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SUMMARY

COCONUT PROCESSING FOR THE PRODUCTION OF COCONUT OIL AND COCONUT PROTEIN FOOD AND FEED PRODUCTS 1/

by

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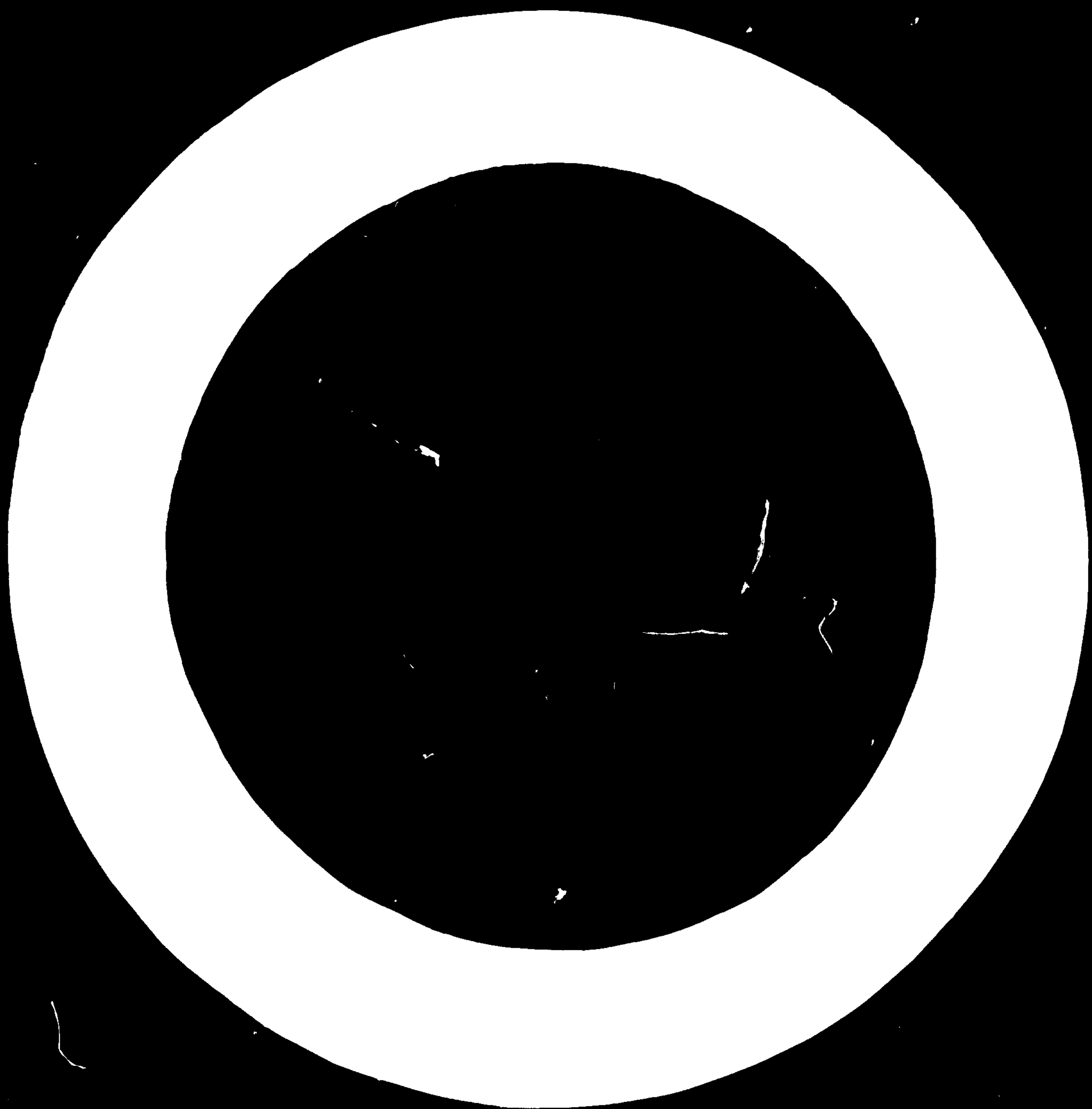

The importance of the coconut varies from country to country, but in most parts of the world it plays an important part in the life of the people, providing food, shelter and fuel, as well as a cash income. Traditionally, coconut oil has two distinct areas of usage, edible and technical. Recent shortages of coconut oil, due mainly to typhoons and drought in the main producing countries, have meant that in many food applications compounded fats have replaced the oil in a number of applications. In technical applications, coconut oil appears to be currently holding its own. Long term prospects are dominated by developments in the Philippines, the world's largest producer.

Copra Production (Chapter II) can be conveniently divided into harvesting, seasoning, husking and shelling, the drying of the coconut meat to afford copra, and copra storage. Essentially, the coconut industry is labour intensive. Harvesting the nuts is carried out either by allowing the nuts to fall, or by reaping, and no efficient machine has yet been invented for husking and shelling the nuts. Methods of preparing good quality copra are well known and documented, yet due to the problems associated with small scale processing, much of the copra produced is of high moisture content, attacked by moulds and insects. No planter will produce a good quality copra or attempt to improve his quality merely for the pleasure of doing so. The introduction of standards, coupled with a price incentive between the various grades, must be considered a first priority in a programme of improvement.

Copra milling and refining are outlined in Chapters III and IV. The importance of preparation and pretreatment, i.e. drying if the moisture content is too [illegible], [illegible], crushing and cooking in all cases. [illegible] conditions must be considered [illegible] ored, and the importance of maintenance [illegible] overlooked. Solvent extraction of copra cake may be carried out either batchwise or continuously. The principles of oil refining, i.e. cleaning, neutralising, distillative deacidification, bleaching and deodourising are discussed.

The properties and utilisation of coconut oil are outlined in Chapter V. While the main properties of an oil will depend on its fatty acid composition, its behaviour in detail, particularly its melting and solidification behaviour, will depend on which fatty acids are combined in the mixed triglycerides, and how they are distributed within the molecule. Coconut oil is used as an edible oil as a cooking oil, in margarine manufacture, in the production of compound cooking fats and various other minor applications. As a technical oil, its main uses are soaps and detergents, but large quantities are also used in cosmetics and pharmaceutical applications.

Copra cake and meal are discussed in Chapter VI. Copra cake is a very valuable animal feed, especially for dairy cattle.

Fresh coconut processes are outlined in Chapter VII. The traditional method of processing coconut through the intermediate copra stage often results in oil of poor quality and copra cake unsuitable for human consumption. A 'wet' process, whereby starting from fresh coconuts, an edible oil and protein can be obtained is obviously attractive. Unfortunately, up to now, no 'wet' process has been successful due for various reasons, e.g. poor siting of plant, in areas where the supply of coconuts is inadequate, lack of basic information on the chemistry of the process, or unfavourable economics. The various processes to date are outlined and discussed briefly.

The production of low-cost protein foods from fresh coconut are discussed in the next chapter. The need for a bottled coconut milk is emphasised and a number of coconut food products discussed. Nutritional and chemical aspects of coconut protein briefly mentioned.

The paper concludes with two chapters devoted to economic aspects of coconut processing, and the market for copra and coconut oil respectively.

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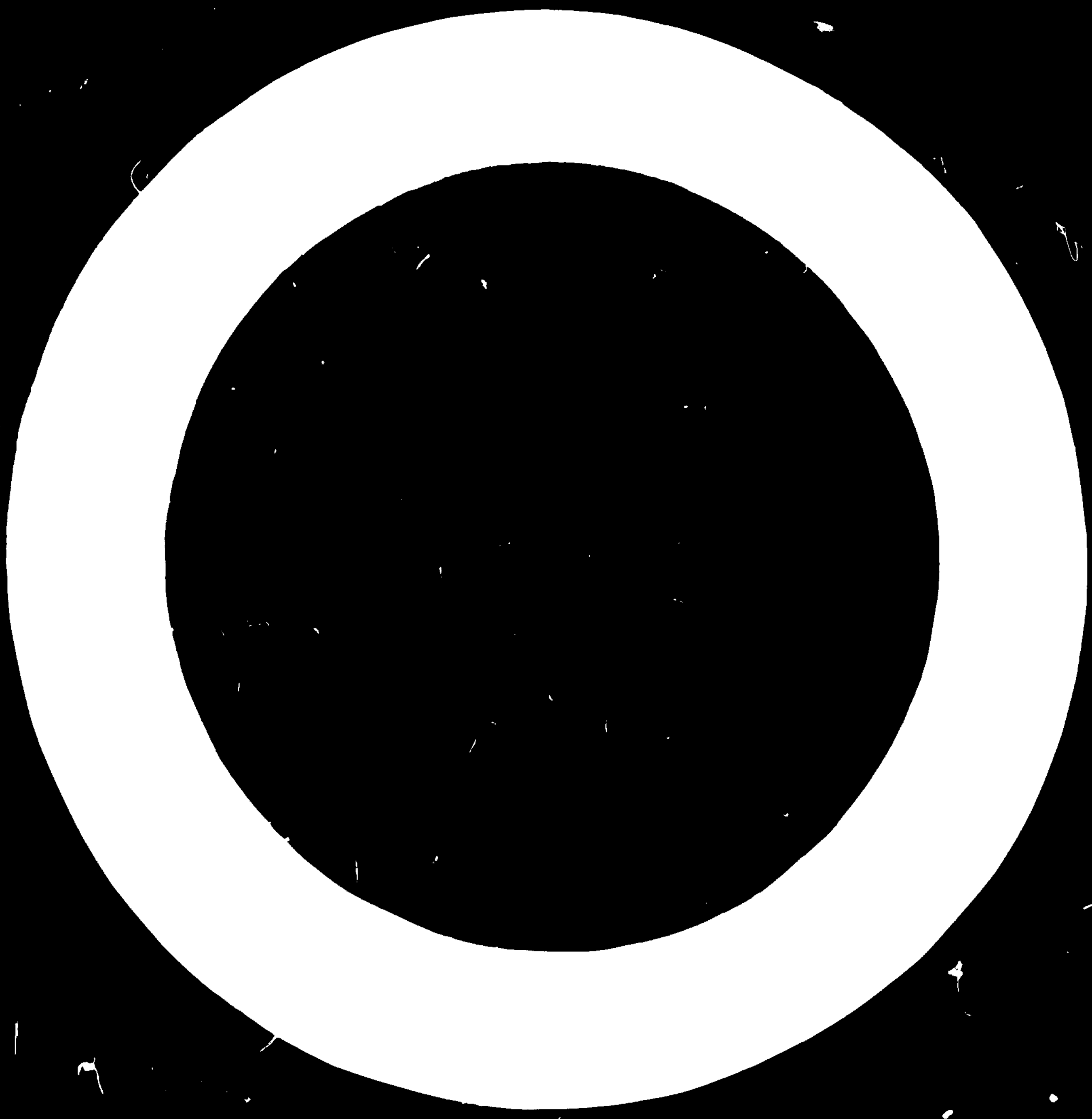

SUMMARY OF CONTENTS

NB Tables and Flowsheets are placed at the end of the chapters to which they refer.

CHAPTER I

INTRODUCTION

Cultivation of the coconut palm (<u>Cocos nucifera L.</u>) is mainly restricted to a relatively narrow belt within the tropics, between approximately Latitudes 20°N and 20°S of the Equator. It grows best on alluvial soils under conditions of high temperatures and sunshine combined with high rainfall. Thus, it is usually found growing on islands and other coastal regions, although, provided conditions are favourable, it will grow well many miles inland from the sea. It is by far the most widely distributed of all the palms, and by far the most useful to man.

In most of the countries where it is grown, the coconut plays a very important part in the life of the people. It is traditionally a smallholders' crop, and provides not only a cash income for the farmer, but also many of the basic necessities of life such as food, shelter and fuel. Its multitude of uses has resulted in the palm being described by phrases such as the "Tree of Heaven" and "King of the Tropical Flora".

The chief commercial products obtained from the fruit of the palm are copra, the dried kernel, and coconut oil and cake, obtained when copra is milled. Desiccated coconut, the dried disintegrated kernel, is produced in some parts of the world. Coir fibre (from the husk), coconut shell charcoal, coconut shell flour and fresh coconuts themselves also enter international trade, but the quantities are relatively small.

The importance of the coconut to the wealth of the country in terms of overseas trade varies greatly from country to country. In certain islands of the Pacific, for example, Tonga, the value of exports of coconut products relative to total exports is near 50%, while in the Philippines, the world's largest producer, the figure is about 25%. Indonesia, on the other hand, the world's second largest producer, derives only about 3% of its export income from coconut. Papua and New Guinea rely upon copra and coconut oil for a substantial part of their export earnings (about 40%), while in Ceylon and Fiji, these products, although important, are a considerably smaller part of the total exports.

The estimated production of coconut in the principal producing countries and areas is shown in Table I/1 and it will be seen from this table that production of coconuts in many countries has remained static over the past few years. There are a number of reasons for this, including palm senility, diseases, and adverse weather conditions. But while the production of coconuts has remained constant, the internal consumption of coconuts in the countries of origin has risen, due to the increase of population, leaving fewer nuts available for industrialisation. The coconut is a traditional food practically everywhere it is grown, the quantity consumed locally varying enormously from country to country. In Thailand, and parts of Indonesia (Java), for example, it is estimated that over 90% of the coconuts produced are consumed in the home, either as water nuts or incorporated into various food dishes, while in India the figure is nearer 57% and in Ceylon 55%. In the Philippines, on the other hand, it has been estimated that less than 2% of the production is consumed locally.

Unfortunately many coconut growing areas are prone to hurricanes and drought. In particular, the Philippines, the largest producer, is often affected in this way, resulting in a world shortage of coconut oil at certain times: the price of coconut oil on world markets then rises considerably compared with other oils. While this results in increased prices for the smaller producing countries unaffected by the catastrophe, the overall result of such shortages can be, in certain cases, substitution of coconut oil by fats compounded from cheaper materials.

This trend is particularly marked in food products, where compounded fats have replaced coconut oil in a number of applications. For non-food uses, coconut oil is still holding its own, although here the main threat is from substitution by synthetics. Synthetic fatty acids are already produced, in, for example, Russia and the United States, but so far inroads into the natural oil market, in the West at least, have been small. This is partly due to price and partly to quality, odour problems occurring, for example, when poor quality synthetic fatty acids are utilized in high quality toilet soap.

Should coconut oil rise in price above the highs of 1967/68, intensive research on methods of producing better quality products are likely to be carried out, leading to large-scale synthesis of fatty acids from petroleum-based materials. If this happens, it is probable that many markets presently held by coconut oil will be lost for ever. However, long term prospects are dominated by prospective developments in the Philippines. Provided no natural catastrophe occurs a substantial increase in the quantity of coconut oil produced can be expected, due to the large acreage of palms that have been planted in recent years. Increases in production in other countries can also be expected.

Thus, at a time when the demand for coconut oil is being threatened by competition from other oil sources, and to a certain extent by synthetics, the effect is likely to be lower prices for copra and coconut oil. In the new situation, buyers will be confronted with a greater choice of copra and coconut oil than before and are likely to show a preference for a high quality product. Good quality copra should, therefore, be the aim of governments who wish to continue in a share of the world market for copra and coconut oil.

In order to obtain the return from coconut plantings, it is important that full use be made of the by-products obtained in copra manufacture, such as coconut shells and coconut fibre. The advantages of centralised processing plants, which properly managed will consistently produce a top quality product, and will, in addition, support other small industries based on coconut by-products, cannot be over-emphasised.

TABLE I/1

Estimated Production of Coconut and Copra in the Principal Producing Countries and Area. (Coconuts in million nuts; copra in 100 metric tons.) (See also Table X/1)

Country and Area	1965	1966	1967	1968	1969	1970
Philippines -						
Coconut	7,090	7,925	7,412	7,849	8,000F	
Copra	14,473	16,072	13,526	12,900	12,550	13,500F
Indonesia						
Coconut	5,593*	5,117*	4,950*	5,121*	5,805*	
Copra	4,856	5,283	4,959	6,290	6,600	6,600
India						
Coconut	4,999	5,192	5,231	5,438	5,440F	
Copra	2,660	2,700	2,843*	2,740*	2,794*	2,800*
Ceylon						
Coconut	2,460	2,244	2,416	2,601	2,700F	
Copra	2,650	2,120	1,908	1,935	2,100*	2,100F
W Malaysia						
Coconut	717*	737*	770*	815*	742*	
Copra	1,260	1,300	1,380	1,460	1,310	1,400F
ASIA and Far East						
Total Coconut	23,482	22,850	22,400	22,468	24,377	
Total Copra	26,908	28,448	25,248	26,224	26,313	27,358
Mexico						
Coconut	792*	798*	778*	809*	791*	
Copra	1,685	1,700	1,702	1,720	1,730	1,730F
LATIN AMERICA						
Total Coconut	2,603	2,257	2,327	2,241	2,197	
Total Copra	2,386	2,386	2,425	2,466	2,441	2,400
AFRICA						
Total Coconut	1,289	1,307	1,397	1,394	1,438	
Total Copra	926	962	1,100	1,118	1,170	1,172
OCEANIA						
Total Coconut	1,671	1,619	1,628	1,737	1,753	
Total Copra	2,782	2,705	2,710	2,926	3,041	3,017
WORLD TOTAL						
Coconut	27,545	28,033	27,752	28,840	29,765	
Copra	33,002	34,501	31,478	32,734	32,965	33,947

NB Some of these figures are based on FAO estimates (F) and unofficial figures (*). Basically from FAO Production yearbook 1970.

CHAPTER II

COPRA PRODUCTION

HARVESTING

The method of harvesting may depend on local tradition, climate, variety of coconut and, sometimes, the method of further processing to be used. In Ceylon for example, the common tall variety of coconut does not usually drop its fruits when ripe, and hence the nuts have to be cut down. In Papua and New Guinea, the nuts fall naturally and this is usually allowed to happen. Dwarf varieties have definite advantages in harvesting. Although after, say, 20 years dwarf varieties can grow as high as ten meters, they will never attain the height of the tall varieties which have been known to reach heights of 30 meters. Obviously with the tall varieties the older the tree becomes, the more difficult harvesting becomes also.

Essentially harvesting can be divided into two methods; (i) free fall and (ii) picking from the tree.

(i) __Free fall__

This method of harvesting has both advantages and disadvantages. Advantages include the cheapness of the method and the high probability that the nuts falling from the tree are fully mature. However, it suffers from many disadvantages, including losses on the ground both through difficulties in detection in thick weeds and to germination. Also some nuts will be damaged when they fall. In addition mature nuts will often not fall from the tree, cases being known where nuts have actually germinated on the tree.

(ii) __Picked harvest__

The manual climbing of trees has many disadvantages. Besides being extremely dangerous, especially when the stem is wet and slippery, climbing the tree is very exhausting and the number of palms a man can manage each day is relatively few, possibly not more than 8 or so. A number of methods of climbing palms have been devised and these vary from region to region. Most use some form of harness with which the climber can go up and down the plam trunk. In some places notches are cut in the stems but this practice is not recommended since the cuts can be sources of infection. In very primitive areas fronds are tied around the trunk and used as a ladder.

However, tree climbing does have one major advantage in that the climber has the opportunity to inspect the crown of the palm, that is to remove moss, lichen, dead leaves and to search for beetles and pests - measures which are necessary to ensure the highest output of nuts.

In some regions, in particular of Thailand, Malaysia and Indonesia, trained monkeys - for example *Pithecus nemestrinus* - are used for harvesting. It is difficult to see any advantage in this method however. Selection of the best nuts and inspection of the crown are impossible, the monkey working on the signals and orders of its owner at the end of a long rope. (In addition, the method means that two mouths have to be fed instead of one!)

The more general method of harvesting coconuts is by reaping the mature bunches with the aid of a knife on the end of a long bamboo pole (up to 18m). Usually the nuts are harvested by this method every other month to economise on labour costs. This means that some immature nuts will be picked and will need storing before conversion to copra. Immature nuts produce a "rubbery" copra which is difficult to mill and has a lower oil content.

In a well laid out plantation the introduction of mechanised harvesting is a possibility. An hydraulic lift towed by a tractor can be used, this having the advantage that the harvester can also get quite close to the crown of the tree for inspection. A combination of an hydraulic lift with a simple collection device such as a shute delivering the nuts to a trailer is possible. An extension of current harvesting methods is the use of a telescopic aluminium pole or ladder mounted on wheels which would be much easier to handle than long poles.

Electric shock and hormone treatments, to induce nut fall, have been suggested, but with no useful outcome to date.

SEASONING

In some parts of the world it is usual to store the harvested nuts before they are processed. This is usually done by placing the nuts in heaps covered by palm fronds for two to four weeks. The advantages of this procedure are:

(i) The moisture content of the endosperm will decrease slightly.

(ii) The oil content will increase.

(iii) Husking is made easier, green unseasoned coconuts being difficult to husk.

(iv) Shelling is cleaner and easier since the endosperm tends to shrink away from the shell.

(v) The resulting shells are dry, hard and husk free and produce a better fuel which burns continuously and produces little smoke when utilized for copra drying.

(vi) A more uniform quality copra may be expected in view of a standardised drying procedure.

(vii) A more regular scheme of drying, irrespective of crop fluctuations will result.

However, it must be emphasized that where the nuts fall from the tree and are already mature, seasoning will only produce additional problems - for example, germination.

HUSKING AND SHELLING

In practically all coconut-producing areas the husk is removed by hand by impaling the nut on a sharp iron or wooden spike fixed to the ground. Attempts have been made to mechanise this process but none has been completely successful, the machines being unable to compete satisfactorily with human labour. In Ceylon, for example, it is possible for a dehusker to handle over 2,000 nuts in a working day.

The husked nut is usually split open with an axe. It is best to break the nut open over a concrete floor sloping to one side of centre from which a drain carries the coconut water to some convenient disposal point. It is important to realise the dangers of contamination from coconut water, particularly when close to rice paddy: water from the splitting area should be drained into fermentation tanks and treated as sewage before discharge into rivers.

In some regions husking is not carried out; the nut is merely split into two with an axe and either the meat is removed with a knife or the half nuts are semi-dried before removal of the meat.

It is likely that there will be attempts in the future to mechanise the husking and shelling processes for coconuts. As wages rise, mechanisation of these steps in certain parts of the world is almost inevitable. Mechanisation is particularly desirable when producing desiccated coconut and other food products in view of the dangers arising from contamination of such products with Salmonella spp.

COPRA

The term copra describes the meat (endosperm) of the coconut dried to a moisture content of about 6 per cent.

It may be devided into three main categories, ball copra, edible copra and commercial copra. Edible copra is copra prepared under specially controlled conditions and shows no sign of discolouration or mould attack. It is usually prepared in hot air dryers. Ball copra, which may be classified as a special type of edible copra, is prepared by allowing coconuts to dry out in shell very slowly, often in the attics of houses. After about a year, removal of the shell is usually a simple task since the meat has shrunk away during the drying period. The international market for edible copras is small.

Commercial copra may be defined as that which is milled to produce oil and cake. There are no international standards for copra quality, although a number of attempts have been made to produce these in the past. A typical definition of various grades of copra are given in Table II/1.

TABLE II/1

DEFINITIONS OF SEVERAL GRADES OF COPRA*

Perfect Supergrade	Smooth, hard, clean, snow white, free from all extraneous and defective matter.
High Grade	Smooth, hard, clean, pale grey to dull white with no discoloured or bad pieces.
FMS made on improved kilns or on estates	Commercially white, dry copra containing between 5 and 50 per cent of somewhat smokey or slightly discoloured pieces
Mixed ordinary smoke dried	Under-dried copra of uncertain and irregular quality.
FM	A blend of dry mixed and dry low grade copra with no hard white pieces but much soft and rubbery copra.
Low grade	Under-dried copra consisting entirely of burned, discoloured, over-smoked, putrid, insect-ridden, rubbery and/or soft glutenous pieces, with much torn and broken material.

Grading is usually carried out on the basis of moisture content, good quality copra with a moisture content of 6% or less being a relatively stable commodity, less attacked by insects and micro-organisms. However, it is important to realize that ther are other factors affecting the quality of copra other than too high a moisture content Thus "rubbery" copra will be produced if immature nuts are used, resulting in difficulties during milling and ready attack by insects. If the initial drying temperature is too high "case-hardening" can occur causing a crust which prevents the remaining moisture from escaping readily. Over-heating during the final stages of drying will cause charring of the copra to occur. Careful attention must be paid during the design of a kiln to ensure that correct and uniform drying rates are achieved.

There are undoubted advantages in producing a good quality copra. Only a good quality copra will produce an edible oil without refining. Traditionally, coconut oil has two main uses; edible and non-edible. However, while good quality copra can be used for the production of oil for both edible and non-edible end uses, poor quality copra can only be used for edible purposes after incurring heavy refining losses. Thus coconut oil with a low free fatty acid content should always be of more value than oil with a high free fatty acid content. Furthermore, the nutritional value of the residual copra

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*"Copra Processing in Rural Industries", FAO Agricultural Development Paper No 63, p106.

cake from high quality copra is undoubtedly superior for use in animal feed to that from poor quality copra.

Unfortunately, however, no planter of smallholder will produce a good quality copra or attempt to improve the quality of his copra unless there is an incentive for doing so. Only the introduction of standards, coupled with a price differential between the various grades, will produce any results in this direction: the need for government legislation, particularly through Copra Boards, is obvious.

The number of coconuts required to produce one metric ton if good quality copra will depend both on the variety and the environment. On the one extreme the San Ramon coconut of the Philippines produces large nuts approximately 3,500 of which are needed to produce one metric ton of copra. The Dwarf varieties, on the other hand, for example, Malayan Dwarf's in Jamaica require between 8,000 and 11,000 nuts to produce one metric ton of copra.

Methods of preparing good quality copra are well known and documented.

Basically there are four methods of drying copra: sun drying, smoke drying, kiln drying using a direct fired method, and kiln drying using modern forced air dryers. The importance of a minimum of delay between breaking open the coconut and applying heat, whichever method of drying is used, cannot be overemphasised.

(a) Sun Drying

Sun drying is still practised in many parts of the world, and providing long periods of sunshine are to be had and certain precautions are taken, this method can produce a good quality copra. However, often the copra produced is very variable in quality.

(b) Smoke Drying

Smoke drying, that is drying coconut meats in simple kilns using any material as fuel, results in copra of rather poor quality, and cannot be recommended.

(c) Kiln Drying

The majority of kilns in existence use the direct fired principle. Well known types such as the Malayan (Cooke), and the Ceylon Standard type kilns are reknowned throughout the world for their ability to produce an excellent quality copra, providing certain basic principles are followed.

(d) Modern Forced-Air Kilns

Commercially produced dryers, usually using oil fired heating, have been in existence for a number of years. They can produce first-class copra, usually within 24 hours. The main advantages of modern kiln drying are:

(i) reduced drying time,

(ii) low maintenance,

(iii) economic fuel consumption resulting from heat conservation, uniform air distribution, controlled temperature,

(iv) freedom from risk of fire leading to marked reduction in insurance premiums.

(v) Ease and simplicity of loading and unloading.

(vi) Minimised labour input.

(vii) Simplicity of operation by automation leading to reduced supervision.

(viii) Ability to utilize by-products, such as coconut shell and fibre, in subsidiary industries.

The main disadvantage of the method is the high initial capital outlay; higher running costs compared with more simple kilns, and possible difficulties in obtaining spares.

Obviously, modern kiln drying would only be economic where a continuous run is possible. This in turn, necessitates linking such drying equipment with a plantation or with production from a number of small farmers, for example, in a co-operative, so ensuring a constant supply of nuts.

COPRA STORAGE

Copra dried to a moisture content of 6 per cent or below will keep well in bulk provided certain basic requirements in warehouse design are met. The warehouse should be constructed so that all surface water will drain away from the building. It is most important to ensure that the floor is completely water-vapour proofed with bitumen emulsion or polyethylene sheeting incorporated as a "sandwich" during construction. The floor area should be unimpeded by pillars and the internal wall surfaces should be smooth to facilitate cleaning and insect control, the shell concrete type of construction being ideal. All ventilation should be closeable in order to facilitate insect control. Rodent proof doors are essential.

CHAPTER III

COPRA PROCESSING

PREPARATION AND PRETREATMENT

This section considers all treatments of the copra between delivery at the mill and extraction of the oil. These pretreatments include drying, cleaning, crushing and cooking.

(a) Drying

Mills prefer to buy copra at less than 6 per cent moisture and, if such is available on the market at an acceptable price, will not need to instal drying equipment. It is not always possible to buy dry copra and, further, more moist copra may be available at a lower price. The selection of a suitable dryer will depend on the size of the mill. Copra can be dried in small, locally built, dryers similar to those used for its manufacture. In-sack or in-bin dryers in which warm air is passed through the copra, can also be used. Cabinet dryers are less convenient as the copra has to be loaded on to the trays and off-loaded when dry. For large mills, continuous drying is desirable as, though capital cost is high, running costs are low. Three types of continuous dryer are in use: tunnel, tower and rotary. In each case the copra moves counter-current to a stream of warm air, generated either by fuel burners or by passing through a heat-exchanger.

(b) Cleaning

Cleaning consists of screening the copra to remove small particles such as sand, pieces of shell, etc. Magnets are used to remove pieces of iron and an aspirator can be used to separate large pieces of foreign matter. A full combined cleaning line will consist of screens, aspirators and magnet.

(c) Crushing

To obtain maximum oil extraction by either pressing or solvent extraction it is necessary to grind (crush) the copra. For this purpose the copra is first broken in an impact mill such as a hammer-mill or a copra cutter. After this pre-breaking the copra is crushed in either a system of rollers or, on a smaller scale, in hammer-mills or similar disintegrators set to produce a fine product. In roller milling the rolls are adjustable so that a differential speed produces slip between the rolls. Copra for expellers should be fine and of uniform size so that pressure distribution is even.

(d) Cooking

The crushed copra is heated on a flat surface with agitation until ready for expelling, which is often carried out at temperatures as high as 130°C. The cooker system is normally built on to the expeller and consists of from three to five kettles, steam-heated, with the copra feeding continuously downward into the expeller.

EXPELLER OPERATION

Choice of expeller has been discussed by Thieme*. Generally speaking, expelling equipment will nowadays be continuous and we shall not, therefore, discuss the operation of batch presses. Basically the expeller consists of a screw rotating in a cage. The copra is pressed continuously down the length of the cage against a choke, which can be adjusted.

The cage consists of flat steel bars set edgewise round the periphery of a cylindrical frame. Oil is expressed through slots between the bars. The screw applies the necessary pressure (up to 100 tons thrust) which may generate considerable heat removable by a cooling system. Various mechanisms are available for the choke. A balance must be made between through-put and oil yields; if the choke is screwed down, yield is increased at the expense of throughput. Achieving optimum economic working conditions will depend initially on availability of capital, and when this is short it may be advisable to run at maximum throughput with lower yield of oil. Doing this has a further advantage in that the moving parts wear much less rapidly under lower pressures. As understood above, a cooling system will be necessary for high pressure operations, adding further capital cost.

If the expeller is being used for pre-pressing before solvent extraction, a low efficiency is desirable, with the expeller cake containing around 10 per cent of oil.

When an expeller is being installed it is extremely important to have all controls and instruments placed at a convenient height for the operator's attention.

MAINTENANCE

This is, perhaps, the most overlooked and most important aspect of expeller operation. Maintenance should be considered even before expellers are purchased: in less developed countries the skilled labour for efficient maintenance of complex machinery may not be available, and choice of expeller must depend on ease of maintenance by the labour available. Training of labour must be arranged - preferably from the expeller manufacturer.

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*Thieme, "Coconut Oil Processing", FAO, Rome, 1968.

Preferably process operatives in charge of expellers should be mechanics with a sound basic knowledge of engineering. Lower efficiencies and other signs of wear will then be noted immediately and the necessary maintenance carried out. A programme of routine maintenance should be included in operating programmes and machinery manufacturers can advise on this. If labour is available, it is also worthwhile to inspect and maintain machinery shut down due to shortage of raw materials. Suitable lifting tackle must be installed over expellers so that the screw and cage may be removed to workshops for relining: sufficient space for screw withdrawal must be allowed for in the plant layout. A model where the screw can be removed without disturbing bearings is easy to maintain. The mill workshops store must have a comprehensive range of spare parts as it is cheaper in the longer term to spend capital on what may appear at first as unnecessary parts, than to face a major shutdown while awaiting delivery, possibly by air at high cost.

Manufacturers now emphasise ease of maintenance in their literature and it is advisable to study this critically in the light of the labour quality available. Wear and tear can be minimised by having built-in lubrication systems and self-adjusting glands.

If an instrument artificer is not available, the process operative must be taught the use and maintenance of the instruments and control systems.

SOLVENT EXTRACTION

Solvent extraction is used mainly on pre-pressed cake, which will contain perhaps 10 per cent of oil. The residual oil content can be brought to under 1 per cent with an efficient solvent extraction plant, and the oil cake obtained is of high grade, since no heat is used in the process. A further advantage, compared with expelling, is that the plant can be used for any oilseed without modification. However, certain features of the process have prevented its full adoption by developing countries.

For example, the scale of operation will generally be at least 25 tons of copra a day and, especially for continuous plants, the plant will be highly automated and capital- rather than labour-intensive. Such plants should be operated in areas where skilled labour can be made available, since mal-operation can lead to expensive solvent losses and can be dangerous - the solvents are either toxic, as in the case of trichloroethylene, or highly inflammable, as with hexane.

Many types of batch and of continuous extractors are now available. The former are based on the Soxhlet principle, solvent percolating through the copra until the desired proportion of oil has been removed. There is usually a continuous solvent recovery system. Continuous extractors work on the counter-current principle. Solvent remaining in the cake is usually steamed out, separated from the steam condensate, and returned to the solvent lines. For safety and economy of operation, all vessels and plant items must be vented through a refrigerated condenser to prevent solvent vapour escaping from the plant.

FEED FROM CAKE AND MEAL

Cake is usually obtained in the form of hard pieces from the expellers. Meal from solvent extraction plants will be in the form of flakes, since the pre-pressed copra will have been flaked to gain optimum solvent penetration. If cake or meal is to be transported, it is preferable to have it in as dense a form as possible. The utilisation of copra cake and meal is dealt with in Chapter VI.

CHAPTER IV

OIL REFINING*

Oil Cleaning

The raw oil flowing from expellers contains suspended matter and moisture. These impurities must be removed before refining the oil and it is customary to clean the oil at the expeller station. The clean, but unrefined, oil is often sold as such, under the name "processed oil".

Oil is pumped from the expeller receiver direct to a filter press in which the filter medium will generally be cloth-coated with a filter aid. Leaf filters can also be used. A pair of filter presses can provide effective continuous operation and, though requiring manual cleaning, are much cheaper in capital and energy use than continuous self-clearing centrifuges.

Neutralisation (alkali)

This is the most used method of removing free fatty acids from edible oils and fats. The acids are washed out of the oil with caustic soda lye, usually of around 10 to 15 per cent strength and a temperature of 60 to 70°C. Agitation should be for a short period - say 10 minutes - only, to prevent saponification of the oil. After separation of soap stock from oil (brining may be necessary to improve separation) the oil is washed, first with dilute alkali and then with water. The kettle for neutralisation should be of iron, not copper or brass. Heating is by steam coils. Such a plant is operated batchwise, but effectively continuous neutralising can be carried out by running twinned kettles alternatively.

For large, modern plants continuous neutralisation processes are used. Lye and oil are mixed continuously, heated in a heat-exchanger and then separated continuously in centrifuges. Oil losses are low since contact time with the alkali is minimal - enough to neutralise the fatty acids but not to saponify the oil. However, capital and running costs are high. Processes using soda ash cannot be recommended as there is a problem of CO_2 removal and of foaming.

Distillative De-acidification

It is possible to remove free fatty acid by distillation under very high vacuum, when relatively lower temperatures are required than would cause degradation of the oil. Unfortunately, the cost of the high vacuum equipment is very high, and the process will probably remain little used.

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*See also Thieme, "Coconut Oil Processing", FAO, Rome, 1968.

Bleaching

Neutralised oil is frequently yellow and, when the market requires a water white oil, a bleaching operation may be necessary. The washed oil is heated, sometimes under vacuum, to remove traces of water and then a mixture of bleaching earth and activated carbon is added. The quantity used will depend on the colour of the oil, but is generally of the order of [illegible] to 1 per cent. The ratio of earth to carbon is frequently 10 to 1. For any factory the manager will have to decide this ratio and the percentage of bleaching mixture used, depending on the colour of the oil, the cost of bleaching earth and activated carbon, and the cost of the oil loss, for it must be remembered that the earth has an oil retention of around 30 per cent, and carbon over 50 per cent. The oil is held at around 100°C for 1 hour under vacuum with agitation and is then pumped or blown under pressure through a filter press to remove the earth. The press should be steamed through and then separated tail runnings blended into a later batch. Where solvent extraction facilities are available, it is worthwhile to extract the spent bleaching earth.

Deodorizing

This is carried out by blowing live steam through the oil, which is heated to 300°C and is held under vacuum during the steaming. The kettle used for this operation should be not more than half full of oil, as the steam stripping causes considerable splashing. Vacuum should be produced by steam ejectors, a three-stage system giving the necessary 5 mm pressure. For steam stripping, around 200 kg steam per ton of oil will be required. Ejectors use many times this, depending on the size of the plant and the speed of evacuation desired.

Continuous deodorizing is much more economical provided that the scale of oil refining operations justifies the high capital cost. Capacities vary from 50 to 250 tons of oil a day. However, total steam usage is under 500 kg for 1 ton of oil.

Refinery By-Products

Soap stock from coconut oil refining finds a ready market for the manufacture of high quality soap, sometimes produced on the same site as the refined oil. By acidification of the soap stock, fatty acids are obtained which can enter commerce as such or be used for chemical manufacture.

The spent bleaching earth can partly be recycled to economise on fresh earth and carbon. The rest is generally thrown away, though care is needed in doing this to prevent environmental pollution.

CHAPTER V

PROPERTIES AND UTILIZATION OF COCONUT OIL

CHEMICAL COMPOSITION

All vegetable oils are mainly composed of fatty acids, in combination with glycerol, principally as tri-glycerides with minor proportions of mono- and di-glycerides. The glycerides are invariably mixed, that is, a mixture of one, two or three different fatty acids. Hydrolysis of the complex mixture of glycerides will afford a complex mixture of fatty acids and glycerol.

While the main properties of an oil will depend on its fatty acid composition, its behaviour in detail, particularly its melting and solidification behaviour, will depend on which fatty acids are combined in the mixed triglycerides, and how they are distributed within the molecule.

The proportions and structures of the glycerides give fats their individual properties. This is most important in the sharp melting of cocoa butter and coconut oil and in the crystal structure of lard. It is the sharp melting characteristic of coconut oil that makes it particularly useful for some food applications, for example, the preparation of biscuit creams.

The other main factor governing the uses of a particular oil is its fatty acid composition. Coconut oil, like its competitors palm-kernel oil and babassu oil, are termed lauric oils, because of the high percentage of lauric acid (C_{12}) they contain. It is also a highly saturated oil. The main technical uses of the oil are based on these two considerations.

The actual percentage fatty acid composition of coconut oil will depend on variety and environment. Table V/1 shows the fatty acid composition of coconut oil, and also the two similar oils, palm-kernel and babassu oils. The two figures shown for each fatty acid represent the lowest and highest values found from analysed samples.

CHEMICAL CHARACTERISTICS

Certain chemical tests are used to identify the character of a particular oil. The most important of these are:-

Acid Value

Defined as the number of mg of potassium hydroxide required to neutralise the free fatty acids in 1 g of oil. This value, depending on the free fatty acid content of the oil, is an important assessment of the quality of the oil, but is not characteristic of the type of oil.

Saponification Value

Defined as the number of mg of potassium hydroxide required to saponify 1 g of oil. The saponification value is a measure of the molecular weight of an oil, and hence an indication of its fatty acid composition. For coconut oil, the saponification value is usually within the range 250 - 264.

Iodine Value

Defined as the number of g of iodine that will react with 100g of oil under standard conditions. The iodine value thus measures the degree of unsaturation in an oil, and will show, for example, whether any particular oil is likely to oxidise readily or be suitable as a drying oil. For coconut oil, the iodine value is usually within the range 7.5 - 10.5.

Other useful characteristics include the Reichert-Meissl value defined as the number of ml of 0.1N aqueous alkali solution required to neutralize the water soluble fatty acids distilled from 5g of the oil under standard conditions, and the Polenske value, defined as the number of ml of 0.1N aqueous alkali solution required to neutralise the water insoluble fatty acids derived from 5 g of the oil under standard conditions. Both these tests are an indication of the amount of low chain volatile fatty acids that occur in some oils. For coconut oil, the Reichert-Meissl value is usually in the range 6 - 8, while the Polenske value is between 15 - 18.

Gas-liquid Chromotography

Gas-liquid chromotography (GLC) is now used to determine accurately the fatty acid composition of fats and oils. Thus, the above chemical tests should now be obsolete, although it is likely, due to the expense and elaborate nature of GLC apparatus, that the iodine value and saponification values will still be used as a guide in the purchas of raw materials and for the control of hydrogenation.

PHYSICAL CHARACTERISTICS*

A number of physical properties may be used to identify the characteristics of an oil. The most important are:-

(i) Refractive Index at a standard temperature.
The normal range for coconut oil is 1.448 - 1.450 at 40°C.

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*Kaufman and Thieme, Neuzeitliche Technologie der Fette und Fettproduck 1956, Part I, p17, Munster, Schendorff

(ii) Specific Gravity at a standard temperature.

The normal range for coconut oil is 0.907 - 0.913 at 40°C.

(iii) The Melting Point

The normal range for coconut oil is 20 - 28°C.

(iv) The Solidification Point

The normal range for coconut oil is 22 - 23°C.

USES OF COCONUT OIL

Food Uses

The tonnage of coconut oil utilized by the food industries of the world has, over the past two decades, gradually decreased. European countries which, unlike the United States, have to import most of their food oils, have traditionally utilized coconut oil in foods. However, in recent years, due to a number of factors, including the high price and uncertainty of supply situation of coconut oil, modern techniques allowing the compounding and blending of various hydrogenated, partially hydrogenated and natural fats to give a product with required characteristics, and the alleged association between saturated fatty acids and atherosclerosis, the amount of coconut oil used in food has declined rapidly.

Coconut oil is usually sold in metropolitan countries as refined oil.

Coconut Oil as a Cooking Oil

In the countries of origin, coconut oil, usually unrefined, is used widely for cooking, the user requiring the typical taste and odour of the crude oil. However, as consumer awareness becomes more sophisticated, it is likely that the need for refined coconut oil in these countries will gradually increase.

Unhydrogenated coconut oil has a high degree of stability against oxidation and is used for frying nuts and snacks where a long shelf-life is required. The short-chained fatty acids present also have a lower viscosity than other oils, feeling less greasy in the mouth.

However, coconut oil does have limitations as a cooking oil. On hydrolysis, highly flavoured short-chain acids are released. This is the reason for the so-called hydrolytic rancidity which causes the development of a disagreeable soapy flavour in the oil. While overall a good frying oil when used alone, for some unknown reason, blends of coconut oil with non-lauric oils foam badly when heated.

Margarines and Compound Cooking Fat

At one time, coconut oil was the major constituent in margarines and cooking fats, but, for reasons mentioned above, this application has decreased. Now, coconut oil is usually only incorporated into the cheaper margarines, used mainly for cooking. The more expensive table margarines are tending to contain more and more polyunsaturated fatty acids.

However, in view of the recent drop in price of coconut oil, it is likely that the amounts incorporated into the cheaper cooking fats will increase.

Filled Milks

Filled milks are prepared from milk solids from which the natural fat has been removed and replaced by a vegetable oil, usually coconut oil. The product costs about half that of cows' milk, and has better keeping qualities. However, the use of oils containing large quantities of saturated fats in such an application is viewed with concern in many quarters in view of the alleged association between saturated fatty acids and atherosclerosis. Moreover, it has been shown that cheaper vegetable oils, for example soya-bean oil, can also be used in such products with success.

Other food applications

Coconut oil has a number of other applications in food industries. In confectionery, it is used as a cocoa butter substitute and as a lubricant in various confections such as caramels and nougats. It is also used in spray coatings for cereals and biscuits. Biscuit creams, designed to melt in the mouth, contain substantial quantities of the hardened oil.

USES AS A TECHNICAL OIL

Coconut oil has been used for centuries in the countries of origin for cosmetic purposes, and as a raw material for preparing soaps, and to some extent as a fuel. In India, Pakistan and Indonesia for example, large quantities of the oil are still used for dressing the hair, giving it a lustrous appearance. It is also used as a body oil. It is said that rubbing an infant with the freshly prepared oil before bathing gives a soft and supple skin. Small quantities of oil are still utilised as a fuel for lamps in rural areas.

In the developed world, coconut oil is sued as a raw material for various products including cosmetics, soaps, detergents, pharmaceuticals, and chemical intermediates. For technical purposes, coconut oil is mainly used in the form of its chemical derivatives and only small amounts of pure, unhydrolysed oil are used.

oaps

or centuries, coconut oil has been used for the preparation of soaps. It could be aid to be an almost ideal raw material for this purpose because of its stability, olubility and the free lathering properties of its sodium salts. It is easily saponi-ied with strong caustic soda even in the cold, allowing soaps to be prepared in rural reas by the "cold" and "semi-boiling" processes, both requiring little skill and echnical know-how. However, soaps prepared by these methods are inferior in quality o those produced by the "full-boiling" process, having undergone no purification: urthermore, the glycerol is non-recoverable.

oaps prepared from coconut oil are particularly useful where the water is very hard, wing to its free lathering properties; marine and salt water soaps for laundry urposes are usually prepared from coconut oil because of their low susceptibility o salting out in sea water due to the lower average chain length of the fatty acids resent.

owever, soaps prepared from coconut oil have some disadvantages. The main draw-back s its skin irritation properties, some people being allergic to, it is thought, sodium aurate and, to a lesser extent, sodium myristate. The other main disadvantages are the softness" of the soap. Although useful for some applications, its ready solubility eans, in practice, that it is wasteful in use. Coconut oil, therefore, is mixed with ther fats, for example, palm oil and tallow, to increase the "hardness" of the product.

n spite of its disadvantages, coconut oil is still used in the composition of practi-ally all types of soap produced today, particularly high quality toilet soaps, where he percentage can be as high as 20% of all fats used.

ne must not overlook the manufacture of soaps from fatty acids rather than crude oil. he reaction is quicker, more effective, and there is no glycerol produced. The inished product is of higher quality, has a better colour, is more uniform in appearance, nd therefore, produces an excellent toilet soap. Liquid hand washing soaps are the otassium and sodium salts of mixed coconut fatty acids, their solutions being thickened ith carboxymethylcellulose. Shaving soaps, and soap-based hair shampoos are made from oconut fatty acids since these have superior hair softening, smooth spreading and non-rritating properties, although as mentioned previously, some people are said to be llergic to certain coconut fatty acid soaps.

etergents

lthough the bulk of synthetic detergent formulations are based on alkylbenzene sulpho-ates, a wide variety of fatty acid derivatives are used in conjunction as foam stabilisers, foam boosters, and for specific uses in the textile, mining, petroleum and cosmetic industries. The non-biodegradable nature of petroleum derived synthetics has resulted in a recent upsurge of interest in detergents derived from fatty acids.

Coconut fatty acids are very suitable for preparing alkylolamides produced by the reaction between fatty acids and diethanolamine, giving a range of products with useful surface active properties. They are used as emulsifiers and wetting agents in textile manufacture and cosmetics. Reaction of the coconut fatty acid with ammonia, formaldehyde, and hydrogen peroxide leads to the production of amine detergents which are biodegradable. Derivatives of the amine have bacteriostatic properties and are often used in specialised detergents for the food industry.

Cosmetics

Coconut fatty acids are finding increasing use in the cosmetic industry. Isopropyl esters, for example, add "slip" to hand lotions. Some esters have also found use as plasticisers in hair sprays and other similar products. Cosmetic oils must have lubricating and smoothing qualities on the skin leaving a favourable impression. Coconut oil and certain other oils such as avocado, fit these requirements, although the oils themselves are subject to rancidity and have only slight solubility for active ingredients. There is a preference, therefore, in such applications for derivatives based on the alcohols which have special solvent properties.

Some cosmetics products in which derivatives of coconut oil are used include preshave lotions, bacteriostatic shampoos, foaming bath oils and clear gel bases.

Fatty acid derivatives of amino acids find specialised applications, the most important being lauryl sarcosinate. This is used in tooth paste and has been shown to have anti-caries activity.

Pharmaceuticals

Hydrogenated fats and high-melting saturated fatty acids are employed in a number of ways in the pharmaceutical industry. They are used as thickening agents for cream lotions and ointments, and also in coatings for tablets. The high-melting grades of these products find uses as coatings for delayed action pills and tablets. These coatings can withstand the acid environment of the stomach without disintegrating and will only breakdown and liberate the active medication when the alkyline enzymatic intestinal tract is reached.

Coconut oil preparations also have application in low calory diet preparation because, in modified form, they have lower calorific values. Their saturated nature also offers advantages in shelf life characteristics where products may be on the market for a number of months. Other important applications for fatty acids in the pharmaceutical industry are in the formulation of suppositories, and coconut oils are now supplanting the previously used cocoa butter in this application.

Other applications

Coconut oil fatty acids and purified lauric acid find considerable outlets in the surface coating industry. They are used in the manufacture of high grade baking enamel in combination with urea and melamine resins. Lauric acid alkyds are particularly sought after for white and pastel shades where yellowing may be a problem. They are also used extensively in the automobile industry, where they impart flexibility without impairing hardness or durability to the otherwise brittle nitrocellulose lacquers.

Other applications of coconut oil include the lubrication of leather after chrome tanning and dyeing; in the manufacture of synthetic rubber to control polymerisation (dodecyl mercaptane); as lauryl peroxide, a catalyst in numerous polymerisation reactions; as an additive to disinfectants, producing the desired cloudiness when diluted with water; and in the form of lauryl methacrylate, as a "viscosity index improver" of lubricating oils, allowing the lubricating properties to continue over a wider temperature range.

TABLE V/1

FATTY ACID COMPOSITION OF COCONUT, PALM-KERNEL AND BABASSU-KERNEL OILS*

Fatty Acid	Coconut Oil %	Palm-Kernel Oil %	Babassu-Kernel Oil %
Caproic Acid C 6	0 - 0.8	trace	0 - 0.2
Caprylic Acid C 8	7.8 - 9.5	2.7 - 4.3	4.1 - 4.8
Capric Acid C10	4.5 - 9.7	3.0 - 7.0	6.6 - 7.6
Lauric Acid C12	44.1 - 51.3	46.9 - 52.0	44.1 - 45.1
Myristic Acid C14	13.1 - 18.5	14.1 - 17.5	15.4 - 16.5
Palmitic Acid C16	7.5 - 10.5	6.5 - 8.0	5.8 - 8.5
Stearic Acid C18	1.0 - 3.2	1.3 - 2.5	2.7 - 5.5
Oleic Acid C18 (unsaturated)	5.0 - 8.2	10.5 - 18.5	11.9 - 16.1
Linoleic Acid C18 (doubly unsaturated)	1.0 - 2.6	0.7 - 1.3	1.4 - 2.8

*Kaufmann, P. Thieme J G, Neuzeitliche Technologie der Fette und Fettprodukte, 1956, Part I, p17, Munster, Aschendorff

CHAPTER VI

COPRA CAKE AND COPRA MEAL AND THEIR UTILIZATION

DEFINITIONS

Copra Cake is defined as the residual oilcake obtained after milling copra. The residual oil content of the cake will vary considerably according to the efficiency and age of the machinery used in the milling process. In some rural areas of India and Thailand, for example, where ghanis and checkkus are still utilized, the residual oil content can be as high as 30%, while using modern high pressure expellers, only 6% or so oil will remain in the cake. Between 5 and 6% residual oil is probably the lowest limit that can be achieved without scorching, resulting in damage to the nutritional value of the cake.

Copra meal is defined as copra cake which has been solvent extracted to remove the residual oil. Usually such meal will contain no more than 0.5% oil.

CHEMICAL COMPOSITION

A typical chemical analysis of copra cake is shown in Table VI/1.

The total digestible component of copra cake is in the order of 75-80%, higher than most vegetable oil cakes.

AMINO ACID COMPOSITION

Copra cake has a useful amino acid profile, lysine probably being the first limiting amino acid for feeding to monogastric animals. The arginine content is high but tryptophan, methionine and histidine levels are low relative to other oilseeds. It is unlikely, however, that this would be a serious drawback in most cases.

OIL CONTENT

While copra cake will usually contain about 8% residual oil, the amount present in solvent extracted copra meal will usually be less than 0.5%. This latter product is obviously less valuable than the cake, and is used solely in combination with other constituents in balanced feeds.

Undoubtedly, the presence of coconut oil in copra cake is desirable. Feeding tests have shown that copra cake will slightly increase the fat content of milk from dairy cattle, and it appears to have an affect on the quality of the butter produced, this having a hard consistency and a good flavour. Substantial quantities are also utilised in feeding to pigs, a fat with a firmer texture and less unsaturation being produced. However the relatively high fibre-to-protein ratio limits the amount of copra cake and meal that can be incorporated into pig and poultry rations. Constipation in pigs has been reported when feeding at high levels.

OTHER CONSTITUENTS

Small amounts of vitamins (of the B-group) are found in copra cake and meal, although it is by no means a high source. Its mineral content is relatively low in phosphorus (about 1.3 per cent P_2O_5) but high in potash (about 2.5 per cent K_2O).

USE AS AN ANIMAL FEED

Copra cake is an important by-product from the processing of coconut oil and is a valuable animal feed. It contains approximately 20% crude protein with about 8% residual oil, making it an excellent feed for livestock. The characteristics of the residual oil, the medium protein content, its palatability and its high capacity for absorbing, for example, molasses, make it particularly useful for cattle, especially dairy cattle. To a lesser extent it has been used as a feed for other livestock for example, pigs and poultry.

Generally, copra cake and meal are blended with other materials to form animal feed. Before blending, the cake is broken either between rollers or, for hard cake, toothed rolls. Feed blending plants are usually designed to produce many different products or "rations" each of which may contain as many as twenty different ingredients. Generally speaking the blend contains a cereal base enriched with oilseed meal and with added vitamins, minerals, or amino-acids depending on the final use. Cereal grains are cracked before blending so that all ingredients are in a relatively freely divided state. Rations may be left as a meal or pelleted. Size of pellet, as well as formulation of the ration, will depend on the final use. Clearly poultry will require a much finer pellet than large mammals.

USE AS A FERTILIZER

Copra cake and meal have limited applications as fertilisers. Usually only poor quality material would be used for this purpose. Although a useful potassium source (the ash contains about 12.5 per cent K_2O), the phosphorus content (about 1.3 per cent P_2O_5 in the ash) is low compared with many other oilseed cakes. For effective use as a fertilizer this deficiency would need to be supplemented chemically.

It has been shown in the Philippines that coconut cake added to clay loam improved both the physical and chemical properties of the soil.

QUALITY AND STORAGE

Copra cake and meal are essentially by-products obtained during the production of coconut oil. It is probably for this reason that no special attention has been given to defining various grades of these materials, and quality varies enormously.

In the United Kingdom, the Fertilizer and Feeding Stuffs Act, 1926 (revised 1960) states that if used as a feedingstuff, the amounts of oil and protein have to be stated, while if used as a fertilizer the percentage weight of nitrogen present must be stated. Most metropolitan countries have similar regulations in force.

Coconut cake and meal will absorb moisture unless stored in a cool, dry place. The moisture content is the main factor affecting deterioration, 13-14% being the maximum moisture content permitted if moulding, resulting in rapid hydrolysis of the residual oil, is to be avoided.

TABLE VI/1

CHEMICAL COMPOSITION OF COPRA CAKE*

Composition	Copra Cake %
Dry Matter	90.0
Crude Protein (N x 6.25)	21.2
Oil	7.3
Crude Fibre	11.4
Carbohydrate	44.2
Ash	5.9
True Protein	19.7

*Rations for Livestock by R E Evans, London. HMSO. Bulletin No 48 MAFF

CHAPTER VII

FRESH COCONUT PROCESSES

WET PROCESSES - MOTIVATION

Up to now, the market economy for coconuts has been based on the need for coconut oil. It has been calculated that for every pound of potential recovery of coconut protein, seven pounds of coconut oil must be processed. Therefore, the total emphasis has been on maximum oil recovery at the lowest possible cost.

Copra processing is often insanitary and the copra meal itself suitable only for animal feed: if the protein could be obtained fit for human consumption the coconut would prove a potentially valuable source.

Improved variants of the copra process have not, generally, proved successful or economic, partly because the product is still essentially copra meal, that is it contains the cellulose as well as the protein, and is not acceptable as human food.

The fresh or "wet" processes which use fresh undried coconut meats for immediate processing into oil and protein flour continue to challenge the imagination because of their inherent sanitary nature and because they offer the potential for obtaining coconut protein products as well as coconut oil of superior quality. It must be borne in mind, however, that if copra is correctly dried and processed, oil of remarkably good quality can be obtained.

COMMON FEATURES OF WET-PROCESSES

In the following critique of some of the efforts at oil and protein extraction from fresh coconuts it will be clear that two major operations are involved:

1. The separation of an emulsion of oil, protein, water, etc from the cellulosic part of the kernel. As far as yield of oil is concerned it is at this stage that most if not all wet processes so far tried fail, in that too high a proportion of the emulsion is left with the cellulose. A milling or pressing operation is a feature of this stage.

2. The splitting of the emulsion, or milk, into oil, protein and an aqueous phase, has proved a very difficult operation to carry out continuously and cheaply, but is efficient in that clear oil may be obtained in yields of about 100 per cent from the milk. In most processes a centrifuge is used to split the emulsion, which is usually pretreated by heat, enzymes, acids and so forth.

All wet-processes require as starting material, fresh kernels. Supply is not necessarily easy to obtain, even for a pilot plant.

Whereas copra may be prepared in villages and small factories, and can then be transported without deterioration provided the moisture content is less than 6%, fresh coconut meat must be used almost as soon as it is extracted from the shell. The wet process plant must, therefore, be sited where there is an adequate supply of fresh coconuts plus the labour needed to obtain the meats. Furthermore, most wet processes require adequate supplies of water, electricity, and the means of disposing of aqueous as well as solid wastes. The unwise siting of pilot plants may have led to premature abandonment of otherwise promising processes.

WET COCONUT PROCESSES - GENERAL OBSERVATIONS AND PROSPECTS

To date, none of these processes is in commercial use. The principal reason for this appears to be that the yield of oil from the wet processes is at best 10 - 15 per cent lower than the yield of oil obtained from the processing of copra, but in terms of yields of oil per unit weight of fresh nuts, the wet processing techniques compare favourably with copra processing. Further, the average dietaries in the coconut-producing countries are deficient in protein and it is important to direct attention to processes which extract protein fit for human consumption.

The economic aspects of wet-processing are described in Chapter IX.

THE MAJOR WET PROCESSES (Flow diagrams and references are given at the end of this Chapter)

a. <u>The Chayen Impulse-rendering process</u>

Impulse rendering is described as "a mechanical rupture of the membranes of the fat-containing cells by a series of high-speed impulses transmitted through the medium of a liquid, whereby the fat in the cells is liberated and is removed by the liquid in violent movement". The impulse-renderer is in fact a flooded hammer-mill. With oilseeds it was found that under the conditions which prevail in the mill, the soluble proteins are associated with part of the lipid, and that subsequent centrifugation yielded three fractions: free oil, a meal containing fibrous matter and a lipid-protein complex. With coconut, the fresh kernels are fed into the hammer-mill with ten times their weight of 0.15 per cent sodium hydroxide solution. The fibre fraction is then removed on a vibrating screen and the emulsion which passes through the screen is centrifuged to separate the free oil from the "lipid-protein complex". Only 80 per cent of the oil and 70 per cent of protein is recovered.

b. The Robledano-Luzuriaga Process

The fresh coconut kernel is grated in a comminuter and then pressed - yielding about equal proportions of emulsion and cake. The cake is pressed again, yielding more emulsion and a residue which is used as animal fodder. The emulsion is passed through a three-phase separator and three fractions are obtained - an oil-rich phase (the 'cream'), an aqueous phase (the 'skim-milk') and a small amount of solids (protein). The cream is subjected to enzymatic action under controlled temperature and pH and then undergoes a "freeze-thaw" operation, the oil being recovered by means of a second centrifuge. The protein contained within the skim-milk phase is coagulated by the application of heat, filtered and then dried to yield a protein-concentrate.

c. The ICAITI Process

This process was developed by the Instituto Centro Americano de Investigacion y Technologia Industrial (ICAITI). It is intended as a general purpose process for the extraction of oil from vegetable materials having a high moisture content. The essential feature of the process is the production of an emulsion by the wet-milling of coconut in a rod mill. The emulsion is then heated, whereupon it separates into three phases - an aqueous phase which is discarded, a light phase and a cream phase. The latter are concentrated by means of an evaporator and a basket centrifuge respectively. The concentrates are then bulked and passed to a rotary dryer where the oil and protein recoveries are effected. Oil yield is around 75 per cent.

d. The Krauss-Maffei/CFTRI Process

This process was originated by Krauss-Maffei AG, and then further developed by the Central Food Technological Research Institute of Mysore, India. The emulsion is produced by pressing the fresh kernel and centrifugal action then separates the emulsi into a "skim-milk" phase, and a cream phase. Yield of oil is around 80 per cent.

e. The Hoxas Process

In this process, shredded coconut meat is pasteurized before passing to the expeller. The purpose of heating the shredded meat is two-fold: to destroy the bacteria, and to coagulate the protein. The emulsion then undergoes a "freeze-thaw" operation and is centrifuged.

f. The Sugarman Process

This process is said to be equally applicable to all oilseeds. The fresh coconut kern is first reduced in size in a grinding or flaking mill. The ground coconut is then milled in a pebble mill with twice its weight of dilute alkali. The slurry is milled for three hours, transferred to a heated mixing tank where more water is added, and is then agitated for one hour. The slurry is separated in a three-phase separator to obtain a meal, skim-milk and cream.

The concentrated oil emulsion (cream) is broken by pH adjustment, followed by colloid milling and, finally, centrifugation to recover the oil. It is claimed that the high shear forces generated by the colloid milling of the cream break down the oil globules rendering the subsequent centrifugation simpler than if the cream were passed straight to the centrifuge from the pH adjustment stage. The skim-milk phase is treated with acid to precipitate the protein which is then filtered, washed and dried.

g. "Integrated" Processes

These processes have frequently been studied in order to use all parts of the nut in one factory, starting from freshly harvested nuts. Husk and shell are used as well as kernel and products include charcoal, tars, acetic acid. Whilst total utilization may appear desirable to prevent environmental pollution, it is unrealistic if the products cannot be disposed of.

h. Texas A & M University

Here extensive studies are being made on wet coconut processing technology, the ultra-structure of coconut meats, coconut protein, and concentrates and isolates. Some attention is also being given to improving more conventional systems of coconut processing.

j. The Tropical Products Institute Process

By using a wedge-die-plate mill it is possible to break down coconut meats to sub-cellular dimensions, a high proportion of cells being cut open. To operate such a mill efficiently it is necessary to feed a slurry of granulated fresh meats through the mill. Die-plate hole diameter and the wedge to die-plate distance are critical in determining oil recovering from the process.

After milling, the celulosic material is separated by continuous sieving and the emulsion is acidified with acetic acid to pH 3.8. Rapid creaming occurs and, after a standing period, the aqueous layer can be discarded and the cream separated in a three-phase separator to give a high-grade oil and a paste containing a high proportion of protein. This is washed with a suitable solvent (isopropanol) to give a buff powder containing 80 per cent protein. The oil yield is between 80 - 85 per cent. The emulsion from the sieving stage can be used to prepare "milks" and "creams".

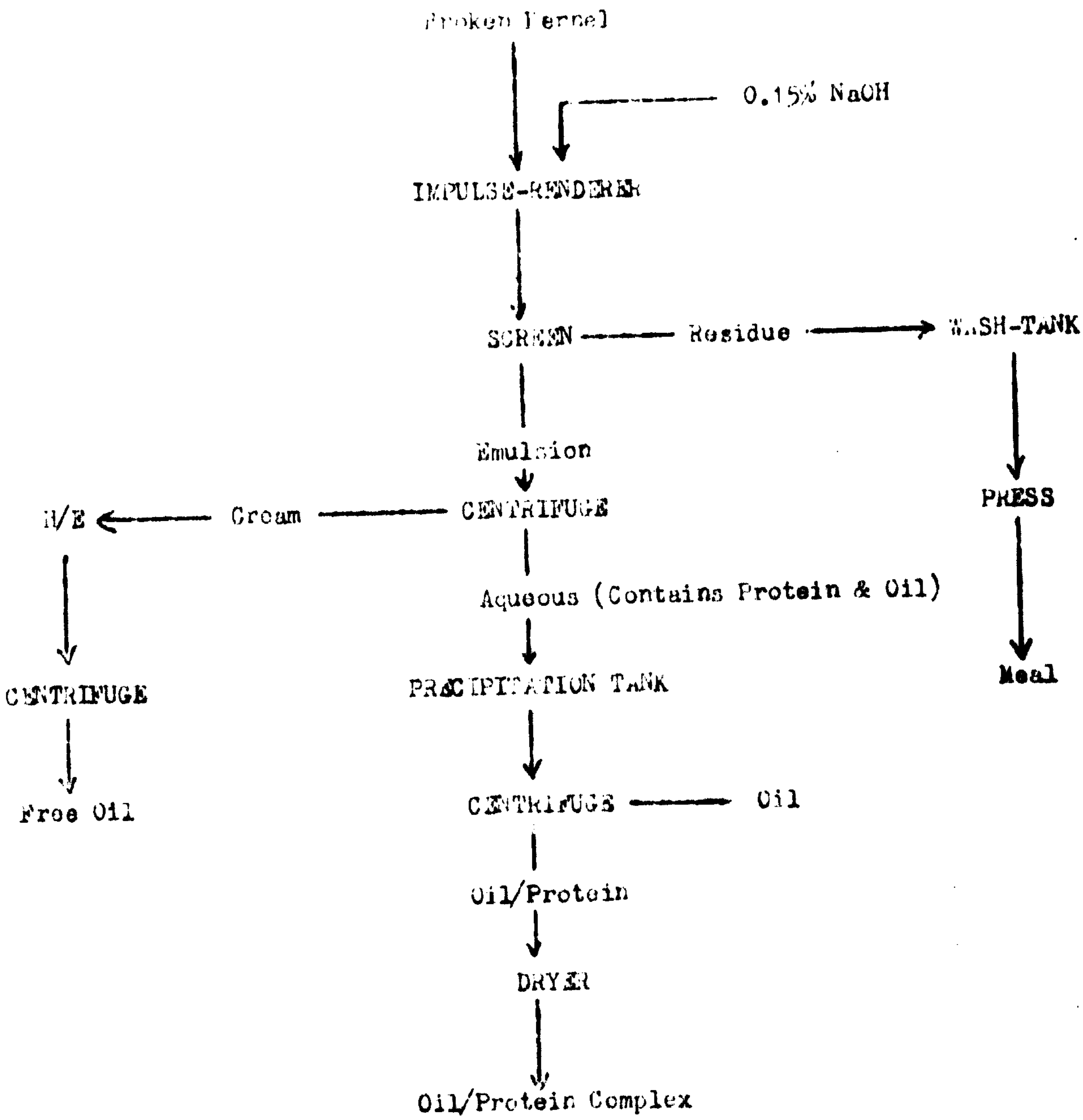
[illegible] FLOW DIAGRAM

THE CHAYEN PROCESS

REFERENCES: Chayen, I H US Pat. [illegible] (1957)
Chayen, I H US Pat. [illegible] (1960)
Chayen & Ashworth J. App. Chem. 1959, 6[illegible]

% Oil & Protein Yields

OIL	80%
PROTEIN	70%



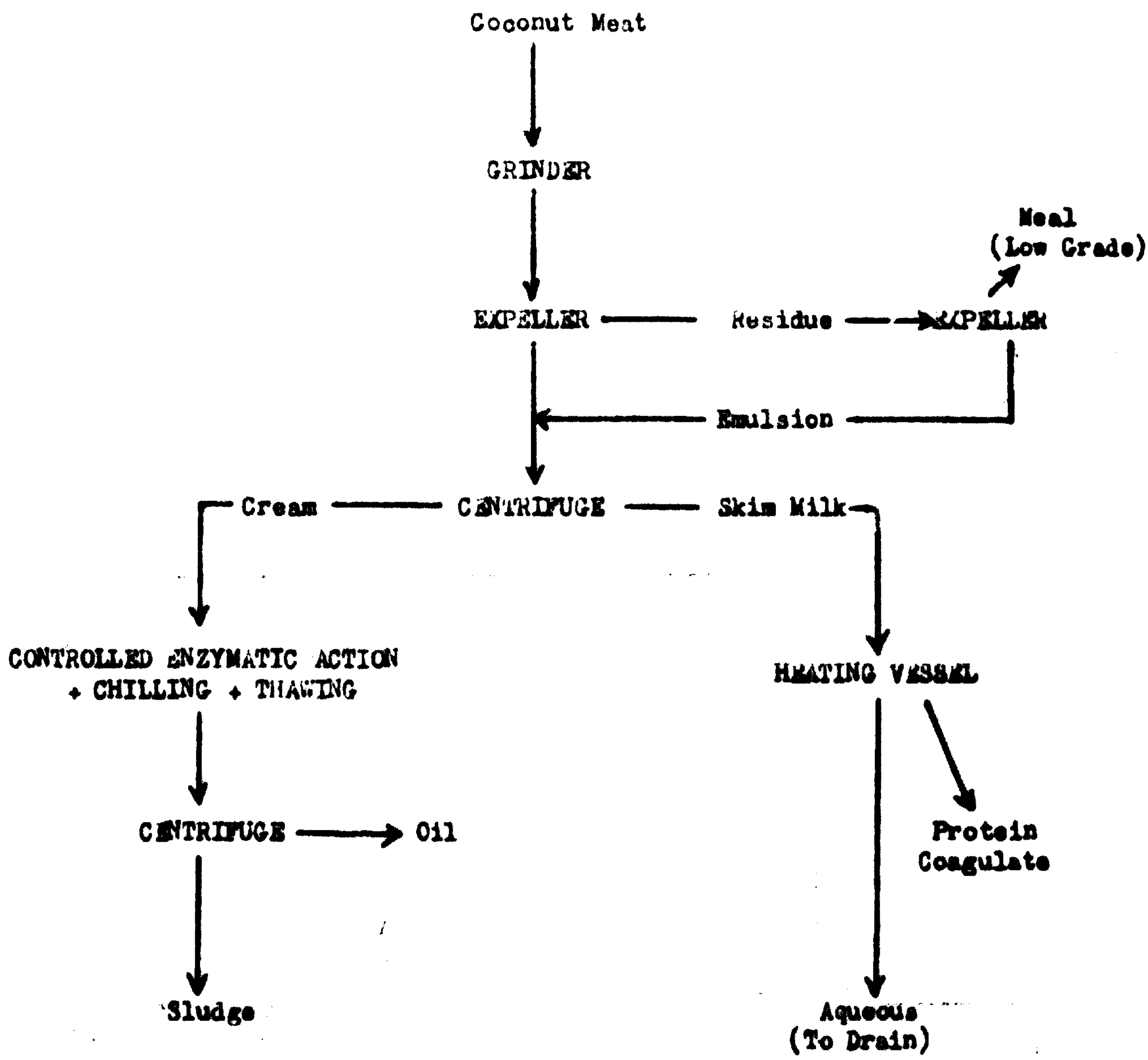
Product Composition

	% OIL	% PROTEIN	% C-H	ASH	B.V.	N.P.U.	D.
OIL/PROTEIN COMPLEX	35	6[illegible]	2.5	2.5	60	50	75%
MEAL	20	[illegible]	75	3.5			

VIII Flow Diagram

THE ROBLEDANO-LUZURIAGE PROCESS

REFERENCES: Robledano & Luzuriage, US Pat 2742487 (1956)
and US Pat 747181 (1956)



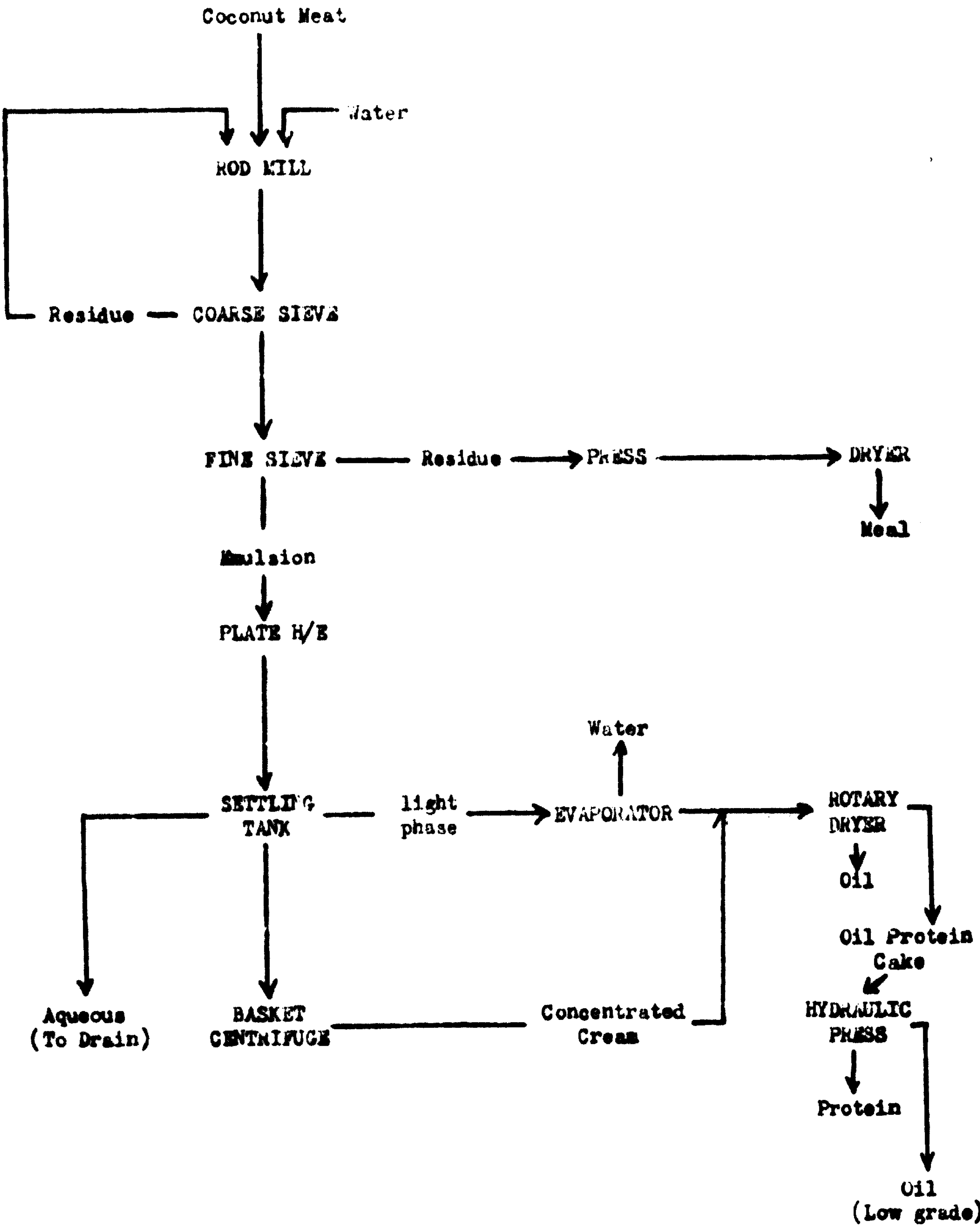
No Data available on overall oil and protein yields.

Protein coagulate said to contain 60% protein.

VIIc Flow Diagram

THE ICAITI PROCESS

REFERENCES: P J Sole Castellanos US Pat 3451990 (1969)
P J Sole Castellanos & C R Asturias, Oleagineux 24, 1969, 419-421, & 505-509



No data available on product composition or protein yields.

% Oil recovery said to be between 75 - 80%.

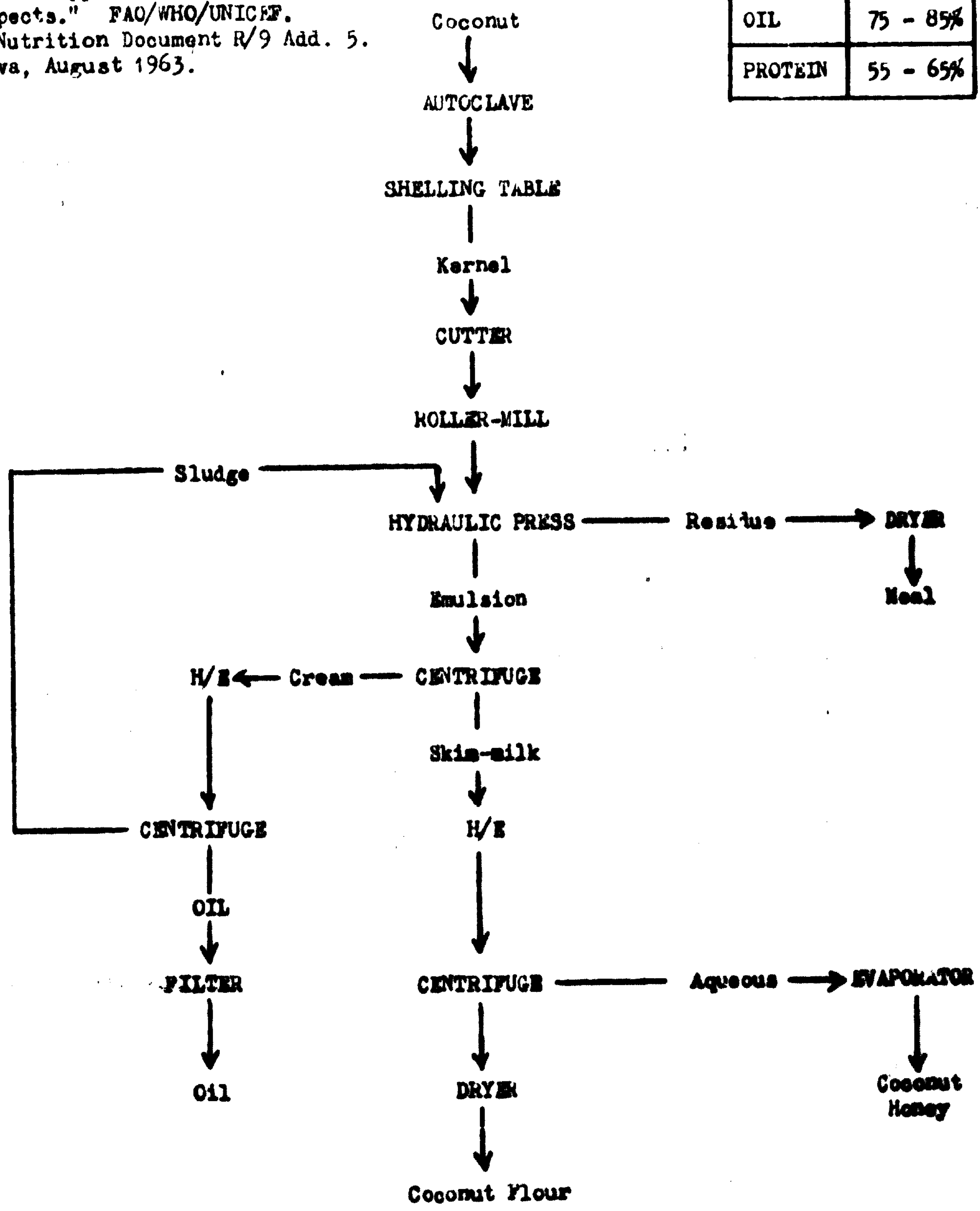
 Flow Diagram

THE KRAUSS-MAFFEI PROCESS

Reference: SREENIVASAN, A., "Use of Coconut Preparations as a Protein Supplement in Child Feeding: Prospects." FAO/WHO/UNICEF. PAG Nutrition Document R/9 Add. 5. Geneva, August 1963.

% Oil & Protein Yields

OIL	75 - 85%
PROTEIN	55 - 65%



Product Composition

	% OIL	% PROTEIN	% MOISTURE	% CRUDE-FIBRE	% ASH
COCONUT FLOUR	3.4	51.7	8.4	0.5	8.2
MEAL	12.2	6.2	6.6	25.1	1.6

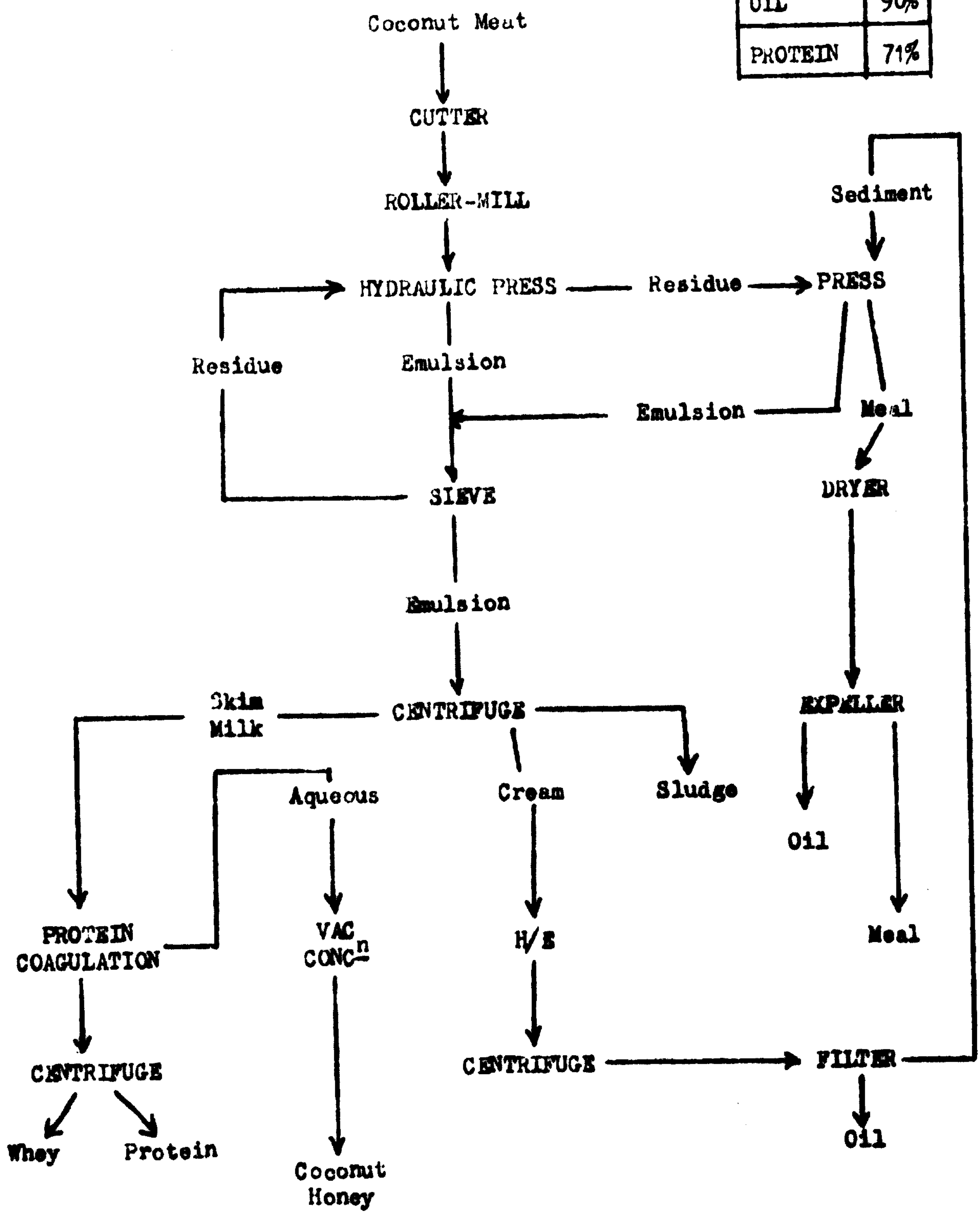
 Flow Diagram

THE KRAUSS-MAFFEI/CFTRI PROCESS

REFERENCES: As for Krauss-Maffei

Oil & Protein Yields

OIL	90%
PROTEIN	71%



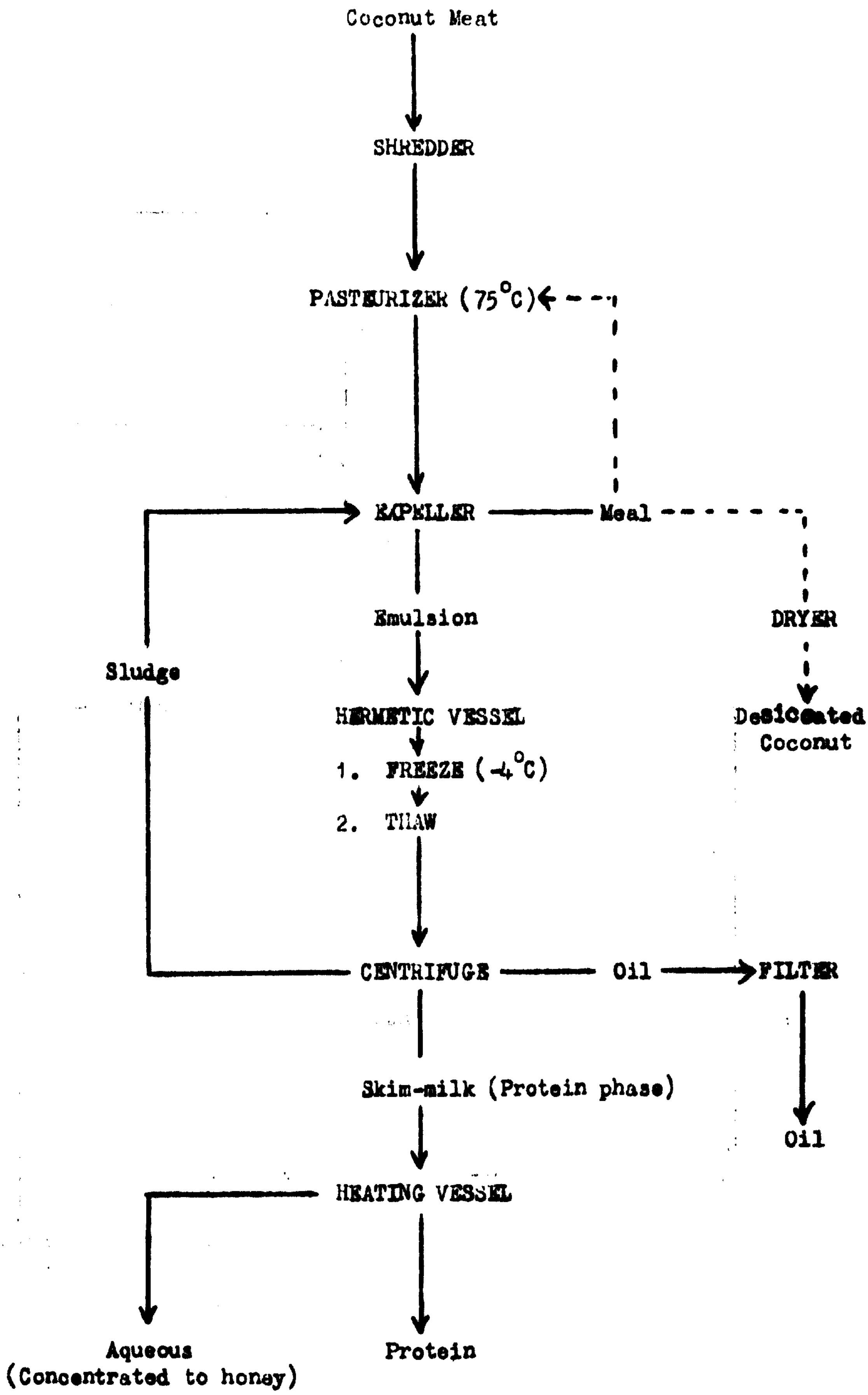
Product Composition

	% OIL	% PROTEIN	% MOISTURE	% C-H	% ASH
PROTEIN	3.4	66.1	8.4	13.9	8.2
MEAL	25.0	6.0	6.0	57.0	6.0
HONEY	2.0	15.6	40.0	35.6	6.8

VIIe <u>Flow Diagram</u>

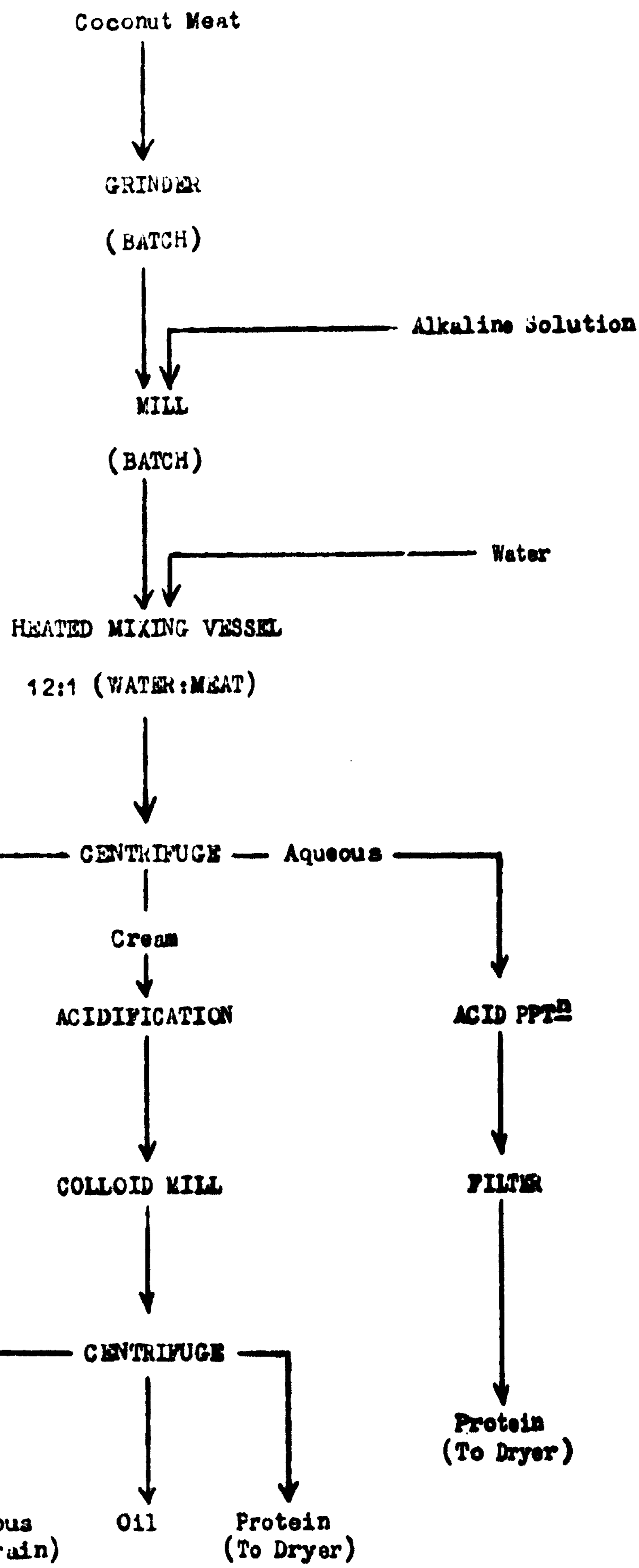
THE ROXAS PROCESS

REFERENCE: P G Roxas, US Pat 3083365, (1963)



VIIf Flow Diagram

THE SUGARMAN PROCESS

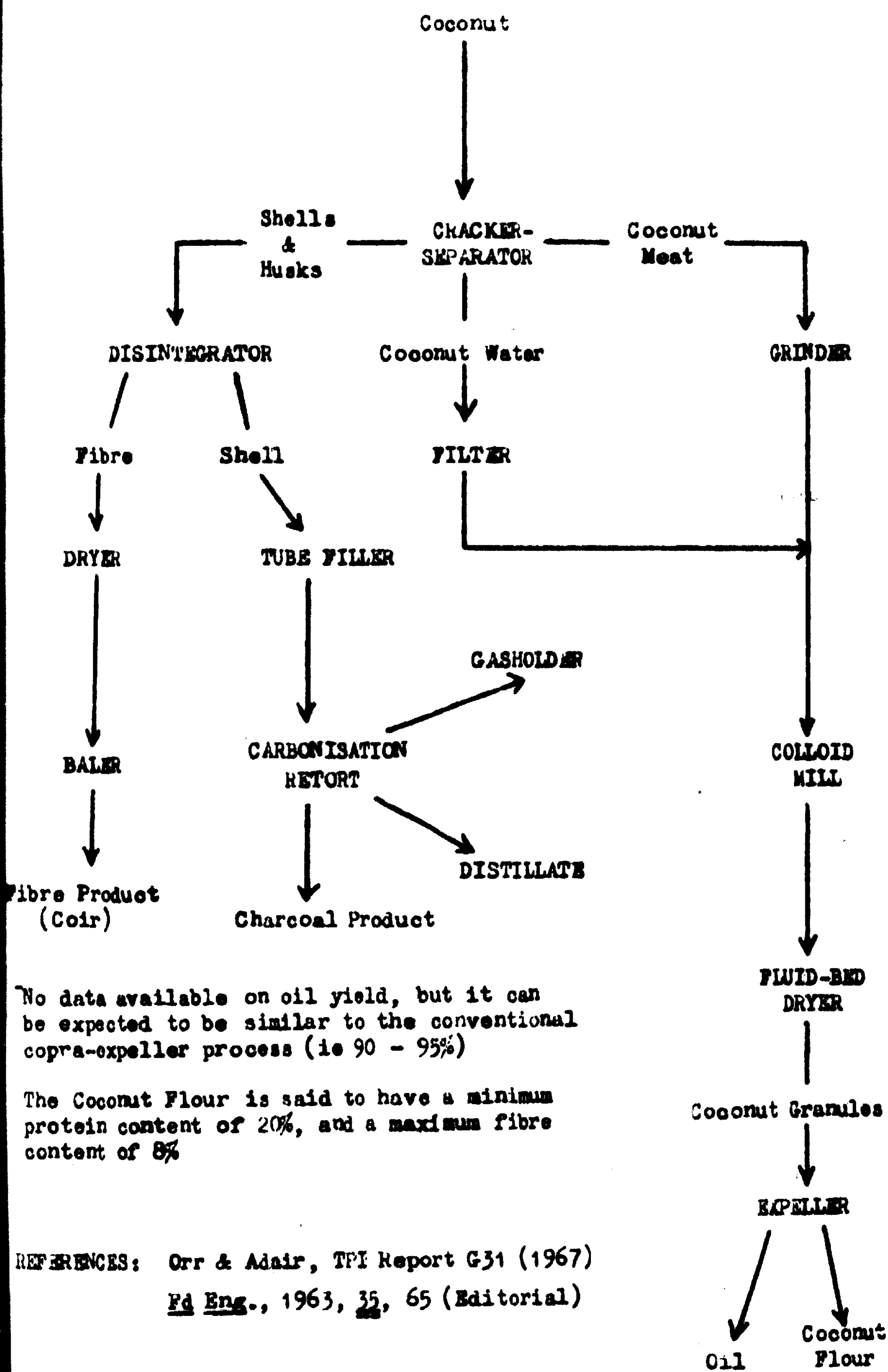


No data available on oil and protein yields, or product composition.

REFERENCE: N Sugarman, US Pat 2782620 (1956)

VIIg Flow Diagram

THE INTEGRATED COCONUT PROCESS



No data available on oil yield, but it can be expected to be similar to the conventional copra-expeller process (ie 90 - 95%)

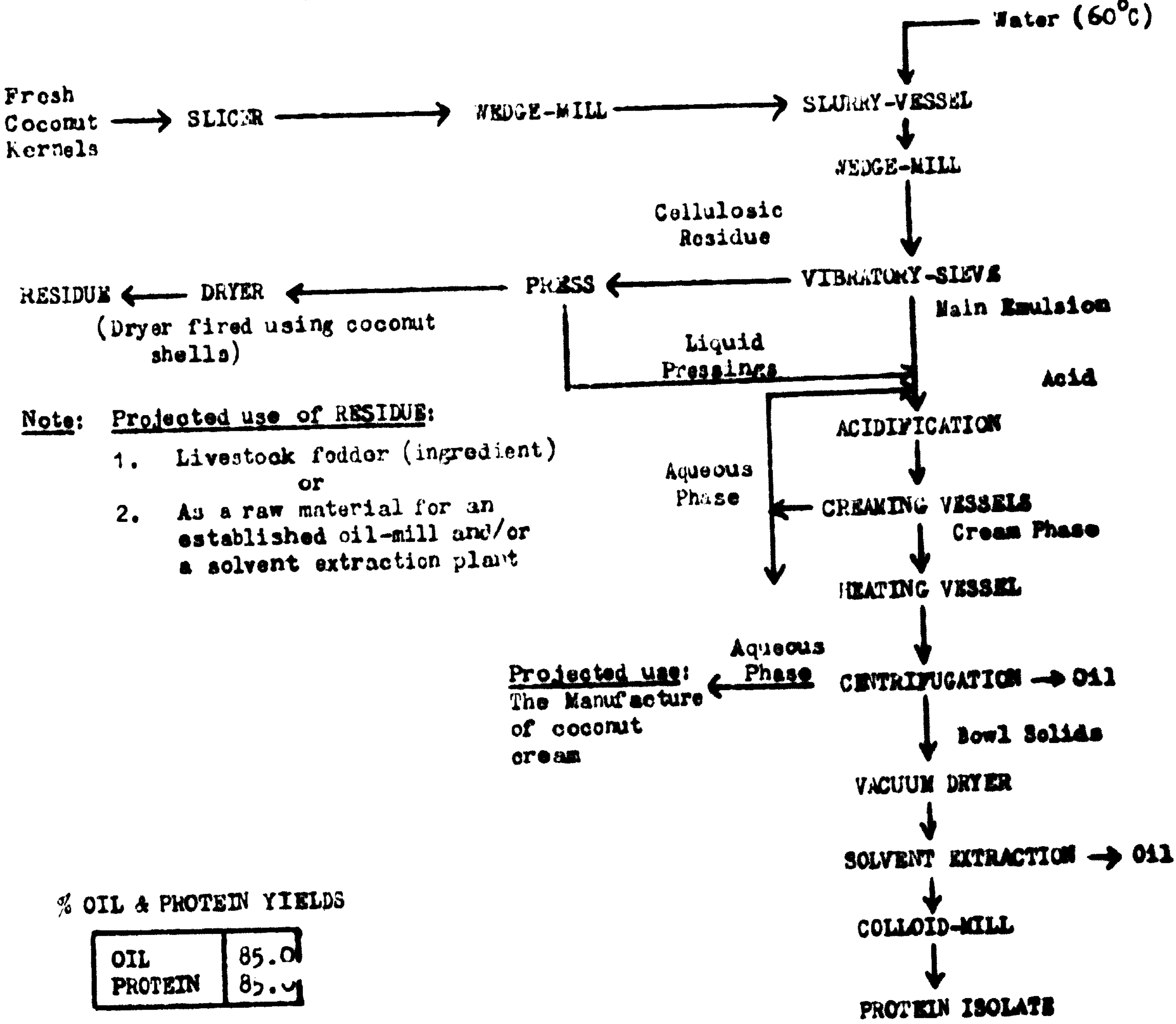
The Coconut Flour is said to have a minimum protein content of 20%, and a maximum fibre content of 8%

REFERENCES: Orr & Adair, TPI Report G31 (1967)
Fd Eng., 1963, *35*, 65 (Editorial)

VIII) Flow Diagram

THE TPI PROCESS

Reference: TIMMINS, W H, "The extraction of protein and oil from fresh coconut" M. Tech., Thesis, Loughborough University of Technology, July 1970.



Note: Projected use of RESIDUE:

1. Livestock foddor (ingredient)
   or
2. As a raw material for an established oil-mill and/or a solvent extraction plant

% OIL & PROTEIN YIELDS

OIL	85.0
PROTEIN	85.0

*FFA of Oil between 0.1 - 0.2% (as lauric)

PRODUCT COMPOSITION

	% Oil (db)	% Crude Protein (N_2 x 6.25)	Moisture	% Crude Fibre	% Ash	% Carbohydrate (by difference)
PROTEIN ISOLATE	7.2	82.0	4.9	0.6	4.95	0.35
RESIDUE	36.4	4.8	5.0	43.6	0.4	9.8

CHAPTER VIII

THE PRODUCTION OF LOW-COST PROTEIN FOODS FROM FRESH COCONUT

TRADITIONAL FOOD USAGE

For centuries, the coconut has been a traditional food in practically all the countries where it is grown. The quantity of fresh coconuts consumed locally will vary enormously from country to country, from over 90 per cent of the total production in, for example Thailand and parts of Indonesia (Java), to less than 2 per cent of the total production of the Philippines.

Coconut enters freely into the diet of the people in many ways: in the form of tender nuts for drinking the water, mature nuts for cooking purposes and the preparation of sweetmeats, and for home oil consumption. Probably the most well-known product is coconut milk, the oil/protein/water emulsion obtained when the grated fresh coconut meat (endosperm) is squeezed through a muslin cloth. The consistency of this milk will vary depending on whether or not water has been added during this process. In addition, in some places it is the usual practice to repeat the operation 2 or 3 times, each time a more dilute emulsion being obtained suitable for different uses in cooking.

The efficiency of coconut milk extraction in the home is low. It has been estimated that up to 50 per cent of the oil and protein can remain in the residue. It is unlikely that any method can be devised for the home which would effectively remove all the nutrients present. However, it must be remembered that in rural areas at least, the residue is not wasted. It is usually fed to chickens or pigs and is a useful supplementary animal feed.

There have been many attempts to produce a bottled or packed coconut milk, and research into this subject is still taking place in, for example, Thailand, The Philippines, Ceylon, Fiji and Jamaica. However, few products have achieved commercial success.

In view of the wastefulness in its preparation in the home, the hard work involved and the tedious nature inherent in the extraction, the demand for a bottled coconut milk prepared by modern milling methods and bottled under hygienic conditions is evident, particularly in large towns, and is likely to increase in the future.

Enormous numbers of coconuts are consumed at the tender stage, mainly for their water content. However, the thin gelatinous layer of endosperm present at this time is used in some areas for infant feeding.

Coconut meat is eaten at practically all stages of maturity. Between the tender and mature stage, when the nuts are still green, the meat provides a most common "in-between" snack, and is also used to prepare a number of fermented condiments.

COCONUT MILK AND CREAM AND OTHER FOOD PRODUCTS

The coconut milk is the main food product from the coconut. In fact, in many areas, it is used in practically all food dishes. It is poured over most foods after cooking, and also mixed with starches and edible leaves before cooking. It is a common constituent in soups, stews and curries.

There is no clear distinction between the terms "coconut cream" and "coconut milk", th two names referring to the same product in different parts of the worlds. It is convenient, however, to consider coconut cream as a concentrated coconut milk, formed by acidification, heating, or centrifugation. The composition of coconut milk will vary considerably according to the variety of the coconut used in its preparation, the age of the coconut and the environment in which it grows. Table VIII/1 shows the variations that can occur in the composition of coconut milk from different sources.

A commercial method of preparing coconut milk will require a very efficient milling system. The preparation is in fact the first essential stage of a wet process to obtain coconut oil and edible protein, and it is interesting to consider the coconut milk to be a by-product from such a method (see Ch. VII 'The Major Wet Processes').

Coconut milk can be used in the preparation of a number of other coconut food product including frozen coconut milk, coconut syrup, coconut milk cream, coconut protein, an concentrated coconut milk. Alternatively the coconut milk can be pasteurised, canned or frozen for direct consumption by the consumer or for manufacture of food products later.

COCONUT SYRUP

This is a mixture of coconut milk and invert sugar, incorporating suitable emulsifie and stabilisers. It is widely used for flavouring desserts and beverages.

FROZEN COCONUT MILK

The coconut milk can be progressively cooled to a sludge, canned and immediately fro in a blast freezer. Prepared in this way coconut milk is said to retain its flavour and freshness when stored at -10°F for one year.

By passing the milk through a vacuum evaporator and then canning and freezing as abo a concentrated frozen coconut milk can be prepared.

OTHER COCONUT FOOD PRODUCTS

There is a number of other coconut food products available in small quantities in various parts of the world. These include coconut chips, thin slices of fresh coco meat which are dried and then toasted. The chips can be either salted or sugared to taste before use.

NUTRITIONAL AND CHEMICAL ASPECTS OF COCONUT PROTEIN

The amino acid composition of coconut protein, compared with animal protein, shew that the former (like most oil seed proteins) is deficient mainly in lysine, methionine and threonine, the ratio of essential amino acids nitrogen to total nitrogen coconut protein being lower than in animal proteins.

Coconut protein compares favourably with groundnut protein as a source of isoleucine, leucine, lysine, threonine and valine. The nutritive value of coconut protein prepared in various ways, as determined in terms of protein efficiency ratio and biological value is shown in Table VIII/3. Positive improvements in the growth and well being of under-nourished children when fed from protein supplement containing coconut meal have been reported. However, when considering fresh or dried coconut meat the other matter of vital concern to the nutritive quality of the coconut is its fibre content. Interference by fibre with digestibility and nitrogen retention in child feeding has been reported, although other studies indicate this not to be the case. Undoubtedly in many parts of the world the coconut contributes significantly to the total fat diet.

TABLE VIII/1

THE CHEMICAL COMPOSITION OF COCONUT MILK (PER CENT)

Component	Popper 1956	Nathanael 1954	Nathanael 1960	Clements & Villacorte 1933
Moisture	54.1	50.0	52.0	47.0 - 53.0
Fat	32.2	39.8	27.0	39.8
Protein	4.4	2.8	4.0	2.6 - 2.9
Sugars	-	3.0	-	2.8 - 3.2
Total Solids	-	10.4	-	10.3 - 10.5
Ash	1.0	1.2	1.0	1.1 - 1.3
Carbohydrate	8.3	-	-	-
Starch	-	0.09	-	0.08 - 0.10

Popper, K et al Food Process and Marketing 1966, 27, 92.
Nathanael, W R N, Ceylon Coconut Quarterly, 1954, 5, 158.
Nathanael, W R N, Ceylon Coconut Quarterly, 1960, 11, 46.
Clements A and Villacorte M, Philippine J. Science, 1933, 3, 7.

TABLE VIII/2

THE NUTRITIVE VALUE OF COCONUT PROTEIN

Sample	Protein Efficiency Ratio PER (1)	Biological value per cent	Digestibility coefficient
Coconut Meal	1.0 - 2.0	69 - 77	86 - 94
Skimmed "milk" (2) coagulate	1.4 - 2.4	-	-
Skimmed "milk" (3) concentrate	1.4 - 1.9	-	-
Whole egg (4)	2.8 - 4.3	85 - 98	92 - 100

(1) Protein intake approximately 10 per cent.

(2) Acid and heat coagulates from skimmed milk from autoclaved and unautoclaved nuts.

(3) Skim milk concentrates from fresh coconuts.

(4) Included for comparison.

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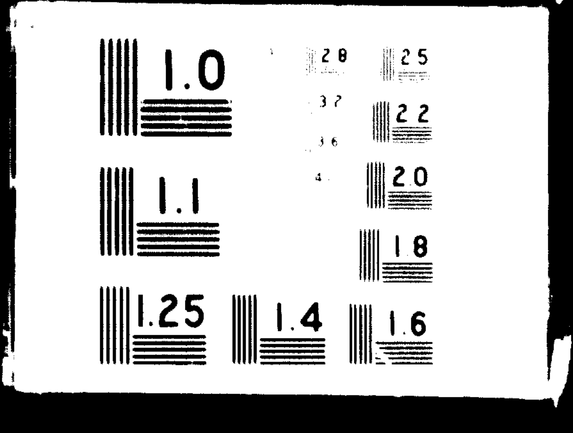

CHAPTER IX

ECONOMIC ASPECTS OF COCONUT PROCESSING

by

Mrs P A Mars

"For long term survival, a reduction in price appears necessary to prevent the elimination of some uses of coconut oil and the consequent decline in demand. Thus greater productivity is imperative for adequate farm incomes and sustained production. The alternative may be the elimination of the industry".

This conclusion emerged from a careful study[1] of the demand functions for Philippine oil and copra, and since it is likely to apply equally to the coconut products of other countries this section will deal largely with cost aspects of coconut processing.

COPRA DRYING

Data from West Malaysia show that there is a fairly wide spread in costs of copra drying from the smallholder to the estate planter. A sample survey undertaken in 1964-5 under the full-time supervision of a "coconut economist" and the surveillance of the regional coconut statistician (both FAO) showed the cost of copra-making by smallholders was £12 per tonne[2]. The corresponding figure for copra made on six West Malaysian estates in 1967 was estimated at £6.3 per tonne[3]. Since the wage inflation is believed to proceed at the rate of only one per cent per year, comparison between years without adjustment is legitimate. In both cases, the cost covers from husking to storing on farm or estate. It is stated that the smallholders dry the copra down to 10 per cent moisture content while the estates are likely to dry down to the standard 6 per cent for shipment. In the case of the smallholders, labour was costed at 40.5 pence per adult male, with adjustments for female and child labour.

Although this rate overlapped with that paid to unskilled workers in industry, there is sufficient evidence to warrant its acceptance. The estates probably achieve lower costs as a result of economies of scale and more efficient organisation. It is suggested that further economies could be achieved by the use of oil-fired dryers[4].

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1 "The Philippine coconut industry in economic perspective" by A J Nyberg, The Philippine Agriculturist. 1968. L11, No 1, 1.

2 "A preliminary report on the survey of coconut smallholdings in West Malaysia" by S Selvadurai Ministry of Agriculture & Co-operatives, Kuala Lumpur, 1968; 130.

3 "The Economics of Coconut Monoculture planting in Malaysia", by G C McCullock. Cocoa and Coconuts in Malaya. Incorporated Society of Planters, Kuala Lumpur, 1968, 96.

4 "Some aspects of copra drying" by J A Palmer, Cocoa and Coconuts in Malaya Op cit 85.

COPRA MILLING

Oil is normally extracted from copra by means of expellers and the process is subject to economies of scale which can be roughly assessed by means of figures provided by a British machinery maker early in 1971. The processing equipment for a 5 tonne per day plant with one Maxoil expeller pressing the same 10 tonnes on successive days would cost between £12,000 fob UK port and a plant with an additional expeller of the same capacity able to process to 10 tonnes per day would cost £18,500. Ten tonnes per day is the average input of the 65 mills processing copra in Malaysia, while 100 tons per day is said to be the minimum economic throughput in the Philippines and one factory is known to be processing 250 tons per day with 12 expellers[5].

The estimated processing cost in 1970 for a factory in Malaysia using two Maxoil expellers to process 8 tonnes of copra per day is of the order of £7 per tonne excluding depreciation and interest. This figure can be broken down into: personnel including management - 45 per cent; power and steam - 34 per cent and miscellaneous, including maintenance, - 22 per cent.

REFINING

The refining industries of advanced countries are strongly protected by their tariff structure, since if the nominal rates on imported refined oil are computed and then recalculated on the basis of the value added in the refining industry in the advanced country, the resulting "effective" rates are much higher. This calculation has been done for refined coconut oil and the results are shown below[6].

	Rates of protection	
	Nominal	Effective
USA	5.7	57.5
EEC	15.0	150.0

As a result of this situation exports of refined coconut oil from developing countries appear in trade returns in negligible quantities. Ceylon exports both "raw" and "processed" coconut oil, while Malaysia appears to be a net importer of "refined" coconut oil[7,8]. In 1968 production of refined oil in Malaysia amounted to about 22 per

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[5] Private communication.

[6] "Economic policies towards less developed countries" by H G Johnson, 1967, George Allen and Unwin Ltd. London, 91.

[7] Ceylon Trade Journal, 1970, XXXV Nos 8-12, 166

[8] FAMA Quarterly Commodity Statistics, 1970 I, No 3, 167, 169

cent of the production of crude oil in "mills off estates". The estimated direct costs of refining oil [illegible] predominant, was 34.50 per tonne of which 25.13 per tonne was the cost of packaging material, leaving 29.37 as processing cost[9].

[illegible]

Since no wet coconut process has so far proved commercially viable, it is not possible to present costs for any of these processes: the relative advantages and disadvantages which would affect the costs of these processes as compared to the copra process can be listed. According to private communications the price paid for fresh nuts for making desiccated coconut in both Ceylon and the Philippines is above the opportunity cost of nuts made into copra because nuts of higher quality are needed. Although nuts of higher quality are not needed for oil production, the emergence of a large scale buyer would tend to raise the price of fresh nuts. The transport cost for raw material would be increased by a factor of 3 or 4.

The available data[10] show that the labour input involved in removing the husk and shell in one operation, which is likely to occur when nuts are made into copra, is about twice that of removing the shell only which must be done in a wet coconut mill. However, the cost of deshelling in a factory is likely to be more than half the cost of removing husk and shell at a smallholder's copra kiln because in general factory wages are higher than earnings in the agricultural sector.

The main advantages of the wet coconut process appear to lie in the avoidance of waste and the production of a better quality product. In the copra process there may be a 10 per cent loss through spoilage during the drying stage[11,12] and 5 to 10 per cent loss from insect or rodent attack during storage and transportation[11]. A further 5 to 10 per cent of oil produced from copra is lost during the refining stage[13,14], although other saleable products accrue. The oil produced by a wet coconut process may attain the quality of refined oil. For the reasons given in the foregoing section, this high quality oil is unlikely to add to the export receipts of developing countries.

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[9] Census of manufacturing industries in West Malaysia, 1968, Department of Statistics, Kuala Lumpur, 442.

[10] According to private communications, a man and a woman can remove husk and shell from 2,400 coconuts per day in Trinidad, while a man can remove shell from 1,200 coconuts per day in a Philippine desiccated coconut factory. The size of nuts in husk and shell may have some affect on this comparison.

[11] By Champaign. Food Technology, 1967, 21, No 3, 37.

[12] By E E Peters and W V D Pieris, C R C Q. Bull. 1953 January, 13 to 15.

[13] "Coconut Oil Processing" by J [illegible] Thieme FAO Agricultural Development Paper No 89, Rome, 1968, 179

[14] E Orr and D Adair Report No G.39 Tropical Products Institute London 1967.

However, there is an increasing internal market for refined oil in these countries[15] and the oil product of the wet coconut process might there command a premium which would tend to offset its disadvantages. The wet coconut process also produces a protein fit for human consumption which might yield a higher return than the cake produced by the copra process. The residual cellulose might be used as feed for ruminants.

The coconut shells which emerge from the wet coconut process as a by-product are used in the copra process for firing kilns and could be used for making charcoal or a filler for plastics, both products having at present increasing markets in advanced countries.

It is probably that the wet coconut process is most likely to be viable in countries where coconuts are produced to a large extent by smallholders who are inefficient copra producers and who tend to sell nuts off the farm. The proximity of a desiccated coconut factory would be an adverse factor tending to raise the prixe of the raw material.

INDICATIONS FOR FUTURE DEVELOPMENTS

Some clue as to the proper direction of efforts to promote this industry may be derived from looking again at West Malaysia, a country which in 1968 was sixth largest producer of copra after the Philippines, Indonesia, India, Ceylon and Mexico, and had in 1960 a higher level of income per caput than the other five except Mexico[16]. Figures provided by the Commonwealth Secretariat show that after an initial fall between 1961 and 1962 both the planted area and production of copra in West Malaysia remained fairly steady until 1967 (the last year covered). However, there was a strong contrast between smallholdings, comprising 88 per cent of the planted area and estates. The area planted by smallholders remained fairly constant at 440,000 acres from 1961 to 1967 while production first declined and then increased almost to its 1961 level. In the estates the planted area fell fairly steadily from 79,700 acres in 1961 to 60,200 acres in 1967 - a fall of 25 per cent. In the same period estate production fell by 19 per cent. As we have seen copra was produced more efficiently by estates than by smallholders. However, estate owners must have had enough capital to move out of a crop that at existing yields was recognised to be less profitable than oil palm and at higher yields far more vulnerable to cost increases due to increasing wages[17].

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[15] "Coconut Oil Processing" Op cit 7.

[16] "World III: A handbook on developing countries" by A Moyes and T Hayten, Pergamon Press, London reprinted with corrections 1965, 129-133.

[17] "The economics of coconut monoculture planting in Malaya", loc cit 99.

In British Honduras, a small country with a higher level of wages than West Malaysia, the coconut - which used to be a significant commercial crop - has almost vanished. In countries such as The Philippines and Ceylon where there is less capital available for radical agricultural changes, the coconut is likely to remain a source of income for smallholders and it seems vitally necessary to find ways to increase productivity on the farm, at the kiln and on the road to the processing factory.

CHAPTER X

THE MARKET FOR COPRA AND COCONUT OIL

by

Miss E Orr

PRODUCTION

Table X/1 gives the production of copra, excluding edible copra, in the principal producing countries for the period 1957 to 1969. As the figures show there was no marked trend in production over the period. The major factors which have contributed to the lack of expansion in production include increased consumption of edible coconut, disease of the palms, ageing plantations, and adverse weather conditions, particularly drought. As Table X/1 shows production of copra is dominated by Asia and, in particular, the Philippines. During 1967-69 Asia accounted for 81% of world production and the Philippines for 40%.

Figure X/1 shows the estimated production of coconut oil in recent years in relation to that of some of the major oils and fats. Its static situation in comparison with soya bean oil and tallow and greases in particular is very marked. World production of coconut oil in 1970 is estimated at 2,071,000 tons, equivalent to about 5% of the total world production of fats and oils*. This figure represents a decline of about 7% compared with average production during 196 -66, when coconut oil accounted for 7% of total world production of fats and oils.

TRADE

Exports of copra are given in Table X/2 and net exports of oil and copra in oil equivalent from the primary producing countries in Table X/3. The latter shows that in recent years there has been a decline in the quantity of copra exported in comparison with coconut oil. Thus during the period 1958-63 73% of total oil and copra exports were in the form of copra and during 1964-69 66%. This development is in line with the general growth of oil milling industries in the less industrialised countries, but is mainly due to the expansion of this industry in the Philippines.

Table X/4 gives a breakdown of imports of copra by countries of destination. The countries of Western Europe as a group provide the largest market for copra; during 1964-69 these countries took 56% of total imports. The major single importing country is, however, the USA, which took around 20% of world imports during both 1964-69 and 1958-63.

Table X/5 gives imports of coconut oil during 1957-69, with a breakdown according to country of destination. As in the case of copra the largest importer by far is the USA,

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*Agricultural Commodity Projections 1970-80, FAO but her position with regard to coconut oil is even more dominating than for copra. Thus during 1958-63 the USA imported 32% of the world imports of coconut oil and during 1964-69 42%. The German Federal Republic and the UK are the other major markets for coconut oil.

PRICES

Table X/6 gives the quarterly and annual average prices of copra during 1960-70. The annual price showed an upward trend from 1960 until 1965. There was a sharp decline in 1966, but thereafter prices rallied and in 1970 were at the highest level for the period. However during 1971 heavy selling pressure from the Far East caused a marked decline in prices and in August 1971 copra was quoted at £68 per ton, the lowest quotation for five years.

Table X/7 gives the average quarterly and annual prices of coconut oil during 1957-70. Although subject to considerable annual variation the general trend has been upwards. Prices during the three years 1968-70 were the highest for the period under review, giving an annual average of £153.4 per ton, compared with an annual average for the decade of £120.1. The high price level was maintained during the first quarter of 1971 the average price being £168. Thereafter there was some decline, and the average price for the second quarter of 1971 was £143.6 per ton.

Figure X/2 illustrates the price of the lauric oils (ie coconut and palm kernel) and of three major soft oils (ie groundnut, soya and cottonseed. It will be seen during the period covered, that is, 1957 to 1969, the price fetched by the lauric oils was almost invariably higher than that of the others and the price differential was often very considerable. There was also a tendency for the price of the lauric oils to fluctuate more widely.

THE DEMAND FOR COCONUT OIL

The demand for individual oils/fats can be divided into "specific" and "interchangeable" demand. With the former the user attaches value to certain natural characteristics of the raw material which cannot be duplicated for his purpose. In the latter case the user has a choice of materials, each with qualities suited to his purpose. Technological advances over the years have increased the interchangeability of oils/fats in general and the role of price as a deciding factor in the choice of oils by users has accordingly become much greater. Interchangeability possibilities are of course greater among oils whose inherent characteristics are similar. Thus oils which remain liquid in temperate ambient temperatures, ie the "soft" oils, notably soya, groundnut, cottonseed, sunflower and rapeseed, have a high degree of interchangeability and their prices tend accordingly to show a close correlation.

The price pattern of the lauric oils, which was referred to above, indicates that their interchangeability with the soft oils in particular is limited and that demand for them, in relation to the supply, tends to be sufficiently "specific" to secure a premium price. There is a specific demand for the lauric oils for both edible and technical purposes. Broadly speaking it is their physical characteristics, and in particular the fact that they remain solid at temperate ambient temperatures, which creates the demand in the edible products field, while their chemical composition, in particular their content of short chain fatty acids, influences demand for technical uses, such as detergents. (It might be noted that although coconut and palm kernel oils have a high price correlation coconut oil usually obtains a small premium).

Detailed information on end uses in all countries using these oils and on the basis on which the choice of lauric oils in preference to other materials is made is not available, but there is some general information on usage.

The traditional major uses of coconut oil in the industrialised countries are in margarine and compound cooking fat and soap. In the two former usages the technological developments referred to above have increased competition between coconut oil and other oils/fats and price is now a more decisive element in this sector of the market. Usage of coconut oil varies according to comparative prices in the oils/fats field but on balance it has lost ground in many markets. Thus one source* estimates that between 1961 and 1969 Western European usage of coconut oil in margarine declined from about 260,000 tons to 120,000 tons.

The use of coconut oil confers a number of desirable features in soap, notably solubility, a hard consistency and good lathering properties. However, because of its high price, high proportions of coconut oil tend to be restricted to a limited range of preparations, such as high quality soaps, soap powders and liquid soaps.

Outside these traditional uses the most important use of the lauric oils in recent years in many markets has been in detergent manufacture, and in particular in the manufacture of short chain detergents, typically shampoos and liquid detergents. The lauric oils provide the only natural source of short chain detergents.

In recent years short chain detergents based on petroleum derivatives have been produced. A number of plants manufacturing the basic raw material have been set up in the US and one is scheduled to begin production in the UK in mid-1972. A strong challenge could therefore be offered to coconut oil in this sector of market in the future.

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*Oil World Semi-Annual, November, 1971.

A breakdown of the usage of coconut oil in the major market, the US, is given in the Coconut Situation, FAO, June 1971, for the period 1966-70. Edible oil accounted for between 42% and 48% of the total during that period. The "traditional" edible uses, however, ie in margarine and compound cooking fat, were of relatively minor importance, accounting for under 20%. The major uses for coconut oil in the edible products field in the US are in confectionery and baked goods and, relatively new among significant uses, in milk and cream substitutes. In the industrial field detergents have been most important, accounting for over 40% of usage in this area, but there has recently been an apparent downward trend.

A number of producing countries, particularly the Philippines, are expanding production of coconut, and the fall in the price of copra to which reference was made above has in fact been ascribed to an increase in supplies due to a sharp increase in bearing-tree numbers and yields per bearing-tree in the Philippines. However in the FAO projection study op cit a very rapid expansion in coconut oil production during the next decade compared with oils and fats generally is not foreseen. Production in 1980 is estimated at 2,910,000 tons compared with 2,079,000 tons in 1970. A more rapid expansion in palm kernel oil production is foreseen, from 492,000 tons in 1970 to 900,000 tons in 1980. Total production of the lauric oils may thus total 3,810,000 tons by 1980, but this will still represent the same share of total world production of fats and oils as in 1970 ie 7%. Although the expected increase in coconut oil supplies is not great in global terms its market prospects are giving rise to some concern. Thus by 1980 FAO has estimated an excess of export availabilities over import requirements of fats and oils of 1.2 million tons. Moreover, there is a natural desire to maintain the premium price position which coconut oil has enjoyed in recent years. At the same time it is recognised that the fluctuation in price to which this oil has been particularly subject is a deterrent to users. Accordingly UNCTAD has undertaken a study at the request of the FAO Study Group on Oilseeds, Oils and Fats into the feasibility of a buffer stock scheme for the lauric oils. The prime purpose of such a scheme would be to introduce a measure of stability to lauric oil prices, in the interests of both producers and consumers.

THE MARKET FOR COCONUT CAKE/MEAL

Table X/8 gives world exports of coconut cake/meal from 1964-69. During this period exports averaged 500,740 tons per year with an annual average value of £9,900,000. Asia accounted for 80% of exports, but a number of European countries, notably the Netherlands, also figured in the export trade and over the period Western Europe accounted for 13 per cent of total exports.

Imports of coconut cake/meal are shown in Table X/9. The import trade is dominated by western Europe in general and by the German Federal Republic in particular. During 1964-69 the German Federal Republic accounted for [illegible] of the total import trade. Outside Europe only West Malaysia is an import market of any significance.

Table X/10 gives the annual average price of coconut cake during the period 1960-70. Although subject to annual fluctuations price has on balance shown an upward trend. Thus the average price for the period 1966-70 was £34.26 per ton, compared with £26.86 per ton for the previous five years. Coconut cake normally finds its place at the lower end of the price scale for oilcakes. Thus, as Table X/10 shows, it tends to fetch rather less on balance than cottonseed cake and appreciably less than groundnut cake, which has a higher protein content and a lower fibre content. As a result of its high fibre content coconut cake is essentially used as a feed for ruminants and to this extent is less flexible than soya or groundnut cake. The large market which coconut cake finds in the EEC countries is primarily due to its use as a cheap carbohydrate source in comparison with cereals, whose prices are maintained at a high level as a result of the Common Market Agricultural policy.

The trade in coconut cake/meal should be viewed in the context of the general development of the market for oilcakes. This has been a dynamic market in recent years, the world trade in oilcakes having expanded at a faster rate than the trade in oils. Between 1955 and 1968 world trade in oilcakes more than doubled in volume. In 1969 there was a slowing down of the growth rate but in 1970 both production and trade reached new record levels, and exports of oilcakes totalled 23.8 million tons*. Although consumption of oilcakes is substantial in a number of developing countries, notably India, Mexico, Pakistan and Brazil, the import market for oilcakes is essentially to be found in the industrialised countries and the growth in demand is due to a rapid increase in the demand for meat, milk and eggs associated with the sustained rise in <u>per capita</u> incomes in these countries. Much of the increase demand for oilcakes has been met by soya, which in 1970 accounted for 55 per cent of world exports. The high non-oil content of the soya bean combined with the comparatively high biological value of soya protein has, in the strong oilcake demand situation which has prevailed in recent years, made the market for the cake as distinct from the oil of increasing importance to soya producers. Producers of high oil content seeds, on the other hand, are essentially dependent on the market for the oil and for them the demand for cake has in general not provided an incentive for increasing the production of the seeds from which they are derived.

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*FAO Commodity Review and Outlook 1970-71.

The consensus of opinion is that the demand for concentrated protein sources for use in animal feedingstuffs will continue to grow. Saturation point in the per capita consumption of animal products has not been reached in the industrialised countries as a whole and in addition their populations are continuing to increase. In the less industrialised countries increasing attention is being paid to the development of animal industries, as a result of the greater emphasis now being placed on nutrition as well as in response to expanding demand. However there are many competitors with oilseed cakes in the protein market, such as fish meal, pulses, and the by-products of the milling, dairying and other industries. There are also current and prospective "synthetic" competitors in the form of urea, synthetic amino acids, and single cell protein, while plant breeding programmes designed to produce cereals with higher protein contents could also lead to greater competition in the animal feedingstuffs market. FAO (op cit) has estimated the world demand for oilcakes in 1980 at 71.4 million tons compared with consumption in 1970 of 55.6 million tons. At the same time production and export availabilities are expected to increase at a rate which may lead by 1980 to an excess of supplies on the world market of the order of 5.4 million tons. Coconut cake's share of the world production of oilcakes is expected to increase, to 2.1% in 1980 compared with 1.9% in 1970, although the higher level is still below the average of 1964-66 of 2.6%. The FAO study does not attempt to estimate the share of the world export trade which might be attributable to the different types of oilcakes. However, as far as coconut cake is concerned it should be pointed out that the prospective expansion in the membership of the EEC could lead to an increased demand for coconut cake, if the high price cereals policy, to which reference was made above, is maintained.

THE MARKETING OF PROTEIN-RICH FOODS BASED ON COCONUT

Since the early 1960s, when the United Nations Agencies first turned their attention to the development of protein-rich foods based on vegetable proteins for the relief of malnutrition, oilseeds have been the major concentrated protein source used in these products. However, although a considerable amount of research has been carried out on coconut as a possible constituent of protein-rich foods, few if any of the protein-rich foods placed on the market have contained coconut. A recent study carried out by the TPI for the Protein Advisory Group of the United Nations identified sixty-nine protein-rich food schemes, including schemes which had terminated production. None of the products involved contained coconut. An analysis of the constituents of forty-six of these protein-rich foods showed that forty-two contained oilseeds. The dominating oilseed is soya, which twenty-seven products contained, followed by groundnut (ten products) and cottonseed (eight products). The only other oilseed used was sunflower, in one product.

Protein-rich foods have now been marketed in developing countries for well over a decade, and the experience gained provides lessons which have relevance for any attempt to market this type of product, regardless of its constituents. One of the major lessons which has been learnt is that high nutritive value alone will not ensure the consumption of protein-rich foods. It is essential that these products should fit in with local food habits and tastes and have organoleptic acceptability. Prior to product formulation information should be obtained not only about the nutritional needs of the target group or groups for whom they are primarily intended, for example pre-school children, pregnant and lactating women, but also about feeding patterns and attitudes. After formulation and appropriate chemical testing the products should be submitted to acceptability and consumer tests, followed by market trials. In this way the consumer's reaction can be obtained not only to the organoletpic acceptability of the product but also to the other factors, such as price, packaging and promotional methods, which make up the consumer's total response to a product.

Provided adequate preparatory work is done, and the gamut of tests shown by experience to be necessary are carried out efficiently, products which combine high nutritional value with consumer acceptability can undoubtedly be made with the use of oilseed materials as a major constituent. However, since the primary target groups are essentially the members of the lowest income groups in the countries concerned the price of the product is obviously of major importance. The price objective for protein-rich foods should be to make them approximate as closely as possible to the cost to the consumer of the item of diet for which they are intended to be partially or wholly substituted. It is generally agreed that protein-rich foods can be highly competitive in price with other foods which have been subjected to modern industrial processing techniques, and that in particular they tend to be significantly cheaper than the majority of the proprietary brands of infant and weaning foods, most of which are imported into developing countries, the difference in price being particularly significant when the respective protein contents are taken into account. However, the types of product with which protein-rich foods mainly have to compete if their nutritional objective is to be fulfilled are the staple foodstuffs of the very low income groups, which typically have not been subjected to complex industrial processing. The difference in the cost to the consumer of a product of this nature and a protein-rich food made to a high quality standard, and whose price must cover processing and distribution costs including packaging and promotion, can be expected to be significant. Accordingly it is now widely accepted that if protein-rich foods are to benefit the lowest income groups in most communities some form of Government involvement is necessary. This may be designed to reduce the price of the product as sold on the retail market. Measures of this type include guaranteed annual purchases of the product by Government for distribution through institutions, which can have an important bearing on the scale of production, remission of duties on imported raw materials etc and of sale and similar taxes. Assistance with promotion, through all the units of Government such as the health and educational services and local authorities, is a particularly valuable form of assistance in view of the high cost of promotion and the lack of development of the conventional communication media in many areas. In recent years the settling of quality standards for all nutritious foods sold within a country has attracted attention as a method of benefitting consumers at large as well as assisting with the marketing of protein-rich foods. These and other measures can contribute to reducing the price of protein-rich foods either directly or by widening the market for them. However, regardless of what can be achieved by these methods, in most countries there will remain a segment of the target group, often considerable in numbers, whose purchasing power is so low that protein-rich foods are beyond their reach. If these are to be benefitted price subsidization or free distribution will be required.

TABLE X/1

Estimated Production of Copra in Principal Countries, excluding edible Copra for direct consumption

Thousand metric tons

Producing countries	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968 (a)	1969 (a)	1970 (a)
GRAND TOTAL	3,513	2,927	2,777	3,240	3,308	3,110	3,324	3,472	3,304	3,451	3,170	3,270	3,278	3,302
Oil equivalent (64% of Copra)	2,248	1,873	1,777	2,074	2,117	1,990	2,127	2,222	2,115	2,209	2,029	2,093	2,098	2,113
ASIA														
Ceylon	188	169	225	190	276	312	248	330	274	235	211	213	198	
India	226	240	241	250	256	258	259	264	266	270	269	274	274	
Indonesia (incl W Irian)	845	546	561	632	642	390	445	592	486	531	511	630	660	
Malaysia (incl Sabah, Sarawak)	161	133	152	203	207	174	183	159	166	176	183	193	204	173
Philippines	1,444	1,202	960	1,312	1,212	1,275	1,515	1,434	1,454	1,611	1,336	1,290	1,256	1,270
Portuguese Timor	2	2	2	1	2	1	1	1	1	1	1	1	1	
Thailand	24	21	20	29	20	22	20	21	21	21	22	22	23	
Vietnam Republic	26	24	26	26	27	26	26	25	26	22	23	23	25	
TOTAL ASIA	2,916	2,337	2,187	2,643	2,642	2,458	2,697	2,826	2,694	2,867	2,556	2,646	2,640	
AFRICA														
Kenya	2	2	2	1	1	1	1	1	1	1	1	1	1	
Mauritius	2	2	2	2	2	2	2	2	2	2	2	2	2	
Mozambique	59	53	42	44	65	58	62	57	39	42	49	49	54	
Nigeria	4	5	9	7	3	2	3	8	7	5	3	3	2	
Sao Tome e Principe	4	5	5	5	6	6	5	6	6	5	5	5	6	
Seychelles	6	6	5	5	5	5	6	7	6	5	7	7	6	
Tanzania	18	27	23	20	21	20	23	30	26	24	25	25	25	
Togo	4	3	5	3	5	2	3	4	1	1	1	1	2	
Other:- Comores, Ghana	5	6	7	6	6	6	5	6	6	6	7	7	8	
TOTAL AFRICA	104	109	100	93	114	102	110	121	94	91	100	100	106	

TABLE X/1 (Continued)

Estimated Production of Copra in Principal Countries, excluding edible Copra for direct consumption

Thousand metric tons

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968 (a)	1969 (a)	1970 (a)
AMERICA														
Dominican Republic	5	6	6	6	8	6	7	7	6	3	4	4	3	
Guyana	5	5	3	6	7	6	6	6	5	6	6	6	7	
Jamaica	11	11	12	15	15	15	15	16	17	17	18	18	21	
Mexico	163	170	171	180	199	204	165	168	169	170	173	172	173	
Trinidad	20	16	15	13	13	12	14	13	13	13	13	13	15	
Other:- Dominica St Lucia St Vincent, Venezuela	19	14	12	14	20	20	23	25	23	22	23	23	26	
TOTAL AMERICA	223	222	219	234	262	263	230	235	233	231	237	236	245	
OCEANIA														
Fiji	39	32	29	35	42	40	42	42	32	25	25	28	...	
New Caledonia	3	3	2	2	2	1	2	3	2	2	1	2	...	
New Hebrides	32	35	35	24	32	31	35	38	28	35	43	41	...	
New Guinea and Papua	99	101	104	107	111	113	109	108	124	108	117	137	122	
Pacific Dependencies:- British	61	57	66	61	63	56	58	58	58	54	57	49	...	
French	24	23	25	30	28	32	32	31	27	26	23	20	...	
United States	12	8	10	11	12	14	9	10	12	12	11	11	...	
TOTAL OCEANIA	270	259	271	270	290	287	287	290	283	262	277	288	287	

... Figures not available

(a) Subject to adjustment

Sources:- 1. Vegetable Oils and Oilseeds } Commonwealth Secretariat
2. Tropical Products Quarterly }

TABLE X/2

Imports of Copra

Thousand metric tons

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968 (a)	1969 (a)
Grand Total	1,896	1,448	1,262	1,735	1,758	1,453	1,532	1,449	1,362	1,460	1,211	1,213	1,100
- of which from:-													
W. EUROPE Netherlands	-	-	-	-	7	1	3	1	1	1	1	-	1
ASIA Ceylon	36	28	44	29	56	73	44	59	42	22	16	22	19
(a) Indonesia	327	173	179	233	278	163	137	190	137	206	127	250	210
(b) Malaysia and Singapore	135	104	82	130	129	55	64	22	30	34	41	39	32
(c) Philippines	1,113	865	671	1,068	961	854	962	857	867	910	763	640	553
Other:- Portuguese Timor, Hong Kong	2	2	2	1	2	1	2	2	3	8	-	-	-
Total Asia	1,613	1,172	978	1,461	1,426	1,146	1,209	1,130	1,079	1,180	947	951	814
AFRICA Comoros	2	3	3	3	3	3	3	3	3	3	4	4	4
Ghana	3	3	4	3	2	1	1	-	-	-	-	-	-
Mauritius	-	-	1	1	-	2	-	1	-	1	-	1	1
Mozambique	46	45	38	41	60	55	47	44	29	34	43	44	41
Nigeria	4	5	9	7	3	2	3	8	7	5	3	4	2
Sao Tome e Principe	4	5	5	5	6	6	5	6	6	5	6	5	5
Seychelles	6	6	4	5	5	6	5	7	6	6	7	6	6
Tanzania	4	13	14	7	10	10	20	16	12	11	5	12	16
Togo	4	3	5	3	5	2	3	4	1	1	1	-	1
Total Africa	75	85	85	75	94	85	87	89	64	66	69	76	76
AMERICA Dominican Republic	4	5	5	4	6	3	7	7	6	3	5	6	4
Mexico	-	-	1	-	-	-	22	7	-	-	-	-	-
Other:- St Lucia, St Vincent, Jamaica	-	-	3	4	3	10	4	4	4	5	6	3	3
Total America	4	5	9	8	9	13	33	18	10	8	11	9	7

TABLE X/2 (Continued)

Exports of Copra

Thousand metric tons

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968 (a)	1969 (a)
OCEANIA	Fiji	1	1	-	2	6	7	6	7	6	2	2	-	2
	New Hebrides	34	34	36	23	33	32	36	38	29	35	43	34	37
	Papua and New Guinea	75	72	63	69	84	75	69	75	84	79	77	79	86
	Other British Oceania	61	52	63	60	64	52	54	53	53	55	33	45	67
	French Polynesia and New Caledonia	22	20	22	27	25	28	26	28	24	24	17	9	4
	US Pacific Is	13	9	8	10	10	14	9	10	12	10	11	10	6
Total Oceania		206	188	192	191	222	208	200	211	208	205	183	177	202

\- Nil or negligible

(a) Subject to adjustment (including in addition, some TPI estimates)

(b) Including Sabah, and re-export figures

(c) Estimated unrecorded shipments to West Malaysia, Singapore, and Sabah

Sources:- 1. Vegetable Oils and Oilseeds } Commonwealth Secretariat
2. Tropical Products Quarterly } Commonwealth Secretariat
3. "Oil World" Mielke & Co (for 1969)

TABLE X/3

Net Exports of Coconut Oil, and of Copra in Oil Equivalent, from Primary Producing Countries

Thousand metric tons

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968 (a)	1969 (a)
Oil		305	259	224	201	280	350	389	435	407	476	407	457	368
Copra (64% oil)		1,091	832	749	1,033	1,040	873	938	912	853	865	787	796	692
Total (as oil) of which from		1,396	1,091	973	1,234	1,320	1,223	1,327	1,347	1,260	1,341	1,194	1,253	1,060
ASIA	Ceylon	78	63	99	75	129	150	111	157	115	87	78	78	68
	Indonesia	208	7	111	145	175	103	85	120	87	82	100	185	138
	Malaysia and Singapore	56	32	20	35	43	11	23	10	17	34	37	74	39
	Philippines	805	637	495	744	689	698	828	781	797	896	723	696	568
	Total ASIA	1,147	839	725	999	1,036	962	1,047	1,068	1,016	1,099	938	1,033	813
AFRICA	Mozambique	38	35	27	27	42	37	40	37	24	26	36	39	34
OCEANIA	Fiji	26	22	15	19	29	23	24	28	19	16	16	17	18
	Papua and New Guinea	60	70	64	62	74	71	66	71	78	73	71	83	77
	Other Pacific Islands	60	55	64	54	62	55	59	60	53	59	78	70	79
	Total OCEANIA	146	147	143	135	165	149	149	159	150	148	165	170	174
Unspecified primary producers		65	70	78	73	77	75	91	83	70	68	55	11	39

(a) Subject to amendment

Sources:- Vegetable Oils and Oilseeds } Commonwealth Secretariat
Tropical Products Quarterly }

Oilword Semi-Annual Mielke & Co Hamburg

TABLE X/4

Imports of [illegible]

Thousand metric tons

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
													(a)	(a)
Grand Total - of which intra-		1,926	1,519	1,260	1,652	1,725	1,473	1,404	1,397	1,340	1,433	1,250	1,150	
W EUROPE EEC	Belgium and Luxembourg	45	19	11	30	37	24	26	35	34	43	41	29	34
	France	106	96	76	87	89	97	90	101	96	97	86	80	63
	German Federal Republic	337	349	164	250	269	233	241	279	243	289	238	158	177
	Italy	17	15	13	23	19	23	27	24	22	22	19	17	21
	Netherlands	100	97	59	47	160	108	126	132	136	168	126	141	124
	Total EEC	605	476	323	537	574	485	510	571	531	619	510	425	419
Other	Denmark	66	34	37	44	43	37	39	31	35	33	22	25	31
	Finland	2	8	5	7	11	7	9	8	8	12	14	9	8
	Norway	43	29	22	26	22	28	24	25	23	32	17	20	22
	Portugal	11	9	7	15	8	6	13	12	11	13	11	14	11
	Spain	8	5	6	10	9	11	10	11	10	12	14	11	16
	Sweden	74	66	62	68	82	32	62	57	69	72	67	45	37
	Switzerland	23	21	13	33	20	11	12	22	15	12	8	3	19
	United Kingdom	114	94	66	76	100	72	77	56	57	56	44	49	46
	Austria, Irish Republic and Turkey	9	11	4	13	14	14	8	4	[illegible]	11	4	2	3
	Total Western Europe	1,035	753	545	829	883	703	764	797	762	872	711	603	612
E EUROPE	Czechoslovakia	22	10	6	5	6	5	7	7	1	5	-	-	...
	Poland, USSR and Yugoslavia	4	2	2	10	22	15	17	16	10	6	3	5	...
	Total Eastern Europe	26	12	8	15	28	20	24	23	11	11	3	5	5

TABLE X/4 Contd

Imports of Copra

Thousand metric tons

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
													(a)	(a)
ASIA	China	25	11	6	2	24	17	6	9	6	6	...	...	...
	India	125	102	90	100	90	92	85	75	49	34	24	18	22
	Israel	15	9	2	5	9	4	4	6	5	6	3	5	9
	Japan	46	48	95	85	80	89	109	85	95	108	112	126	109
	Lebanon	8	4	3	3	6	5	4	9	5	5	...	...	...
	Malaysia and Singapore	191	147	95	121	127	84	64	23	25	26	21	24	31
	Burma, Iraq, Korean Republic, Pakistan, Syria, Hong Kong and Taiwan	o	5	11	12	9	7	4	6	3	11	15	5	17
	Total Asia	419	326	262	328	345	298	276	213	188	196	175	178	188
AFRICA	Kenya	2	1	1	1	1	2	2	2	1	2	1	-	...
	Madagascar, Morocco and South Africa	3	4	3	3	-	-	-	-	-	-	2	4	...
	Total Africa	15	5	4	4	1	2	2	2	1	2	3	4	5
AMERICA	Colombia	64	60	28	35	29	28	13	16	5	12	-	1	1
	United States	293	272	320	354	348	324	237	248	279	243	276	292	272
	Venezuela	28	42	48	47	44	51	39	49	47	50	34	21	4
	Barbados, Canada, Mexico, Panama, Surinam and Tobago	16	11	6	6	11	11	12	13	10	10	13	11	13
	Total America	401	385	402	442	432	414	301	326	341	315	323	325	290
OCEANIA	Australia	37	37	36	30	32	32	34	33	33	34	30	30	32
	New Zealand	3	1	3	4	4	4	3	3	4	3	5	5	4
	Total Oceania	40	38	39	34	36	36	37	36	37	37	35	35	36

Sources:- 1. Vegetable Oils and Oilseeds } Commonwealth Secretariat
2. Tropical Products Quarterly }

\- Nil or negligible
... Figures not available separately
(a) Subject to amendment

TABLE X/5

Imports of Coconut Oil

Thousand metric tons

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968 (a)	1969 (a)
Grand Total		390.3	324.5	270.1	270.0	316.2	373.7	415.3	460.1	447.6	490.3	504.6	524.2	512.7
- of which into:-														
W EUROPE	Belgium-Luxembourg	4.7	5.8	3.2	3.3	4.3	7.2	10.5	8.3	10.2	8.0	7.1	10.9	12.0
	France	4.1	1.4	1.5	1.7	4.0	3.2	4.6	3.1	4.0	10.6	14.9	13.3	21.5
	German Federal Republic	38.9	28.7	31.8	40.2	36.7	33.4	42.0	47.6	55.3	35.5	43.6	61.0	45.0
	Italy	24.0	19.4	14.1	22.6	19.8	17.8	15.4	16.1	15.9	18.7	24.0	23.9	28.3
	Netherlands	1.6	1.4	2.7	0.4	1.5	0.1	2.2	1.4	2.7	1.6	6.1	8.8	8.7
	Total EEC	73.3	56.7	53.3	68.1	66.3	61.7	74.7	76.5	88.1	74.9	95.7	117.9	115.5
	Austria	14.5	10.3	5.6	5.7	7.1	5.7	8.2	11.9	9.8	12.4	11.7	7.0	7.2
	Denmark	3.6	1.6	0.5	0.8	3.1	2.0	1.8	0.3	0.3	1.0	0.6	0.1	-
	Finland	13.5	7.1	4.5	2.4	0.6	0.2	0.7	0.1	0.2	0.1	-	-	-
	Sweden	3.0	1.7	1.0	1.1	0.3	2.4	6.4	3.2	2.5	1.6	0.4	1.5	1.3
	Switzerland (b)	5.8	5.4	3.4	7.1	7.1	4.5	2.8	3.7	3.2	3.6	2.6	2.1	2.6
	United Kingdom	52.1	32.9	26.7	25.3	40.4	32.2	43.0	47.6	42.7	37.5	39.0	48.1	43.2
	Cyprus, Iceland, Irish Republic, Norway, Portugal and Spain	3.4	2.9	1.9	1.8	2.5	1.7	2.8	2.0	3.8	5.1	3.0	6.5	5.2
	Total Western Europe	169.2	118.6	96.9	112.4	127.4	129.4	140.4	145.3	150.6	136.2	153.0	183.2	175.0
E EUROPE	East Germany	3.6	4.4	1.0	4.5	0.5	7.6	1.9	7.7	8.1	9.2	6.1	2.9	...
	Poland	6.1	3.1	6.1	3.7	3.6	4.8	2.6	12.2	6.0	12.0	3.2	8.6	...
	USSR	15.1	11.8	5.6	2.3	2.8	7.6	10.6	12.9	10.2	16.9	8.4	31.9	14.8
	Bulgaria, Czechoslovakia, Hungary and Yugoslavia	7.3	3.3	2.7	4.6	6.0	7.3	4.1	5.8	6.7	4.2	6.1	9.4	29.7
	Total Eastern Europe	32.1	22.6	15.4	15.1	12.9	27.3	19.2	38.6	31.0	42.3	23.8	52.8	44.5

TABLE I/5 continued

Thousand metric tons

		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
													(a)	(a)
ASIA	Burma	19.4	5.3	5.5	2.7	4.2	6.1	2.3	8.9	7.6	0.7	0.3	1.1	2.0
	China	6.6	3.8	3.3	4.1	13.2	12.2	15.[illegible]	14.7	12.0	6.6	9.5	9.2	16.4
	India	17.5	7.4	2.7	1.0	-	3.1	2.7	0.1	0.1	-	-	-	-
	Malaysia and Singapore	1.1	1.0	1.9	3.0	2.4	1.8	2.1	1.4	3.3	2.3	15.4	13.4	14.6
	Pakistan	3.2	6.1	4.7	9.3	14.8	13.1	15.0	17.3	11.7	17.0	16.9	6.0	10.9
	Taiwan	1.2	0.7	0.9	1.0	2.2	2.0	0.4	0.7	-	0.9	1.0	1.3	...
	Hong Kong, Iran, Iraq, Khmer Republic, Lebanon Saudi Arabia and Thailand	8.3	6.4	7.6	7.5	5.0	3.2	3.3	4.4	8.4	3.2	7.1	6.7	8.9
	Total Asia	57.3	30.7	26.6	28.6	41.8	41.5	41.1	47.5	43.1	30.7	50.2	37.7	52.8
AFRICA	Kenya, Tanzania, Uganda	7.4	6.3	4.1	4.9	4.9	6.6	3.1	5.0	5.6	5.5	2.9	2.9	...
	Morocco	3.1	2.5	1.6	1.5	2.4	1.9	1.8	4.4	1.8	2.0	0.7	0.9	0.4
	South Africa	7.6	7.3	4.8	6.9	7.5	8.2	8.5	7.4	6.8	9.4	7.2	8.8	7.6
	UAR, Egypt	5.3	5.5	1.9	2.6	1.9	1.3	3.6	7.9	0.8	6.2	5.1	2.9	3.1
	Malawi, Rhodesia, Somalia, Sudan and Zambia	1.8	1.0	1.1	1.0	1.8	2.0	2.7	1.3	1.9	2.4	0.8	5.8	6.9
	Total Africa	25.2	22.6	13.5	16.9	18.5	20.0	19.7	26.0	16.9	25.5	16.7	21.3	18.0
AMERICA & OCEANIA	Canada	14.1	20.5	16.0	16.1	26.3	24.7	17.2	18.0	18.0	19.3	20.2	20.5	21.6
	Cuba	2.0	2.5	4.0	3.0	10.6	5.1	5.1	3.0	2.5	1.0	-	0.1	...
	United States	83.2	98.3	89.3	70.6	75.9	120.5	168.9	180.1	182.5	231.5	237.2	201.3	193.8
	Argentina, Barbados, Colombia, Chile, Ecuador, Nicaragua, Peru, Surinam, Trinidad, Uruguay, Australia and New Zealand	7.2	8.7	6.4	7.1	4.8	5.2	3.7	1.6	3.0	3.0	3.5	7.3	6.8
	Total America and Oceania	106.5	130.0	117.7	97.0	115.6	155.5	194.9	202.7	206.0	255.6	260.9	229.2	222.2

Sources:- 1. Vegetable Oils and Oilseeds } Commonwealth Secretariat
2. Tropical Products Quarterly }
3. Official Trade Reports

\- Nil or negligible
(a) Subject to adjustment
(b) From 1957 to 1962 included Palm Oil

[illegible]

[illegible]

Quarterly and Annual Average Prices

£ and decimals per metric ton

		I	II	III	IV	Annual Average
Philippines/Indonesia cif West European Ports						
	1960	33.3	72.3	65.4	61.9	72.0
	1961	60.2	58.1	55.6	56.8	58.5
	1962	57.0	58.3	67.0	61.6	53.5
	1963	63.2	[illegible]	64.9	70.7	65.7
	1964	67.3	68.3	71.2	71.3	69.7
	1965	80.9	90.4	75.0	76.7	80.7
	1966	76.0	67.1	[illegible]	61.0	66.6
	1967	64.9	[illegible]	70.6	[illegible]	71.7
	1968	112.5	84.3	84.6	82.4	90.9
	1969	83.0	78.2	83.7	[illegible]	[illegible]
	1970	[illegible]	96.5	86.4	94.5	93.2
January and February	1971	93.1				

Source:- Tropical Products Quarterly
Commonwealth Secretariat

TABLE X/7

COCONUT OIL

Quarterly Averages and Annual Range
cif Prices - United Kingdom

(£ and decimals per metric ton)

		I	II	III	IV	Annual Average
CEYLON 1% cif Rotterdam	1957	98.4	95.3	95.7	101.6	97.7
	1958	108.5	107.8	110.0	[illegible]	112.8
	1959	131.9	145.7	129.7	140.0	136.8
	1960	134.6	112.4	103.1	96.0	111.5
	1961	93.2	91.5	87.6	84.4	90.4
	1962	87.8	89.1	86.4	92.7	89.0
	1963	96.6	99.2	103.3	106.1	101.3
	1964	[illegible]	101.1	109.0	113.2	105.3
	1965	127.9	144.4	122.8	119.4	128.6
	1966	124.0	116.1	108.9	95.8	111.2
	1967	106.6	106.3	111.2	137.1	115.3
	1968	163.5	172.9	153.0	150.3	161.2
	1969	157.5	137.8	[illegible]	139.8	141.6
	1970	166.6	152.6	147.6	162.7	157.4

Source:- VEGETABLE OIL AND OILSEEDS
COMMONWEALTH SECRETARIAT

Table 4/8

COCONUT CAKE AND MEAL

WORLD EXPORTS BY CONTINENT

		1964	1965	1966	1967	1968	1969
WESTERN EUROPE							
Belgium & Luxembourg	Met Tons £'000	1,530 42	920 26	16,700 566	1,640 47	620 23	2,700 94
Denmark	Met Tons £'000	21,200 636	20,030 637	13,130 449	15,600 481	11,220 395	11,200 387
France	Met Tons £'000	10,450 259	3,670 111	3,000 99	620 19	1,150 41	5,500 113
German Fed Rep	Met Tons £'000	1,220 36	2,240 75	2,560 88	15,180 427	1,410 55	3,070 101
Italy	Met Tons £'000	920 25	1,850 59	1,920 68	1,300 42	1,250 46	1,310 61
Netherlands	Met Tons £'000	31,940 966	41,020 1,339	49,580 1,782	34,900 1,103	40,100 1,499	23,570 838
Norway	Met Tons £'000	- -	- -	- -	- -	- -	2,330 71
Sweden	Met Tons £'000	740 20	140 5	1,120 37	310 8	- -	290 11
TOTAL For Europe	Met Tons £'000	68,000 1,984	69,870 2,252	88,010 3,089	69,550 2,127	55,750 2,057	48,470 1,688
ASIA							
Burma	Met Tons £'000	330 8	450 10	- -	- -	- -	- -
Ceylon	Met Tons £'000	17,540 362	9,500 236	290 4	40 -	180 3	- -
Hong Kong	Met Tons £'000	10 -	680 22	320 9	4,560 72	- -	- -
India	Met Tons £'000	25,600 573	19,930 537	20,840 525	6,840 138	6,460 144	9,240 218
Indonesia	Met Tons £'000	157,300 1,570	125,320 1,402	142,600 2,022	165,760 1,112	160,910 816	187,060 661
Japan	Met Tons £'000	1,250 23	100 3	810 23	2,260 49	- -	- -

Table X/8 Cont'd

COCONUT CAKE AND MEAL

WORLD EXPORTS BY CONTINENTS

		1964	1965	1966	1967	1968	1969
Malaysia	Met Tons	100	20	150	130	110	700
	£'000	3	-	4	3	4	22
Sarawak	Met Tons	120	170	160	100	100	100
	£'000	2	2	3	1	1	1
Pakistan	Met Tons	-	-	210	1,770	2,290	550
	£'000			6	37	58	14
Philippines	Met Tons	193,120	184,930	234,850	193,610	207,600	184,160
	£'000	4,324	4,328	6,025	4,164	4,951	4,068
Singapore	Met Tons	3,830	4,340	3,030	22,030	11,630	19,370
	£'000	112	107	86	473	281	454
Thailand	Met Tons	6,030	8,930	11,800	4,590	10,470	8,800
	£'000	127	213	262	96	208	184
Vietnam Rep	Met Tons	5,360	8,860	6,360	100	-	-
	£'000	130	187	125	3	-	-
TOTAL for Asia	Met Tons	410,590	363,730	421,620	401,640	399,750	409,960
	£'000	7,239	7,047	9,097	6,148	6,468	5,617
AFRICA							
Ivory Coast	Met Tons	-	-	-	1,460	950	1,720
	£'000	-	-	-	37	30	49
Kenya	Met Tons	2,110	2,230	1,210	1,690	2,240	2,340
	£'000	46	56	35	39	62	[illegible]
Morocco	Met Tons	-	-	240	900	180	90
	£'000	-	-	6	19	4	2
Mozambique	Met Tons	5,590	4,290	2,610	5,560	4,940	6,5[illegible]
	£'000	123	102	67	120	123	163
Tanzania	Met Tons	3,840	4,380	3,350	3,120	4,740	5,880
	£'000	85	116	97	71	148	168
Togo	Met Tons	-	-	-	-	450	980
	£'000	-	-	-	-	38	[illegible]
TOTAL for Africa	Met Tons	11,540	10,900	7,410	12,730	13,500	17,590
	£'000	254	274	205	236	405	498

Table X/[illegible] Cont'd

COCONUT CAKES AND MEAL

WORLD EXPORTS BY CONTINENTS

		1964	1965	1966	1967	1968	1969
AMERICA							
Dominican Rep	Met Tons	-	1,220	-	200	-	-
	£'000	-	39	-	5	-	-
El Salvador	Met Tons	50	50	10	-	-	-
	£'000	1	1	1	-	-	-
Trinidad & Tobago	Met Tons	330	60	150	-	-	370
	£'000	7	1	3	-	-	8
TOTALS for America	Met Tons	380	1,330	160	200	-	370
	£'000	8	41	4	5	-	8
OCEANIA							
Fiji	Met Tons	9,670	5,440	5,310	5,120	7,420	8,080
	£'000	180	117	133	103	180	183
French Polynesia	Met Tons	-	-	-	-	2,720	4,3[illegible]
	£'000	-	-	-	-	58	93
New Guinea	Met Tons	11,930	13,880	12,100	13,360	10,620	11,430
	£'000	222	249	291	265	248	276
TOTALS for Oceania	Met Tons	21,600	19,320	17,410	18,480	20,760	23,820
	£'000	402	366	424	368	486	552
GRAND TOTAL	Met Tons	512,110	465,150	534,610	502,600	489,760	500,210
	£'000	9,887	9,980	12,819	8,934	9.416	8,364

- Information not available.

Source:- FAO Trade Return, Rome.

able X/9

OCONUT CAKE AND MEAL

ORLD IMPORTS BY CONTINENTS

		1964	1965	1966	1967	1968	1969
ESTERN EUROPE							
ustria	Met Tons	1,650	1,900	1,720	1,770	1,210	1,320
	£'000	51	63	61	59	48	49
elgium & Luxembourg	Met Tons	16,270	11,230	95,830	10,960	10,660	8,990
	£'000	450	343	2,954	325	389	311
enmark	Met Tons	79,790	65,660	50,300	60,160	37,190	30,790
	£'000	2,176	1,966	1,637	1,628	1,233	1,030
rance	Met Tons	5,100	2,490	5,190	3,840	3,120	4,530
	£'000	143	70	175	117	116	148
erman Fed Rep	Met Tons	284,840	320,530	382,730	322,780	366,190	374,520
	£'000	8,055	9,914	13,134	9,693	12,865	12,486
taly	Met Tons	130	120	510	320	50	940
	£'000	1	4	20	11	2	30
etherland	Met Tons	38,100	22,810	29,980	82,080	39,400	58,240
	£'000	901	535	677	2,098	1,151	1,908
orway	Met Tons	300	5,080	-	-	990	-
	£'000	10	166	-	-	40	-
weden	Met Tons	35,480	39,120	30,850	34,580	32,970	27,830
	£'000	1,071	1,320	1,098	1,076	1,238	985
OTALS for Western Europe	Met Tons	461,660	468,940	597,110	516,490	491,780	507,160
	£'000	12,858	14,381	19,756	15,007	17,062	16,947
ASTERN EUROPE							
ungary	Met Tons	-	-	280	200	-	-
	£'000	-	-	7	7	-	-
OTALS for Eastern Europe	Met Tons	-	-	280	200	-	-
	£'000	-	-	7	7	-	-
SIA							
ong Kong	Met Tons	940	1,370	320	2,460	270	110
	£'000	17	31	9	53	7	3
apan	Met Tons	2,140	3,620	350	300	290	-
	£'000	36	57	6	7	7	-

Table X/9 Cont'd

COCONUT CAKE AND MEAL

[illegible] IMPORTS BY CONTINENTS

		1964	1965	1966	1967	1968	1969
Malaysia West	Met Tons	14,110	12,900	11,040	17,610	15,700	20,280
	£'000	377	360	270	381	325	493
Sabah	Met Tons	-	-	-	-	10	40
	£'000	-	-	-	-	-	2
Sarawak	Met Tons	120	150	240	510	160	220
	£'000	4	5	7	13	5	7
Singapore	Met Tons	7,080	8,890	5,130	5,010	730	2,850
	£'000	184	237	137	38	21	61
Vietnam Rep	Met Tons	-	100	-	-	770	1,970
	£'000	-	1	-	-	32	79
TOTALS for Asia	Met Tons	24,390	27,030	17,060	23,890	17,930	33,470
	£'000	618	691	429	492	397	645
AMERICA							
Trinidad & Tobago	Met Tons	-	-	-	110	40	-
	£'000	-	-	-	3	1	-
TOTALS for America	Met Tons	-	-	-	110	40	-
	£'000	-	-	-	3	1	-
GRAND TOTALS		486,050	495,970	614,470	540,690	509,750	540,630
		13,476	15,072	20,193	15,509	17,480	17,592

- Information not available.

Source:- FAO Trade Return, Rome.

TABLE 4/10

COCONUT CAKE

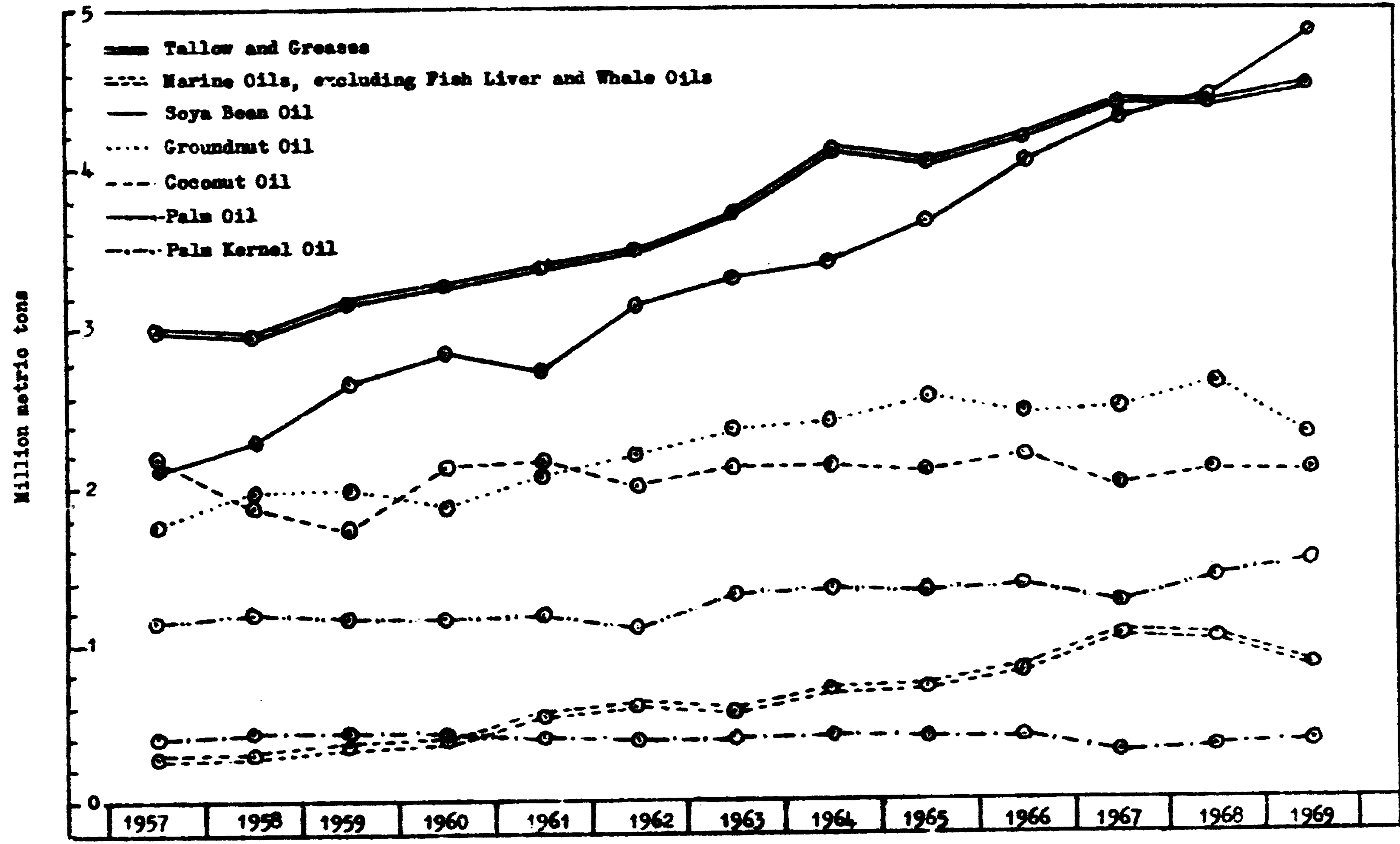
Prices cif European Ports

£ and decimals per metric ton

	Coconut Cake	Ground-Nut Cake	Cotton-Seed Cake
1960	28.1	35.1	29.0
1961	24.6	33.1	28.3
1962	32.0	36.4	32.0
1963	31.4	38.0	32.5
1964	28.3	39.2	32.6
1965	28.0	43.0	33.5
1966	33.7	39.6	33.0
1967	29.4	40.0	35.0
1968	35.5	44.2	37.5
1969	34.3	46.0	36.1
1970	38.4		

Sources:- COCONUT SITUATION Nos 23 and 24
FAO ROME
Production Yearbook 1970 FAO Rome

ESTIMATED PRODUCTION OF SELECTED FATS AND OILS, ANNUAL TOTALS (CHINA EXCLUDED) FIGURE XI



Source:- Coconut Situation, F.A.O. United Nations

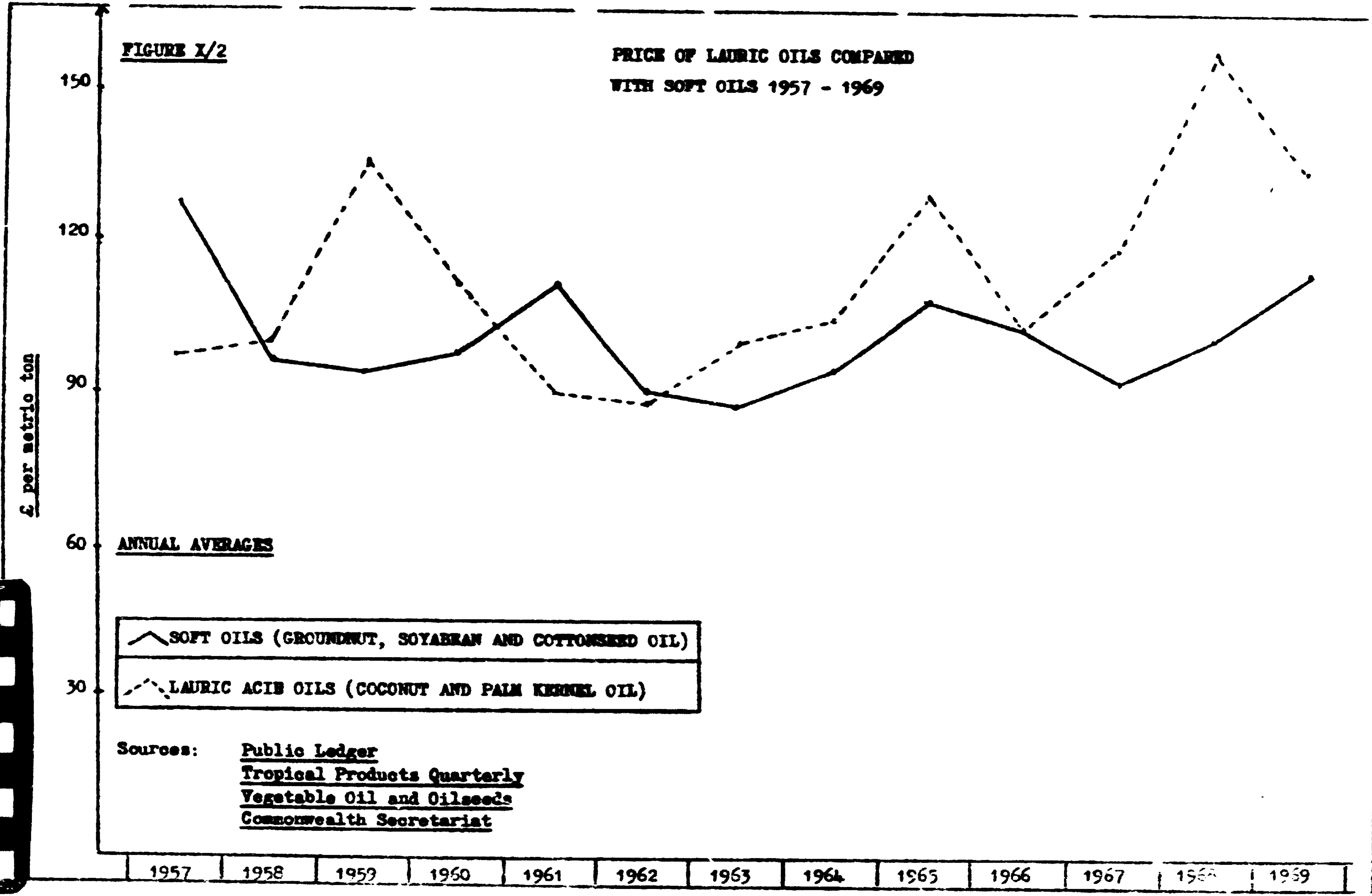


FIGURE X/2
PRICE OF LAURIC OILS COMPARED
WITH SOFT OILS 1957 - 1969
£ per metric ton
150
120
90
60
30
ANNUAL AVERAGES
SOFT OILS (GROUNDNUT, SOYABEAN AND COTTONSEED OIL)
LAURIC ACID OILS (COCONUT AND PALM KERNEL OIL)
Sources: Public Ledger
Tropical Products Quarterly
Vegetable Oil and Oilseeds
Commonwealth Secretariat
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1969

4. 2. 74