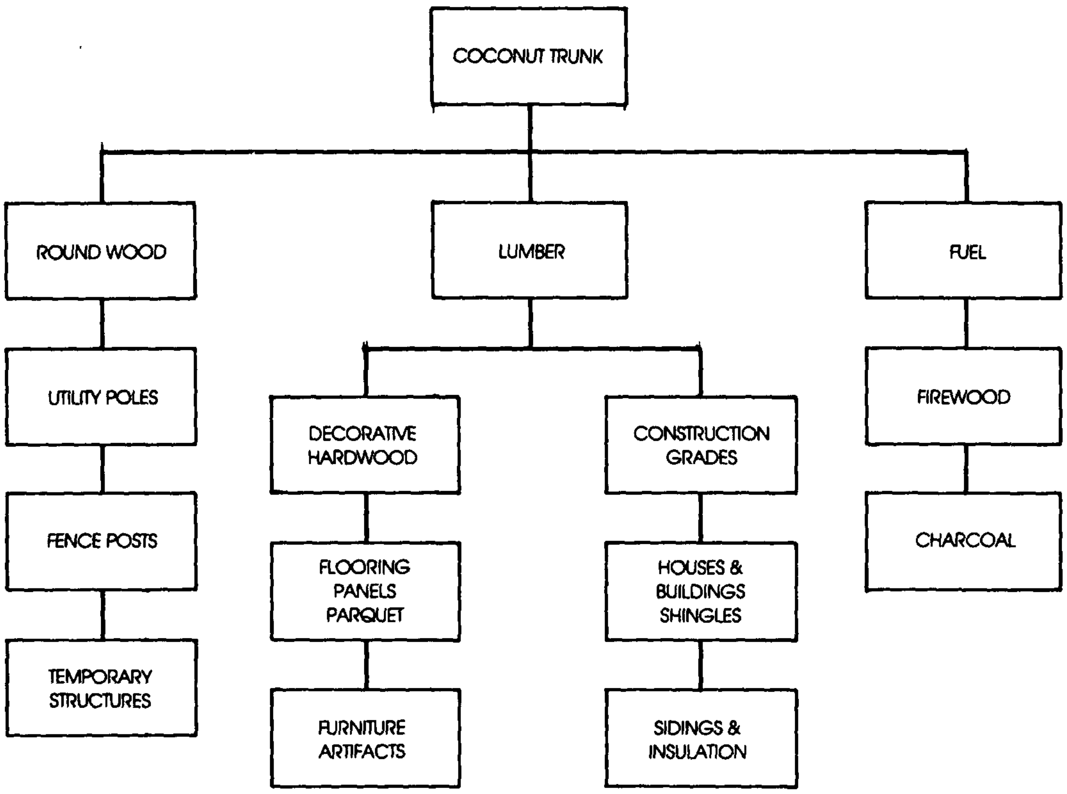
Figure I—2: COCONUT WOOD



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Source: After D. Meadows.

II. THE CHARACTERISTIC OF THE PRODUCT

A. Physical

The coconut is a fibrous drupe with an outer smooth skin or exocarp, the color of which usually ranges from green to red-brown but some varieties are ivory in color. When the fruit is very mature the exocarp dries out to a greyish-brown color. Beneath the exocarp is a fibrous covering or mesocarp of thickness up to 5 cm or more, according to variety. The exocarp, together with the mesocarp, form the husk. Beneath the mesocarp, covered by a very hard shell or endocarp, is the nut. When immature, the nut is almost completely filled with a watery liquid called coconut water. Most of this liquid disappears by the time the nut is completely mature, as it is transformed into the firm white endosperm. When the nut is young, the endosperm or meat is thin and jelly-like, but as the nut matures it increases to about 1 cm in thickness and becomes firm. For the larger varieties, such as the San Ramon nut of the Philippines, the ratio of shelled weight to husked nut weight is about 0.2. For average sized Sri Lankan nuts the ratio is about 0.25 and for dwarf nuts it may reach 0.35.

The meat from freshly opened nuts contains about 50 percent moisture. A typical composition for coconut meat dried to 5 percent of moisture is shown in Table II-A1.

Table II-A1: COMPOSITION OF COCONUT MEAT

	%
Moisture content	5.0
Crude protein	6.1
Oil (ether extract)	65.9
Crude fiber	4.5
Carbohydrate (nitrogen free extraction)	16.8
Ash	1.7

Source: After R.E. Evan, Rations for livestock, Ministry of Agriculture, Fisheries and Food Bulletin No. 48 (London: 1960).

Copra and coconut oil

The main industrial use of the coconut is in the production of copra, from which coconut oil and copra meal are derived.

Copra is the dried meat (endosperm) of the coconut. The essential requirement of copra drying is to bring down the moisture content of the wet meat from 50-55 percent to 5-6 percent. The normal process of drying is to expose the split halves of the nut to the heat of the sun or some artificial heat source. The period of drying is related to the temperature under which the copra is dried which, in turn, depends on the method of drying employed.

The oil content of copra varies from about 57 percent to 75 percent depending on source, the method of preparation and the size of the nut. Copra produced in Sri Lanka, Fiji, Papua New Guinea and West Malaysia is considered of good quality. The quality of milling copra ultimately determines the quality of the oil and the residual meal. Good quality copra will yield edible oil of less than 1 percent free fatty acid (ffa) content without refining. The nutritive value of the copra cake or meal is also higher from good quality copra than that from poor quality copra. An ffa of 1-3 percent is not unusual for coconut oil produced from Philippine copra, while in Thailand coconut oils of up to 5 percent ffa are said to be quite common.

Coconut oil is a colorless to pale brownish yellow oil. It is a fluid in the tropics but changes into a solid fat in temperate areas. In the solid state its melting point ranges from 23-26°C.

The main characteristic distinguishing coconut oil from other natural fats is that it contains a higher proportion (about 90 percent) of saturated fatty acids. Only two other vegetable oils, palm kernel and babassu, have similar levels of saturated fatty acids. 1/ Coconut oil is particularly high

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1/ For technical classification of fats and oils, see Fats and Oils Handbook.

in lauric and myristic acids, which confer good lathering properties when used in soap, shampoo, and shaving cream.

Coconut oil has the highest saponification value (250-260) and the lowest iodine value (8-10) of all the vegetable oils in industrial use. 1/

There is no uniform international quality standard for coconut oil. The Asian and Pacific Coconut Community has recently recommended grade specifications for the different types of oil. The following five grades have been recommended:

Grade I - Refined and deodorised oil

Grade II - Refined oil

Grade III - White oil obtained by wet processing

Grade IV - Industrial oil No. 1 (obtained by the process of extraction)

Grade V - Industrial oil No. 2 (obtained by the process of solvent extraction)

The quality requirements suggested for the different grades of oil are given in Table II-A2.

Copra cake and meal

Copra meal, which may be pressed into pellets, is the residue from solvent (usually hexane) extraction; copra cake is the residue from expellers or presses. In practice, the two terms are often used interchangeably, as will be the case in this handbook.

1/ Saponification is the process of reacting a fat with an alkali to yield glycerol and a salt or soap of the akali metal. The saponification value is the number of milligrams of caustic potash (potassium hydroxide) required to saponify (or convert into soap) one gram of oil. The iodine value is the number of grams of iodine absorbed by 100 grams of oil. This figure does not indicate any iodine content of the oil, but is a measure of the chemical unsaturation of the oil. A low iodine value or low unsaturation indicates a low content of unsaturated acids such as oleic and linoleic.

Table II-A2: QUALITY REQUIREMENTS FOR COCONUT OIL OF DIFFERENT GRADES

Characteristics	Grade I	Grade II	Grade III	Grade IV	Grade V
Free fatty acid as lauric (Maximum in percent)	0.10	0.10	1.0	6.0	10.0
Moisture and insoluble impurities (Percent by weight)	0.10	0.10	0.25	0.5	0.5
Unsaponifiable material (Percent by weight, maximum)	0.50	0.50	0.50	0.8	1.0
Color on a 1-inch cell on a Lovibond scale expressed as Y+5R, not deeper than	2	2	4	11	30
Saponification value, minimum	255	255	255	248	248
Iodine value	7.5-9.5	7.5-9.5	7.5-9.5	7-11	7-11
Specific gravity at $30^{o}C/30^{o}C$	0.915 to 0.920	0.915 to 0.920	0.915 to 0.920	0.915 to 0.920	0.915 to 0.920
Refractive index at $40^{o}C$	1.4480 to 1.4490	1.4480 to 1.4490	1.4480 to 1.4490	1.4480 to 1.4490	1.4480 to 1.4490
Mineral Acid Content	nil	nil	nil	nil	nil

Source: A.K. Thampan, Handbook on Coconut Palm (New Delhi: Oxford and IBH Publishing Co., 1981).

In comparison with most other meals, copra meal is relatively low in protein and calorific value, and high in fiber and nitrogen free extracts. By way of comparison, Table II-A3 gives details of the composition of copra meal and of a medium protein meal (linseed meal) and a high protein meal (soybean meal).

Table II-A3: COMPOSITION OF VARIOUS MEALS

	Copra Cake	Copra Meal	Linseed Meal	Soybean Meal
	(%)			
Protein	21.2	21.4	36.6	45.7
Fat	6.7	2.4	1.0	1.3
Fiber	11.2	13.3	9.3	5.9
Nitrogen-free extract	47.4	47.4	38.3	31.4
Mineral matter	6.5	6.6	5.8	6.1
Moisture	7.0	8.9	9.0	9.6
Total	100.0	100.0	100.0	100.0

Source: F.B. Morrison, Feeds and Feedings (Clinton, Iowa: 1961).

B. Economic

Coconut oil

Coconut oil is extensively used for edible and industrial purposes, Figure II-1 and Table II-BI. Oil obtained by direct processing of wet kernel or by crushing good quality copra under hygenic conditions is used for cooking, without need of further refining. However, coconut oil received from the conventional milling process may contain free fatty acid (ffa) and various impurities and is generally refined before being used for edible purposes.

The refining of crude coconut oil involves three or more processes: neutralization, bleaching, de-odorizing and polishing. Neutralization removes free fatty acids and gums from the crude oil through the application of

Figure II–1: THE END-USES OF LAURIC OIL AND ITS DERIVATIVES.

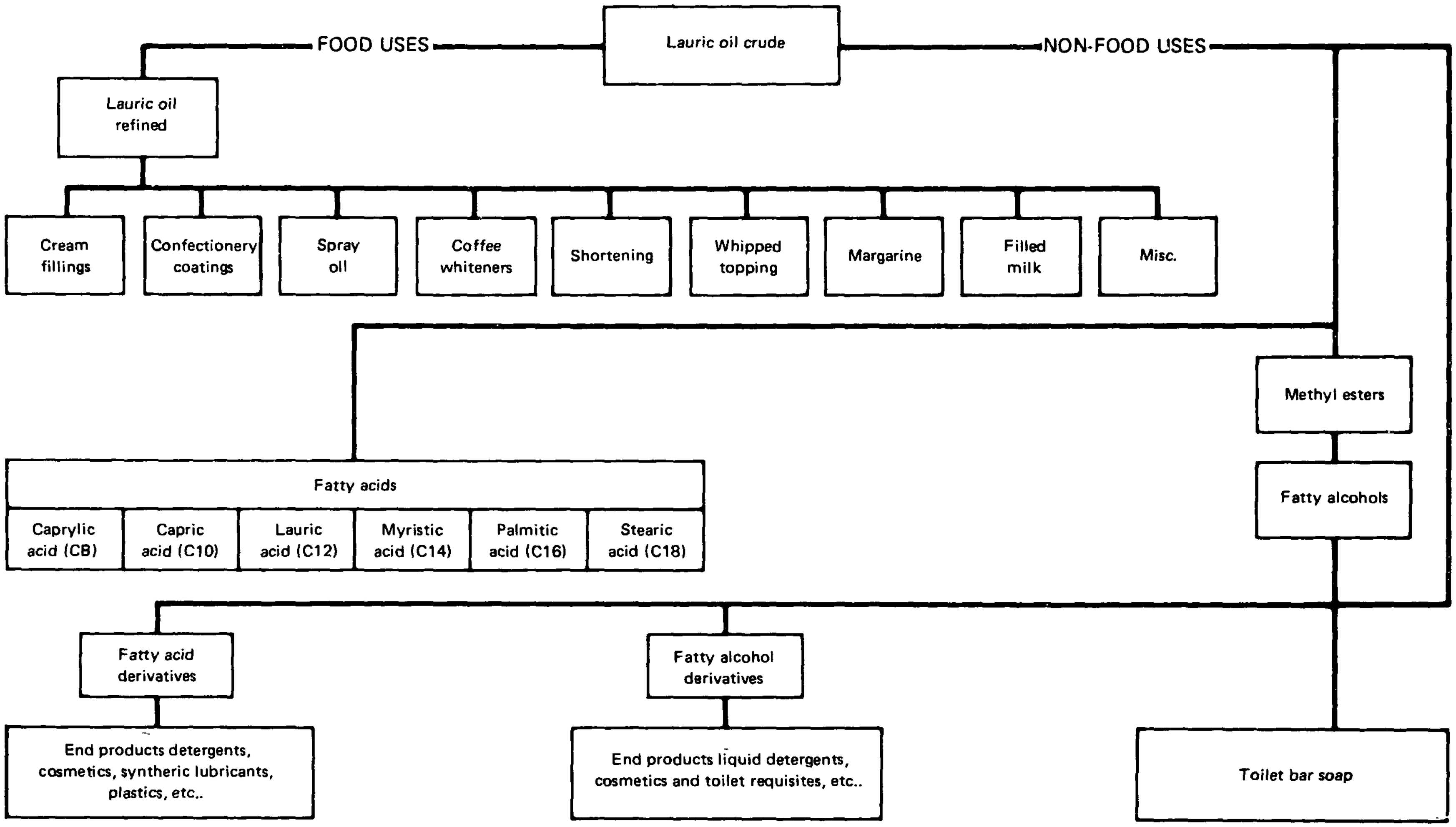

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Table II-B1: LAURIC OILS--MAJOR END-USES, RELEVANT PROPERTIES AND COMPETING MATERIALS

End-uses	Form in which used	Relevant Properties	Competing Materials Natural	Synthetic
Margarine	Coconut oil (refined or not)	One of first vegetable oils to be used in margarine manufacture since the 1920s, because of its similarity with butterfat (plasticity, etc.)	Most fats and oils (mainly hydrogenated)	-
Shortening	Refined coconut oil	Appropriate melt index and range, texturizing qualities. Because of its relatively low smoke point, it is not regarded as suitable for high temperature cooking.)	Soyabean, cottonseed, groundnut hydrogenated), palm and corn oils, animal fats	-
Dairy products non-dairy creamers Whipped toppings filled milk non-dairy ice-cream savory dips	Refined coconut oil	Especially suitable because of its stability, resistance to oxidative rancidity and bland taste (in comparison with other oils).	Most hydrogenated vegetable oils	-
Confectionery coatings	Blends of cocoa powder and refined coconut oil	Favored substitute for cocoa butter because of its higher melting point	Hydrogenated non-lauric oils	-
Cream fillings	Refined coconut oil	Relatively high melting point and stability. Glossy appearance	Animal fats, other edible vegetable oils (palm oil after fractionation	-
Spray oil	Refined coconut oil	Appearance and resistance to oxidative rancidity	Most edible vegetable oils	-
Ice-cream coatings	Refined coconut oil	Physically similar to hard butters (less stringent technical requirements in terms of melt index).	Most edible vegetable oils	-
Soap	Fatty acid (lauric) Fatty alcohols (lauryl)	Lathering and creaming action (high saponification value)	Babassu and tall oils, inedible tallow and greases, palm oil	Fatty acids
Surface-active agents	Fatty acids and fatty alcohols (lauryl)			
Synthetic detergents (a) Heavy duty (b) Light duty	Sodium lauryl sulphate Lauryl diethanolamides Sodium polyphosphate Lauryl alcohols	Foam boosters and stabilizers	Babasu and palm oils	Fatts acids and alcohols
Textile Chemicals	Fatty acid amine condensate (solution of 1%)	Coconut oil derivatives perform three general functions: (i.e., removing the oils and grease present in wool), washing and dyeing.	Tallow derivatives	Various (from petroleum)
Cosmetics & toiletries Toothphaste, shampoos, Basic preparations, eyelash make-up, pre-shave lotion and bath oil	Fatty acid (lauric): Sodium lauryl Sulphate	High foamability and cleansability. Special emollient properties	Groundnut oil, other vegetable oils	Fatty acids
Leather Chrome tanning	Crude oil and coconut oil sulphate (1:1)	Lubricating action in the fat-liquoring step that follows chrome-tanning. The fat-liquoring of leather consists in lubricating the fibers to give them strength and flexibility. Coconut oil is particularly indicated for treatment of high-value (white or pastel) leathers.	All types of oils. Cod oil is mostly used	Poromeric materials
Surface coatings Non-drying alkyd resins	Fatty acid (lauric)	Color retention, flexibility and durability	Castor oil, other short-chain fatty acids	Pelargonic acid
Rubber chemicals	Fatty alcohol: dodecyl mercaptan	Control of molecular weight and other properties of the polymer formed	-	Petroleum derivatives
Lubricating additives	Fatty alcohol (lauryl): Lauryl methacrylate monomer	Viscosity index improver (ability of the oil to lubricate over a wider temperature range)	Castor oil	Fatty alcohol
Plastics Vinyl plastics	Fatty acids (short-chain) & fatty alcohols Capryl alcohol	As plasticizers, coconut oil derivatives are added to acid in vinyl fabrication; as stabilizers, they are added to prevent discoloration and other degradation during fabrication or while in use.	Castor oil, other lauric oils	Fatty alcohols
Others /a Disinfectant	Fatty acids	Agent to produce the cloudines desired when the product is diluted with water	-	Various
Lauryol peroxide		Catalyst for polymerizatrion reactions	-	Various

/a Small quantities are used in synthetic perfumes, flavor and essence, dyestuffs, pharmaceuticals, printing inks and other organic compounds.

Source: J. Nusbaumer and R. Franco, "Substitution between Vegetable Oils and the Trade of Developing Countries," Tropical Science, Vol. 20, No 1, 1978.

caustic soda. Neutralization leaves a byproduct, soapstock, 1/ a raw material used in the manufacture of soap or acid oils. (The amount of soapstock produced in neutralization is about 1.4 times the ffa of the crude coconut oil treated.) Bleaching, undertaken with absorbent agents such as Fuller's Earth and activated carbon, removes color and any other unwanted constituents. (Oil which has only been neutralized and bleached is normally known as semi-refined oil.) De-odorizing is the removal of odors or off-flavors through the blowing of live steam through the heated oil. The fourth process which refined oil frequently undergoes is polishing. This consists of passing the de-odorized oil through a polishing or filtering press which removes any final particles remaining, resulting in a clear, bright oil.

Although the technology involved in coconut oil refining is said to be relatively simple, the production and trade in processed coconut oil is still relatively small. Much of the processed oil traded has apparently not been even partly refined. 2/

In producing countries, where the oil is liquid at ambient temperatures, the main use is as a cooking oil. Unrefined oil was largely used for this purpose in the past, but there is now an increasing demand in these countries for the refined material. In industrial countries with a temperate climate, coconut oil is used as a cooking fat. However, it is not very suitable as a major ingredient of cooking fat due to its narrow plastic range. 3/ If other fats are mixed with coconut oil to improve the plastic range, it cannot be used for deep frying, as the mixture is liable to froth

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1/ Soapstock, the byproduct of the neutralization stage, is an important raw material from which lauric acid oil, the basis of many chemicals, is produced.

2/ McNerney, "Industrial Processing of Primary Products: Coconut Oil Refining" (Discussion Draft), (London: Commonwealth Secretariat, 1981).

3/ The distinguishing feature of plastic substances is their property of behaving as solids and completely resisting small stresses, but yielding at once and flowing like a liquid when subjected to deforming stresses above a certain minimum value.

over the pan. However, coconut oil is an excellent component of fats used for making shortbread and similar products.

By cooling coconut oil slowly to a temperature of about 23°C so that a portion of the oil crystallizes out and then pressing in bags in a hydraulic screw press, solid coconut stearine and liquid oleine can be separated. Varying grades of stearine can be separated by pressing coconut oil which has been subjected to various degrees of hydrogenation. Refined coconut stearine finds use as a cocoa butter substitute for chocolate and chocolate coatings. It is also used in the manufacture of biscuits, particularly "puff biscuits," for pharmaceutical purposes, and in the preparation of lard substitutes. The refined coconut oleine is used as a baking fat for pastries, cakes, and in the manufacture of toffees, caramels and similar products.

A relatively new use of coconut oil has been in filled milk products, or fluid milk substitutes. In these products the vegetable fat (usually coconut oil) replaces the butterfat in milk. Regular skim milk is homogenized with the vegetable fat. Refined coconut oil has physical characteristics similar to butterfat--it changes abruptly from a relatively hard and brittle solid to a clear oil within a temperature change of a few degrees, and the transition occurs in the range of ordinary room temperature. The basic reason for substitution is the cost difference between vegetable fat and butterfat. However, concern about possible health problems associated with the use of the highly saturated fatty acids in coconut oil has led to substitution of other oils. It is reported that several vegetable oil products, some relatively high in polyunsaturated acids, have recently replaced the coconut oil generally used in the imitation products.

In many producing countries, coconut oil has been used for toilet and cosmetic purposes such as for hair dressing and for skin care since time immemorial. The oil finds use as a lamp oil in more remote rural districts in tropical countries since it burns with a non-smoking flame when used in open lamps with wicks. The major industrial use of unrefined coconut oil is in the manufacture of soap and detergents. 1/

Coconut oil is easily saponified, even in the cold, and is an ideal raw material for soap manufacture in developing countries. Coconut oil is the ideal raw material for the manufacture of soap by the cold process which, being very simple and not requiring elaborate and expensive equipment, is particularly suitable in a cottage industry. However, a wider range of soaps can be produced if the coconut oil is blended with other oils in which case it is preferable to use a semi-boiling process. The full boiling process, generally used in industrial countries, produces the best soap. In this process the glycerol released by the saponification process may be recovered from the spent soap lye by concentration and purified by fractional distillation. Glycerol finds use in the manufacture of nitroglycerine, in pharmaceuticals, cosmetics, and for numerous other purposes.

Biodegradeable detergent manufacture accounts for a large percentage of coconut oil used nowadays, particularly in the US. In one type, the detergent is based on the alcohols derived from the mixed fatty acids, or from lauric acid in particular, by reduction.

Fatty alcohols from coconut oil have to compete with petroleum derived alcohols, particularly in the US. However, a substantial proportion of detergents is still being manufactured from natural fats and from coconut oil in particular.

Myristic acid, obtained from coconut oil fatty acids by fractionation, is used for the production of isopropyl myristate which is used as an anti-perspirant. Capric (C_{10}) and shorter-chain acids from coconut oil are used in the manufacture of synthetic lubricants for jet engines.

1/ Coconut oil imparts to soap a hardness and lathering property which no other oil except palm kernel oil can match.

Other industrial uses for coconut oil include the production of plasticisers and the manufacture of safety glass for aircraft and automobiles. It is further used in synthetic resins for lining food containers and in the manufacture of rubber substitutes such as hospital sheeting. Lauryl alcohol is used in the manufacture of tires, in the pulp industry, in dyeing textiles, in electroplating, and in insulating materials. Coconut oil can also be cracked under pressure (3.2 kg/cm^2) to yield motor fuel and diesel. Coconut oil also contains glycerine which is used in the manufacture of explosives.

Copra Meal

Within the protein content of meals, the balance of amino acids is important for different types of feeding and for feed formulation (see Table II-B2 for the animo acid composition of copra and other meals). In

Table II-B2: AMINO ACID COMPOSITION OF SOME MEALS

	Copra	Soybean	Groundnut	Fish
	------(grams per 16 grams nitrogen)------			
Arginine	10.8	7.0	10.8	6.6
Histidine	1.7	2.5	2.1	2.2
Isoleucine	4.0	5.8	4.0	7.0
Leucine	6.2	7.6	6.8	7.5
Lysine	2.6	6.6	4.0	8.8
Methionine and Cystine	1.6	1.1	0.8	3.0
Phenylalanire	4.2	4.8	5.0	4.3
Threonine	3.3	3.9	2.8	4.5
Valine	5.4	5.2	5.2	5.4
Tryptophan	0.9	1.2	1.0	0.8
Tyrosine	1.8	3.2	3.7	2.7

Source: A.M. Altschul, Processed Plant Protein Foodstuffs, (Academic Press: New York, 1958).

particular, lysine is essential for most young monogastric animals, while methionine (which can be relatively easily synthesized) is indispensable. In view of its low lysine composition, copra meal or cake is mostly used as an ingredient in feeds for dairy cattle. It is also satisfactory as a protein supplement for fattening cattle and lambs, but it is recommended not to use it as the only protein supplement for pigs and poultry. Poor quality cake/meal unfit for animal consumption can be used as fertilizer.

Other Coconut by-products

Desiccated coconut

Desiccated Coconut is prepared from selected fresh coconuts under hygenic conditions. The husked, selected nuts are shelled by hand to ensure that the kernel is kept whole, and the brown testa is peeled off with a special knife or peeler. The parings are dried and processed for oil, which is used in local soap manufacture. After washing in clean water to remove any traces of coconut water, the kernel pieces are sterilized by immersion in boiling water or by steam treatment. They are then shredded mechanically and the resulting material is artificially dried to a moisture content of from 2.5 to 3.5 percent. After cooling, the dried coconut is graded and packed, generally in kraft paper sacks. The principal producers of desiccated coconut are Sri Lanka and the Philippines, with the latter taking an increasingly larger market share.

Besides the more general use for confectionery purposes, desiccated coconuts is used in the manufacture of coconut flour, creamed coconut, coconut chips, toasted coconut and sweetened coconut.

Coconut shell charcoal

The shells of coconuts can be used for fuel or for firing copra kilns. A major outlet is in the production of coconut shell charcoal, which is used in the manufacture of activated carbon. It originated as a means of defense against poisonous gases in warfare and rapidly found industrial applications. At the present time, activated carbon is mainly used in the refining of vegetable oils (both as a decolorizer and deoderizer), sugar molasses, fruit juices, glycerine and syrups, as a gas absorbent and in water purification (especially in the beverage industries). Owing to the fact that activated carbon is the best all-round absorbent for toxic gases, it is used almost universally in gas masks, and for removing and abating industrial stenches. Activated carbon is also used in the pharmaceutical industry for its absorbent action on alkaloids, enzymes and poisions of various sorts, as well as contact catalysts in a number of chemical reactions of industrial importance.

Coir or coconut fiber

Coir or the fiber obtained from the husk of the coconut belongs to the group of hard fibers. Most of the world's coconut fiber is produced in two countries, India and Sri Lanka. There is, however, a marked contrast in the method of fiber extraction in the two countries, as well as in the end products into which the fibers are used. In India the main product is coir yarn and to produce this the green husks are retted for up to nine months and the fibers extracted by hand beating. The so-called "white" fiber produced is spun, either by hand or by a simple hand-operated machine, into yarn which is either exported as such or woven locally into mats and matting. Sri Lanka, on the other hand, is the main producer of "brown" fiber obtained from ripe coconut husks. The brown fiber is used for brush making and in mattresses.

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III. COCONUT GROWINC AND PROCESSING

A. Coconut Varieties

There are only two distinct types of coconuts, the tall (typica) and the dwarf. Owing to cross pollination, especially in the talls, a wide range of cultivars occur. These variations may relate to the height of palm, color, shape and size of the nut as well as yield and quality of copra.

Apart from varietal differences, different names are often given to the same type or cultivar in different countries. However, the name of the country of origin or locality is almost invariably attached to the name of the cultivar for identification. A brief account of the characteristic features of the two coconut varieties and their crosses is given below.

Tall variety: The tall variety is extensively cultivated, constituting an estimated 95 percent of all the planted coconut palms in the world. It has a long and stout trunk with a more or less swollen base called "bole." This variety is characteristically tall, growing to a height of about 15 to 18 meters. It is a comparatively hardy type, late bearing, and can live up to 80-90 years. In general it comes into bearing in five to seven years after planting. The nuts mature within a period of 12 months after pollination. The tall variety is largely allogamous or cross-pollinating as male and female flowers do not open simultaneously on the same inflorescence.

In the Philippines the most commonly grown tall is the Laguna while the favorite of the Indian farmer is the West Coast Tall.

Dwarf variety: Dwarf coconuts are known to occur in most of the coconut growing countries. This variety is characterized by its short stature and early fruiting. It is generally autogamous or self-pollinating as male and female flowers on the same inflorescence open together. It has a thin trunk without a swollen base or "bole" and its fully developed frond rarely exceeds 4 meters (as compared to about 6 meters in the case of the tall variety). Under normal conditions, the palm starts flowering in about two years when the trunk is just above the ground, and a fully grown tree rarely exceeds 10 meters in height. It yields heavily, but has a tendency to bear irregularly. The conventional belief is that the dwarf variety does not live as long as the tall variety and that its yield tends to decline after about 25 years of production. The dwarf produces a large number of small nuts, having a much lower copra content than the nut of the tall variety. Moreover, under conditions of low soil fertility, the kernel of the dwarf nut produces inferior copra, more rubbery in quality than that produced from the tall variety. Since the dwarf is smaller in stature, more can be planted per unit area than the tall variety, and, therefore, total yield of nuts and copra from a specific stand would normally be similar to a stand planted with palms of the tall variety. In recent years, the dwarf variety has received much attention because of the use as a parent in evolving high-yielding hybrids. The Malayan Dwarf, one of the most important dwarf types in the world is reported to be resistant to the "lethal yellowing" disease (see Section D on Diseases and Pests).

Hybrid Palms: 1/ While a hybrid will result from crossing between any two cultivars, the term is generally used to indicate the products of crosses between dwarfs and talls. While these occur naturally from time to time, the first hybrids resulting from controlled (hand) pollination were produced in Fiji in 1927. Similar experiments were later conducted in India and Sri Lanka. The earlier bearing (precocity) and higher yield of hybrids was noted by the early workers, but the use of hand pollination was impracticable for large scale commercial hybrid seed production.

1/ The section on hybrid palms was updated by D. Meadows.

The good performance of some hybrids can be explained in part by the combination of the dwarf characters of precocity, higher numbers of bunches per year and more nuts per bunch, with the talls' higher copra content per nut. In addition, hybrids also benefit from hybrid vigor (heterosis), particularly when the parent cultivars have widely different geographical (and thus genetic) origin. Conversely hybrids between cultivars which have co-existed for many generations tend to have disappointing performance.

The commercial utilization of hybrids became practicable with the development of open controlled pollination seed gardening in the early 1960s by the Institut de Recherches pour les Huiles et Oléagineux (IRHO) in the Ivory Coast. In these, the female parents--dwarfs for convenience of access--were interplanted with the tall male parent. The former were routinely emasculated to prevent the production of pure dwarf seed by self pollination and the female flowers were then pollinated by natural agents (wind and insects) by the available pollen from the talls. Subsequently, in 1972, the system was modified to permit greater flexibility in the choice of male parents and higher seed production. To this end, solid blocks of dwarfs were planted in isolation as female parents--being routinely emasculated as before. Blocks of potential male parent cultivars are planted separately as sources of pollen which is applied artificially to the female flowers of the dwarfs.

One hectare of this type of seed garden can produce sufficient hybrid seed to plant 50 to 60 ha. per year. Global hybrid seed production capacity is probably between 30 and 40 million nuts per year.

These seed gardens almost all produce hybrids whose performance has been evaluated for over ten years. These include the best known--PB 121 or MAWA (Malayan Yellow Dwarf x West African Tall), Malayan Red Dwarf x Rennel, PB 132 (Malayan Red Dwarf x Polynesian Tall) and PB 111 (Cameroon Red Dwarf x West African Tall). The PB hybrids, in particular, have performed well under the poor soil and climatic conditions in the Ivory Coast and have been adopted for extensive planting in Brazil, Indonesia, Malaysia and the Philippines, where their performance has been even better. Farm yields of 3 to 3.5 tons of copra per ha are achieved under the Ivory Coast conditions, while 4.5 to 5 tons are obtained under good rainfall conditions. The respective precocity is 4 1/2 to 3 1/2 years. Research station yields are of course considerably higher. Fortunately, these hybrids have shown better tolerence of drought, poor nutrition and some diseases and pests than their parent cultivars.

Hybrids are sometimes critized on the assumption that, like high yielding cereals, they will only thrive with heavy fertilizer application. This comparison is a fallacy as it overlooks the fact that high yielding cereals have been bred over many generations to tolerate and respond to heavy fertilizer. By contrast, hybrid coconuts are the result of the first generation of breeding and no such sophistication is involved. Available evidence shows that their vigor enables them to outperform talls, even under poor management. 1/ Likewise concern over the possible introduction of disease has proved to be misplaced as major producing countries have introduced parent material and hybrid seed without any mishap.

B. Climate and Soil

The coconut palm grows best when favored with a hot, moist climate. The ideal mean temperature for coconut growing is considered to be around 20°C. The palm is found mainly between latitudes 20°N and 20°S and since the best situations are coastal, coconut cultivation has developed most extensively on islands and peninsulas. However, the palm is not necessarily

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1/ However, where their performance has not been adequately tested under marginal environments such as tidal swamps or low rainfall areas, it may be prudent, according to a recent (1980) Staff Appraisal Report on smallholder coconut development in Indonesia, to use local varieties. In Sri Lanka, local talls and tall x tall hybrids were, apprently, found to be more suitable than dwarf x tall hybrids for planting under suboptimal environmental conditions.

confined to the sea coast or sea level. The bases of foothills where there is sub-soil water movement may be suitable. Coconut palms can be found up to 1,200 m above sea level near the equator; however, an elevation of 600 m seems to be the limit for commercial growing. Maximum growing altitude decreases with distance from the equator. For example, in Jamaica (18°N) the palms are not grown commercially above 120 m.

The palm thrives best with a well distributed rainfall between 1,500 and 2,300 mm a year. Water supply is the most important factor influencing coconut yields and in times of drought the coconuts may be reduced both in size and number.

Many different tever, an elevation of 600 m seems to be the limit for commercial growing. Maximum growing altitude decreases with distance from the equator. For example, in Jamaica (18°N) the palms are not grown commercially above 120 m.

C. Cultural Practices

Many aspects of the management of a coconut holding such as nursery and transplanting techniques, planting density, weed control, cultivation and cover-cropping are established practices. Since they have been well-covered in technical books on the subject 1/ as well as being very much local matters related to soil and climate and to economic and social conditions, these practices need not be considered here.

D. Diseases and Pests

Diseases: The coconut palm is subject to numerous diseases which fall into four categories: (a) diseases of uncertain origin; (b) a probable mycoplasma disease; (c) a bacterial disease; (d) fungal diseases and (e) a viroid disease.

1/ See, e.g., R. Child, Coconuts, (London: Longman, 1974).

Diseases of uncertain origin: Wilt diseases have been reported from a number of coconut growing countries, but by far the most important is the root wilt disease of Travancore in South India. It is also known as Kerala wilt. Its main features are a flaccidity of the leaves, followed by yellowing and marginal necrosis. It is often associated with a leaf-rot and the two diseases are sometimes featured in combination. The condition causes considerable yield losses. Adverse soil conditions, chemical and physical as well as bacterial and fungal soil flora have been associated with the disease. A fungal pathogen has even been implicated but inoculation tests suggest that this is a virus disease.

Mycoplasma (lethal yellowing): Lethal yellowing is a very serious disease in Jamaica, Florida and nearby areas. It has been the subject of considerable research and has been shown to be associated with the presence of mycoplasmas in the phloem. The vector is thought to be airbone and probably a leafhopper. Certain strains of the Malayan Dwarf coconut are highly resistant to the disease. Dry bud rot a disease of seedlings and young palms, particularly Malayan Dwarfs, has also been associated with the presense of mycoplasma.

Bacterial disease: Bacterial stripe of coconut seedlings has been reported from the Philippines but no successful treatment is apparently available.

Fungal diseases: There are a number of fungal diseases but they are not of great major concern as most can be held in check by efficient plantation management.

Viroid disease: Cadang disease which is present in certain parts of the Philippines and Tinangaja disease on Guam and some nearby islands are caused by a viroid.

Pests: Many insects attack the coconut palm and some cause very serious damage. Some are only of localized importance but there are several examples where one species or a few closely related species occur almost everywhere coconuts are grown. Among the most serious pests are the rhinoceros beetle (Oryctes rhinoceros L), the red palm weevil (Rhynchophorus ferrugineus 01) and related species. Other insect pests are leaf-eating and wood-boring beetles. The coconut scale (Aopidiotus destructor sign.) occurs wherever coconuts are grown and cause serious damage in islands where it has no natural enemies. In addition to insects that damage palms directly, there are others that are of concern because they transmit coconut diseases. Smallholder ownership presents special problems in relation to insect pests because a failure by one owner to practice control measures can endanger all the surrounding holdings. In any case, mechanical and chemical control measures are often uneconomic for use, since very expensive equipment is needed if chemicals have to reach the crowns of mature coconut palms. Wherever possible, biological methods are preferred for controlling insect pests.

E. Harvesting

Mature coconuts are harvested by two main methods, free fall and picking from the tree, depending on the cultivar. In some cultivars, the mature nuts fall naturally to the ground, from where they are collected at regular intervals. This method has two main advantages, the low cost of collection and the fact that the fallen nuts are usually fully mature.

The method of harvesting coconuts by picking from the tree is usually carried out by tree climbers from the ground with the aid of a curved knife on the end of long bamboo poles, or in some areas by trained monkeys.

F. Drying

Most coconuts are processed for their oil and cake by processing copra, the dried endosperm or meat. Fresh coconut meat has a moisture content of 50-55 percent. To prevent deterioration this has to be reduced as quickly as possible to about 5-6 percent. There are three drying methods in general use: (a) sun-drying; (b) smoke drying or drying over an open fire in a direct drier or klin, where the drying coconut meat comes into direct contact with the combustion gases; and (c) indirect hot air drying, where the drying coconut meat does not come into direct contact with the cumbustion gases.

The method of drying adopted is generally decided by the price that the copra will command in any particular production area or by grading regulations. Commercial driers are usually only an economic proposition when supplying a market which requires first grade copra and pays a premium for this quality. Drying is otherwise carried out by the simplest and cheapest method, frequently resulting in poor quality copra which is insufficiently dry and often mouldy and infested with insects. Smoke contamination also reduces the quality and foreign matter, such as sand, can damage the expellers.

G. Processing

The bulk of the world production of coconuts is dried for copra, which is then processed into coconut oil and cake/meal.

Traditional methods: Traditional methods of oil extraction still practised in some rural areas make use of animal driven "chekkus" or "ghanis." These consist of a mortar made from wood or stone around which is r##a ghani can be as high as 55 percent but in practice is usually lower. As a first step in mechanization, ghanis can be power driven, in which case it is the mortar which is rotated against the pestle.

Large-scale methods: Most copra is processed in continuous screw presses or expellers. The expressed crude oil is filtered while the residue of copra cake or poonac, which is in the form of lumps or scales, is broken down into small pieces or powder and packed in sacks. Depending on the eficiency of the milling equipment, the first processing of the copra may only extract about 30 percent of oil; the cake is again passed through the expeller to extract a further 10-14 percent. This two-stage process uses low pressure expellers for the first copra crushing, followed by high pressure expellers for milling the residual cake. Where copra is being extracted on a large-scale, i.e., approximately 50 tons per 24 hours, the cake from a low pressure expeller is further extracted with a solvent such as hexane, which will extract virtually all the oil and leave a residual meal with an oil content of about 1 percent.

"Wet" processing methods: Established processes for the extraction of oil from copra generally involve a down-grading of coconut protein. Furthermore, where copra is processed inefficiently or it is stored under unsatisfactory conditions, deterioration results from chemical, microbiological, insect and rodent damage. Although oil is still, in practical terms, recoverable in food grade condition from copra despite this deterioration, protein is not.

A number of attempts have been made to conserve the full food value of coconut meat through the development of processes which omit an intermediate drying stage (copra production). These processes, e.g., the Texas A&M University Process and the Tropical Products Institute (TPI) process are broadly similar and are categorized as "wet" processing. The steps involved are commonly the "wet" milling of coconut meat, separation of the oil in the water emulsion so formed from the residual solid material, mainly cellulose, breaking of the emulsion to yield the oil, followed by precipitation and recovery of the protein present in the aqueous phase. So far as is known, none of the processes reported have been taken beyond the pilot plant stage, except for the commercial production of coconut cream.

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IV. THE WORLD COCONUT INDUSTRY

A. Structure

Coconut growing has traditionally been a smallholder activity. For centuries the palm was planted exclusively for household use. Commercially oriented plantings began less than a century ago, in response to the growing demand for coconut oil from Europe.

With the main exception of Papua New Guinea, where about 60 percent of the coconut area is under plantations, smallholdings constitute the bulk of the coconut area in the major producing countries. Thus, in the Philippines in 1978, out of the 3.3 million ha of coconuts, over 80 percent of the holdings were below 4 ha. In India, and probably many other countries, the average holdings is less than 1 ha, so that, world-wide the crop directly affects the livelihood of many millions of people.

While practically all smallholdings are locally-owned, a few coconut plantations in Papua New Guinea, Fiji and other Pacific islands are still owned by foreign nationals.

B. Production

Data on the area and production of coconuts in different countries are incomplete and of doubtful accuracy. However, Thampan (1981) has recently estimated that the total area under coconuts is about 9 million ha with an annual production of some 35,000 million nuts. This would roughly translate into a yield, in terms of copra equivalent, of about 770 kg/planted ha. Based on Thampan's figures of planted area and the FAO's figures on production, yields have been estimated for selected major producing countries, Table IV-B1. These figures should, however, be treated with caution.

The largest producers of coconuts (oil equivalent) are the Philippines, Indonesia, Sri Lanka and India (see Table IV-B2) but significant

Table IV-B1: AREA AND PRODUCTION OF COCONUTS IN SELECTED COUNTRIES, 1978

Country	Area ('000 ha)	Coconut Production (million nuts)	Yield in Copra Equivalent (kg/ha)
Philippines	3,317	10,072	607
India	1,083	4,065	751
Sri Lanka	466	1,677	720
Thailand	400	860	430
Malaysia	325	1,202	740
Papua New Guinea	252	800	635
Fiji	89	245	550

Source: Area - P.K. Thampan, Handbook on Coconut Palm, (New Delhi: Oxford 1BH Publishing Co., 1981)

Production - FAO, Production Yearbook, (Rome: FAO, 1981).

quantities are produced in most tropical countries of South and Southeast Asia, Central America and the Caribbean, the Pacific, and East and West Africa. Indonesia was the largest producer before World War II, but has since been overtaken by the Philippines.

Weather conditions remain the basic factor affecting coconut production. The production shortfalls experienced in 1977 and 1979 were the result of prolonged drought in the Philippines, the most important producer. The increased concentration of production in that country has probably increased the instability in world coconut production.

Supply response: In the handbook on palm oil it is pointed out that producers of oil-bearing trees, such as coconut palm and oil palm, are likely to be less responsive to price changes than producers of annual oilseed crops. The long time lag between the planting decision and production, and their low variable costs of production relative to their fixed cost components, result in coconut oil and palm oil production having a highly inelastic production response to

Table IV-B2: COCONUTS (OIL EQUIVALENT) -- PRODUCTION BY MAIN COUNTRIES AND ECONOMIC REGIONS

Countries/ Economies	Actual 1961	1970	1975	1980	Growth Rates /a 1961-80	1970-80
	--------('000 tons)---------				---(% per annum)---	
Industrial	..	-	-	-	-	-
Centrally Planned	20	18	19	28	1.7	4.8
Developing	2,287	2,460	2,686	2,862	1.2	1.8
Asia	1,827	2,040	2,258	2,406	1.5	1.9
Philippines	826	1,052	1,091	1,270	2.3	2.7
Indonesia	511	472	641	629	1.3	2.5
India	170	230	232	240	1.6	0.4
Malaysia	128	128	133	147	1.3	1.3
Sri Lanka	177	134	129	80	-5.2	-5.5
Africa	99	96	92	106	0.5	1.1
America	179	144	142	128	-1.3	-0.9
Mexico	126	92	93	76	-1.9	-0.9
Oceania	183	180	195	224	0.9	2.8
Papua New Guinea	70	82	85	89	1.2	1.6
World	2,307	2,479	2,705	2,891	1.2	1.8

/a Least squares trend for historical periods (1961-80).

Sources: FAO, Production Yearbook tapes.

short-run price movements. This expectation was borne out in a study of the Philippine coconut industry which found a short-run elasticity of 0.30 and a long-run elasticity of 0.66, Table IV-B3.

Table IV-B1: PALM PRODUCTS -- SUMMARY SHEET FOR COMMODITY SUPPLY: PRICE AND INCOME ELASTICITIES

	Variables			Own Price Elasticity			Other Price Elasticities		Income Elasticity	Data Interval	Period	Quality					Source
	Quantity (a)	Price (b)	Form (c)	Short run	Lag Period	Long run Static	Variables	Elasticity Value		(d)		Method (e)	Data Source (f)	Number	Equation	Significance (g)	
Philippines (numbers of palm trees)	S	F	AL	.299	1	.66				A	1953-66	S	X	14	.975	X	Nyberg
	S	W	AL	-.0008	1	-.012				A	1953-66	S	X	14	.973	0	Nyberg

NOTE

(a) Supply = S, Exports = X
(b) Farm level = F, Wholesale = W, Retail = R, Unit Value = U, c.i.f. = C, f.o.b. = B
(c) Actuals = A, First differences = F, Logarithms = L, Prices Deflated = P
(d) Annual = A, Quarterly = Q, Monthly = M, Weekly = W, Daily = D, Cross-sectional = C
(e) Arc Computation = C, Graph = G, Guestimate = E, Ordinary Least Squares = O, Simultaneous Equation Method = S, Flexibility = F
(f) Data Source Indicated, Insert = X, Otherwise = O
(g) Significant at 95% = X, Nonsignificant at 95% = O, Otherwise blank.

Source: UNCTAD, "Survey of Commodity Demand and Supply Estimates," 1974.

C. Consumption

Although more than half of the world's coconut output enters international trade, either as copra or coconut oil, an important part of world coconut output is not exported, but is retained for domestic consumption in the developing producing countries. In terms of apparent consumption, Indonesia is the leading consumer of coconuts (oil equivalent), followed by the US, the Philippines, India and the Federal Republic of Germany, Table IV-C1. On a per capita basis, Indonesia is also the leading coconut oil consumer, with a per capita consumption of 4.8 kg in 1975/77, followed by the Philippines with 3.5 kg and Malaysia with 2.3 kg, Table IV-C2. However, unlike in Indonesia, where coconut oil is still preferred, and per capita consumption of coconut oil increased sharply from the 1972/74 level, per capita consumption has stagnated in the Philippines while it has declined in Malaysia. The reason for the decline in coconut oil consumption in Malaysia is because refined palm oil, which is cheaper than coconut oil, has increased its market share. Among the major coconut oil importing industrial countries, per capita consumption is highest in the US at 0.7 kg.

Consumption of coconut oil in the major importing countries in the early 1970s was almost equally divided between inedible and edible uses. Among the inedible uses are intermediate products such as fatty acids and fatty alcohols, and a wide range of end-uses including soaps, synthetic detergents and plastics. The main edible uses are for margarine, shortenings, cooking fats as well as in confectionery, bakery and imitation dairy products. The share of coconut oil in the edible market is expected to increase as the price of petroleum-based feedstocks continue to rise.

Demand response: While the world price demand for fats and oils as a group may be price inelastic (0.4 in 1975, according to FAO), the results from empirical analysis of price and income elasticities of demand for individual fats and oils are generally higher. The elasticity values can also be expected to be different between regions and countries.

Table IV-C1: COCONUTS (OIL EQUIVALENT) -- APPARENT CONSUMPTION BY MAIN COUNTRIES AND ECONOMIC REGIONS

Countries/ Economies	Actual				Growth Rates /a	
	1961	1970	1975	1980	1961-80	1970-80
	--------('000 tons)---------				---(% per annum)---	
Industrial	1,027	888	1,091	995	0.6	1.5
N. America	321	402	427	403	1.8	1.9
United States	294	381	401	383	1.8	2.0
EC-10	534	321	516	457	0.1	2.5
Germany, F.R.	205	115	184	180	-0.5	2.3
Centrally Planned	61	58	83	135	3.9	7.8
Developing	1,201	1,475	1,410	1,713	1.7	2.3
Asia	899	1,223	1,082	1,383	2.1	2.2
Indonesia	338	349	593	566	3.6	5.0
India	227	241	232	260	0.5	1.3
Philippines	142	444	-6	275	3.6	-3.6
Malaysia	70	79	90	74	1.5	-0.3
America	229	157	189	154	-1.5	0.1
Mexico	126	92	93	96	-1.0	0.6
World	2,289	2,421	2,584	2,844	1.4	2.1

/a Least squares trend for historical periods (1961-80).

Sources: FAO, Production Yearbook tapes.

The demand for coconut oil is a derived demand based on the demand of consumers for the final products. There are three main factors affecting demand. Two obvious factors are changes in population and incomes. A third factor is the new end-uses which have developed.

The demand for coconut oil is highly price inelastic both in the short- and long-term. The price elasticity of demand for coconut oil in the US is about -0.2 (-0.19 in the short-run and -.25 in the long-run) and the

Table IV-C2: PER CAPITA CONSUMPTION OF COCONUT OIL BY MAIN COUNTRIES

Countries	1972/74	1975/77
	--------(kg/year)---------	
United States	0.7	0.7
United Kingdom	0.2	0.1
Indonesia	3.1	4.8
India	0.2	0.2
Philippines	3.4	3.5
Malaysia	3.5	2.3
Mexico	0.9	1.3

Source: FAO, Food Balance Sheets (Rome: FAO, 1977, 1980)

income elasticity is about 0.6, indicating that per capita demand for coconut oil is responsive to income changes, Table IV-C3. It will also be seen from the table that the long-run own price elasticity of demand for coconut or lauric oil was higher in Europe than in the US during the period 1953-66, while the converse was true of the income elasticity of demand. The higher income elasticity of demand in the US is consistent with data indicating that the US has overtaken the EC as the major importer and consumer of coconut oil.

D. Trade

Coconut oil exports account for a little over 10 percent of the total world exports of the major edible vegetable oils. The pattern of exports of coconut products is broadly similar to that of production. Exports are highly concentrated in the Philippines. The Philippines has increased its share in world exports considerably since the 1960s and its dominance is more striking in trade than in production, particularly for coconut oil, Table III-C1. It now accounts for nearly 90 percent of world exports of coconut oil. In contrast, Indonesia, the second largest producer, retains most of its output to meet domestic requirements, while India consumes all its copra domestically.

Table IV-C3: PALM PRODUCTS -- SUMMARY SHEET FOR COMMODITY DEMAND: PRICE AND INCOME ELASTICITIES

	Variables: Quantity (a)	Variables: Price (b)	Variables: Form (c)	Own Price Elasticity: Short run	Own Price Elasticity: Lag Period	Own Price Elasticity: Long run / Static	Other Price Elasticities: Variables.	Other Price Elasticities: Elasticity Value	Income Elasticity	Data Interval (d)	Period	Quality: Method (e)	Quality: Data (f)	Quality: Number	Quality: Equation	Quality: Significance (g)	Source
Philippines (palm oil)	D	W	AP			from -.302 to -.381			1.0	A	1950-67	S and TS		18			Librere
Philippines (palm oil) (export demand)	M	W	AP			from -.874 to -1.278	Cottonseed oil	From .814 to 1.278	From 2.3 to 2.5	A	1950-67	S and TS		18			Librere
							Palm kernel oil	From .780 to .997									
(Lauric Oils) U.S.	D	W	LP			-.241			.522	A	1953-66	TS	X	14		X	Nyberg
" U.S.	D	W	LA			-.238			.596	A	1953-66	TS	X	14		X	Nyberg
" Europe	D	W	LP			-.786			.144	A	1953-66	TS	X	14		X	Nyberg
" Europe	D	W	LA			-.570			.614	A	1953-66	TS	X	14		X	Nyberg
" U.S. (per capita)	D	W	LA			-.220			.368	A	1953-66	TS	X	14		X	Nyberg
" Europe (per capita)	D	W	LA			-.579			.197	A	1953-66	TS	X	14		X	Nyberg
(Copra) Philippines	D	W	LA			.093			.583	A	1953-66	S	X	14	58	0	Nyberg

NOTE

(a) Supply = S, Exports = X
(b) Farm level = F, Wholesale = W, Retail = R, Unit Value = U, c.i.f. = C, f.o.b. = B
(c) Actuals = A, First differences = F, Logarithms = L, Prices Deflated = P
(d) Annual = A, Quarterly = Q, Monthly = M, Weekly = W, Daily = D, Cross-sectional = C
(e) Arc Computation = C, Graph = G, Guestimate = E, Ordinary Least Squares = O, Simultaneous Equation Method = S, Flexibility = F
(f) Data Source Indicated, Insert = X, Otherwise = O
(g) Significant at 95% = X, Nonsignificant at 95% = O, Otherwise blank.

Source: UNCTAD, "Survey of Commodity Demand and Supply Estimates," 1974.

There has been a marked change in the form of products exported. While in the early sixties about 70 percent of total exports of coconut oil equivalent took place in the unprocessed form of copra, the proportion has been slowly changing so that now, more oil is exported as such than contained in shipments of copra. This has mainly been brought about by events in the Philippines where government policy, particularly by charging higher export duties on copra than on its processed products, has favored the development of the domestic crushing industry. Four out of five tons exported from the Philippines are in the form of coconut oil and not copra. Other exporters account for less than 5 percent each of the total.

Table IV-D1 shows that world exports of coconut oil have tended to rise in recent years, as nearly all producing countries are following a long-term policy of exporting coconut oil rather than copra in order to increase value added and to create employment.

Industrial countries are responsible for the bulk of world imports of coconut products. The US is the most important importer, with about 35 percent of total world imports. The US now imports only coconut oil, more than 90 percent of which comes from the Philippines. The other major importers of coconut oil are Germany (14 percent), the USSR (7 percent) and the Netherlands (5 percent), Table IV-D2.

E. Freight Rates

Freight rates for coconut products are not readily available. However, recent figures on freight costs obtained from the Philippines indicate that the freight for coconut oil from the Philippines to N.W. Europe is about \$60/ton.

Table IV-D1: COCONUT OIL -- GROSS EXPORTS BY MAIN COUNTRIES AND ECONOMIC REGIONS

Countries/ Economies	Actual 1961	1970	1975	1980	Growth Rates /a 1961-80	1970-80
	--------('000 tons)---------				---(% per annum)---	
Industrial	44	57	212	59	6.4	0.2
EC-10	35	50	192	40	5.9	-0.8
Netherlands	30	52	67	19	0.6	0.1
Germany, F.R.	3	12	115	10	24.2	-4.6
Centrally Planned	3	0	-	-	-10.7	-
Developing	297	559	830	1,152	7.0	8.3
Asia	241	487	760	1,060	7.5	9.0
Philippines	74	338	614	918	11.4	11.6
Sri Lanka	93	58	54	3	-10.8	-17.5
Malaysia	46	47	38	63	1.8	1.7
Singapore	27	38	26	35	3.5	1.5
Oceania	45	51	55	67	3.1	3.7
Papua New Guinea	21	22	27	28	1.8	1.9
World	344	617	1,043	1,211	7.0	7.6

/a Least squares trend for historical periods (1961-80).

Sources: FAO, Trade Yearbook tapes.

Table IV-D2: COCONUT OIL -- GROSS IMPORTS BY MAIN COUNTRIES AND ECONOMIC REGIONS

Countries/ Economies	Actual 1961	1970	1975	1980	Growth Rates /a 1961-80	1970-80
	--------('000 tons)---------				---(% per annum)---	
Industrial	232	446	734	866	7.5	8.0
N. America	100	282	435	422	7.4	6.7
United States	74	260	409	401	8.2	7.1
Canada	26	21	26	20	1.0	0.0
EC-10	116	148	252	377	7.6	8.8
Germany, F.R.	37	32	36	156	6.0	15.2
United Kingdom	40	48	38	46	1.7	1.6
Netherlands	1	8	64	56	31.4	12.9
Italy	28	20	32	41	4.5	9.2
France	1	19	47	43	21.4	8.6
Centrally Planned	27	37	46	88	4.4	8.9
USSR	3	23	20	79	11.0	20.0
Developing	82	109	173	188	6.7	7.1
Asia	53	58	79	107	6.0	8.4
China	15	21	41	33	5.1	0.2
Africa	20	29	24	26	1.7	-2.8
America	7	19	40	33	11.9	6.4
World	341	593	953	1,142	7.1	7.9

/a Least squares trend for historical periods (1961-80).

Sources: FAO, Trade Yearbook tapes.

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V. MARKETING AND MARKET PRICES

A. Marketing

Like most smallholder crops produced in developing countries the internal marketing of coconut products is conducted through a relatively long marketing chain. It is estimated that more than 90 percent of all copra in the Philippines is sold directly to village buyers, while the rest is sold to town buyers. Most of these buyers are purchasing agents of bigger processors, middlemen and/or exporters. The longer the marketing chain between the producer and the exporter, the smaller the proportion of the world price that can be expected to be received by the producer.

Other problems encountered include lack of a proper grading system, storage facilities and inadequate transportation facilities. Copra buyers normally pay producers on the "buen corriente" basis. This means that the price paid for the copra does not take account of the quality of the product sold as all producers receive practically the same price. This system does not encourage producers to produce better quality copra.

The fact that most producers do not have storage facilities tends to weaken their bargaining position as they will have to move their copra quickly to prevent deterioration. The lack of adequate transportation facilities increases marketing costs and may lead to multiple handling of copra by a large number of middlemen.

The complexity of buyer-seller relationships, involving in some cases the advancing of goods rather than cash, makes it difficult to analyze the operation of market forces in this sector of the economy. However, farm prices on the average are correlated with export prices. In the Philippines the average price received by the coconut farmer is estimated to be about 70 percent of the average export price.

A law passed in the Philippines in 1955 requires the use of moisture meters to determine the moisture content of copra for every first domestic purchase of copra. A moisture content lower (higher) than 5 percent would result in a corresponding premium (discount). It was hoped that the level of prices received by farmers would rise and that the quality of the copra would improve. However, its use has apparently not been enforced.

B. Market Prices

The coconut oil or lauric oil market is typical of many primary commodity markets in that supply originates almost entirely in developing countries and exports mainly go to industrial countries.

While it is frequently alleged that coconut and coconut oil prices are principally determined in the US and Western European markets, with the Philippine market exerting a secondary effect, the market is said to be fairly well balanced in the sense of having approximately the same numbers of large buyers and sellers and this would ensure that prices are set fairly competitively. 1/

The market prices which are most often cited include those of (1) the Philippines, (2) the US-Pacific Coast, (3) US-New York, (4) Sri Lanka and (5) Rotterdam. Table V-B1 provides coconut oil prices in the US-Pacific Coast and Rotterdam, unit export value, as well as prices of copra and copra meal.

A related aspect of the market structure for coconut or lauric oil is the degree of substitution which exists between lauric oil and other fats and

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1/ However, the Philippines has recently taken certain measures to support prices. In an attempt to raise coconut oil prices the Philippine government on September 2, 1982 placed a limitation on exports of coconut oil by limiting coconut oil exports to only four firms and, 12 days later, suspended all exports of copra. The suspension was ordered on the recommendation of the Philippine Coconut Authority (PCA) following an earlier report that copra exports in the first eight months of 1982 were more than triple the level in 1981 and that coconut production for the year would be down by 4.6 percent. Thus the suspension was justified as a means to ensure sufficient copra supplies to local coconut oil mills.

Table V-B1: PRICES OF COCONUT PRODUCTS

	Copra		Coconut Oil			Copra Meal	
	N. W. Europe /a	Unit Export Value /b	U.S /c	Rotterdam /d	Unit Export Value /b	Hamburg /e	Unit Export Value /b
	($/ton)						
1955	187		320	259		84	
1956	182		313	265		80	
1957	179		313	275		70	
1958	206		322	312		72	
1959	249		403	378		89	
1960	207		315	312		88	
1961	170	141	254	254	227	71	43
1962	166	143	238	251	219	77	59
1963	186	157	260	286	255	77	64
1964	194	164	287	297	277	76	50
1965	227	189	329	348	305	96	55
1966	185	162	269	324	258	103	61
1967	204	160	297	328	260	98	44
1968	232	196	369	399	311	94	41
1969	202	168	300	361	268	90	35
1970	225	185	359	397	302	91	47
1971	189	167	300	371	280	81	53
1972	141	118	215	234	194	91	49
1973	353	210	517	513	350	153	80
1974	662	508	1,119	998	906	118	103
1975	256	237	442	394	400	145	97
1976	275	183	447	418	352	155	98
1977	402	312	613	578	539	178	122
1978	470	368	752	683	615	176	118
1979	673	549	1,052	985	922	214	146
1980	454	426	701	674	643	214	137
1981	379	304	578	570	528	194	127
1982	314		465	464		182	

/a Philippines/Indonesia Bulk, c.i.f. N.W., Europe.
/b Developing Countries' Export Unit Value.
/c Philippines, Crude in tanks, Pacific Coast.
/d Philippines/Indonesia, Bulk, c.i.f. Rotterdam.
/e 26% Philippines, c.i.f. Hamburg.

Sources: Oil World, UNCTAD, USDA.

oils. One useful way of describing the substitution process is to classify substitution as being economic or technical. Economic substitution implies that a fall in price of one oil induces greater use of that oil relative to other oils. Thus, the consumption of lauric oil is likely to decline as the price differential between lauric oil and other oils widens in favor of the latter. While the adjustment of a firm or processor to such a differential may not be instantaneous, some reaction is to be expected if the differential is sustained. Whether or not the adjustment remains permanent depends on the nature of the technical substitution process which can take place. Technical substitution occurs when developments in technology permit or make preferable the use of one oil rather than another and this substitution generally implies a more permanent adjustment to a sustained price differential.

Results of earlier price analysis of lauric oil and other competing oils did not indicate clear substitution patterns. 1/ The pattern has become clearer over time as the disparities between market prices of different vegetable oils have trended downwards, following general improvements in oil-refining techniques. This development can be seen by comparing the correlation coefficients of different pairs of fats and oils between two time periods. Correlation coefficients calculated on the basis of annual data for the periods 1950-65 and 1966-67 are given in Table V-B2. There is a marked increase in the simple price correlation between the two periods, thus confirming that technical substitution between oils has increased over time with improvements in refining technology. Over time, the price of coconut oil, a premium oil, has steadily fallen in relation to the other major competing oils such as soybean and palm oil.

Tables V-B2 to V-B5 indicate that there is generally a close relationship between the international market prices of coconut products and the export unit values of these products in the main exporting countries.

1/ W.C. Labys, "An Econometric Model of the International Lauric Oils Market: Considerations for Policy Analysis," UNCTAD, July 1971.

Table V-B2: CORRELATION MATRIX OF PRICES OF SELECTED VEGETABLE OILS FOR 1950-65 AND 1966-76

Oils	Groundnut		Coconut		Palm Kernel		Linseed		Castor		Soybean		Sunflowerseed	
	50-65	66-76	50-65	66-76	50-65	66-76	50-65	66-76	50-65 /a	66-76	50-65	66-76	50-65	66-76
Palm	0.65	0.97	0.14	0.87	0.37	0.92	0.75	0.98	-	0.71	0.47	0.99	0.60	0.98
Groundnut			0.09	0.79	0.21	0.85	0.63	0.95	-	0.68	0.75	0.97	0.76	0.99
Coconut					0.89	0.99	-0.15	0.89	-	0.49	-0.09	0.87	-0.24	0.83
Palm Kernel							0.03	0.93	-	0.60	0.06	0.92	-0.32	0.89
Linseed										0.71	0.51	0.98	0.68	0.97
Castor /a											-	0.68	-	0.67
Soyabean													0.96	0.99

/a Data not available for this period.

Source: GATT Secretariat.

Table V-B3: REGRESSION RESULTS BETWEEN EXPORT UNIT VALUES OF COPRA IN SELECTED COUNTRIES AND INTERNATIONAL MARKET PRICES OF COPRA, /a 1961-81.

Country	Constant (a)	Coefficient (b)	R^2
Comoros	62.11 (1.45)	0.68 (5.20)	0.59
Cook Island	33.93 (0.63)	0.76 (4.62)	0.53
Dominican Rep.	171.02 (9.11)	0.25 (4.42)	0.51
Nigeria	111.40 (4.83)	0.35 (4.95)	0.56
Niue	38.37 (0.94)	0.69 (5.58)	0.62
Philippines	97.41 (1.94)	0.51 (3.32)	0.38
Seychelles	-5.22 (-0.06)	1.33 (5.11)	0.58
Sri Lanka	-34.94 (-0.36)	1.63 (5.53)	0.62
St. Vincent	99.59 (3.20)	0.46 (4.86)	0.55
Tanzania	-54.52 (-0.72)	1.15 (4.93)	0.56
Togo	-9.55 (-0.13)	1.26 (5.54)	0.62
Papua New Guinea	43.32 (1.16)	0.68 (5.74)	0.65

/a Philippines/Indonesia, bulk, CIF N.W. Europe.

Figures in parentheses are t-values.

Source: Calculated from FAO figures.

Table V-B4: REGRESSION RESULTS BETWEEN EXPORT UNIT VALUES OF COCONUT OIL IN SELECTED COUNTRIES AND INTERNATIONAL MARKET PRICES OF COCONUT OIL, /a 1961-81.

Country	Constant (a)	Coefficient (b)	R^2
Ivory Coast	-51.92 (-0.94)	1.01 (7.8)	0.79
Malaysia	-68.14 (-2.56)	1.07 (20.50)	0.96
Mozambique	-30.41 (-0.92)	0.92 (14.17)	0.91
Philippines	-55.43 (-2.95)	0.97 (26.30)	0.97
Papua New Guinea	-0.36 (-0.00)	0.91 (7.46)	0.75
Sri Lanka	-47.85 (-0.94)	1.06 (10.59)	0.86
Fiji	-62.06 (-4.20)	0.99 (34.23)	0.98

/a Philippines/Indonesia, bulk, CIF Rotterdam.

Figures in parentheses are t-values.

Source: Calculated from FAO figures.

Table V-B5: REGRESSION RESULTS BETWEEN EXPORT UNIT VALUES OF COPRA MEAL IN SELECTED COUNTRIES AND INTERNATIONAL MARKET PRICES OF COPRA MEAL, /a 1961-81.

Country	Constant (a)	Coefficient (b)	R^2
India	11.54 (1.25)	0.57 (7.83)	0.76
Ivory Coast	4.75 (0.60)	0.66 (10.53)	0.85
Kenya	27.64 (2.49)	0.46 (5.29)	0.60
Mozambique	39.06 (0.92)	1.53 (4.56)	0.52
Papua New Guinea	17.07 (1.67)	0.51 (6.25)	0.67
St. Lucia	8.08 (0.77)	0.55 (6.75)	0.71
Thailand	17.78 (2.08)	0.43 (6.45)	0.69

/a 26%, Philippines, CIF Hamburg.

Figures in parentheses are t-values.

Source: Calculated from FAO figures.

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VI. SPECIAL ISSUES

Barriers to Trade and Protection 1/

A. Tariffs

In contrast to imports of copra which are permitted duty-free entry, most industrial countries impose import duties on coconut oil. Table VI-A1 sets out the effective mfn (most favored nation) tariffs on crude and refined coconut oil on January 1, 1980 for the EC, the US, Japan, Australia and Canada. Where GSP (Generalized Scheme of Preferences) rates have been established for developing countries, the rates as of January 1, 1980 are listed. In general, the GATT negotiations held under the Tokyo Round (1973-79) and incorporated in the 1979 Geneva Protocol to GATT do not show significant concessions in respect of coconut oil, except in the case of the US for which the 1979 duty of 1¢/lb on imports of coconut oil, crude or refined, was reduced to 0.2¢/lb for 1980, and to nil for 1981.

The heaviest duties are those imposed by the EC, where the ad valorem rates on crude oil for technical uses (other than the manufacture of food-stuffs) are 5 percent and 8 percent, respectively, although the respective rates are reduced to 2.5 percent and 6.5 percent under the GSP. In the case of edible or food use, the duty on crude oil is 10 percent and 15 percent on "other than crude," or 7 percent and 13 percent, respectively, under the GSP. Since all primary producing exporters are developing countries, the rates under the GSP rather than the general tariff are the relevant ones.

Under the provisions of the Lome Convention, imports of most products from the ACP (Asian, Caribbean, and Pacific) countries are admitted into the EC free of duty. About sixty ACP countries enjoy the duty-free status, but so

1/ This section borrows extensively from J.J. McNerney (1981)

Table VI-A1: IMPORT DUTIES ON COCONUT OIL ON FIRST JANUARY 1980

European Economic Community	Common Customs Tariff	G.S.P. Rate
	------(%)------	
Coconut Oil		
1507D. 1. Intended for technical or industrial purposes other than the manufacture of foodstuffs:		
(a) Crude	5	2.5
(b) Other	8	6.5
II. Other		
(1) Solid in immediate packings of a net capacity of 1 kg or less:	20	18
(2) Solid, other; fluid:		
aa) Crude	10	7
bb) Other	15	13

Note: Under the terms of the Lome Convention imports of coconut oil from ACP (African Pacific and Caribbean) countries are admitted into the Community free of duty.

United States	Most Favored Nation (m.f.n)
	(¢/1b)
176.17 Coconut oil, crude or refined	0.2

Note: The duty on coconut oil is reduced to nil effective January, 1981. Prior to 1980 it was 1¢/1b. There is no GSP rate.

Japan	Most Favored Nation (m.f.n) (per cent or yen/kg)
ex. 15.07 fixed vegetable oils, fluid or solid, crude, refined or purified. Coconut oil	.10 per cent or 10 yen/kg whichever is the greater.

Note: Under the Tokyo Round the m.f.n. duty is to be reduced in eight equal stages, commencing 1st January 1950, to 9 percent, or 10 yen per kg, whichever is the greater. The duty quoted in that on 31st Dec. 1979.

Australia	Most Favored Nation (m.f.n)
424.30 Other fixed vegetable oils, fluid, or solid, crude, refined or purified: coconut (copra) oil	Free

Canada	Most Favored Nation	British Preferential Tariff & General Preferential Tariff (G.P.T).
27711-1-27716-1 Vegetable oils, crude or crude degummed, including coconut oil	10	Free
27731-1 Coconut oil, other than crude or crude degummed	17 1/2	12 1/2

Source: J.J. McNerney (1981).

far as coconut oil exports are concerned the main beneficiaries are Papua New Guinea and Fiji, as well as other Pacific island states intending to establish copra crushing plants in the near future. The ACP concession on processed oils of 13 percent is clearly an important one but it is of greater potential than real value since the "processing" of oil exported from Papua New Guinea and Fiji has apparently added little value to it.

B. Non-tariffs:

There are no major non-tariff barriers to the trade in crude and refined coconut oil. No quantative restrictions to the import of coconut oil are applied by any of the major industrial country importers. However, many countries have health and sanitary regulations. In the U.S., for example, a number of complex regulations on the labelling of products require disclosure of coconut oil usage. In the various member states of the EC there are different rules on the use of coconut oil in ice-cream and chocolate products. For example, chocolate containing coconut oil can be described as "chocolate" in the UK but not in West Germany or France.

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