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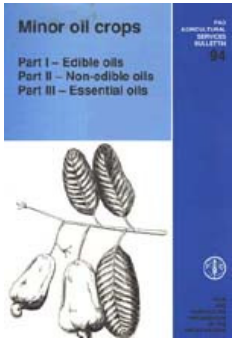

Minor oil crops

Part I - Edible oils
Part II - Non-edible oils
Part III - Essential oils

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Preface

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Oilseed crops especially those produced in developing countries have been used traditionally since the origin of humanity by populations in Africa, Asia, Europe and the Americas. Besides food uses, many such crops also find applications in industries such as those relating to cosmetics, medicine, soap manufacturing, flavouring and perfumes. Apart from a limited number of documented cases very little is known about the conditions of their production, post-harvest handling, processing, trade and utilization.

Developing countries can no longer rely on quasi monoculture in order to support their growing economies. Under the current conditions, such dependency has, in fact, led them to vulnerability and losses because of the declining prices paid for the goods. It is, therefore, imperative for them to diversify their production and create value added through processing thereby reducing risks and opening new local and export markets. There is a necessity to investigate new opportunities. In this connection, minor crops could provide an answer. The purpose of this publication is to present a

series of monographs on minor oil crops for food and non-food use as well as for use as essential oils. It has been divided into three sections namely: (1) Minor edible oil crops, (2) minor non-edible oil crops, and (3) minor essential oil crops. In compiling these monographs, it became clear that the information available varied to a considerable extent, depending on the commodity and on the technical field. In many instances, there was little or no scientific and technical data on aspects of production, post-post-harvest handling, processing and utilization. Major gaps of knowledge were recorded concerning equipment, processing costs, perspective for improvement in methods of production and processing. FAO will therefore be grateful for any contributions readers would wish to make to a possible new edition. All suggestions should be addressed to the Chief, AGSI, FAO, Rome, Italy.

Morton Satin
Officer in Charge
Agricultural Services Division

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Abbreviations

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BTU	British thermal unit
C	Celsius
cm	Centimetre
deg	Degree

ha	Hectare
hr	Hour
kg	Kilogram
km	kilometre
m	Metre
mt	Million tonnes
(n)	Refer to bibliography

Introduction

This document takes the form of a series of monograph" covering twenty three minor edible oil crops and is the result of a desk study carried out in the UK. Some 800 references have been consulted and library/data base searches carried out in the Natural Resources Institute, Kew Gardens, Silsoe College and CAB International. In many, if not, most cases there are considerable gaps in information available on the oils from the crops researched, and this is particularly true of the traditional methods that are used for oil extraction. It is suspected that more, possibly unpublished, data is available in the countries in which the commodities occur.

Some of the commodities covered particularly those of the Curcubitaceae family, it appears, are little used for direct oil extraction. At the rural level the quantity of seed available is unlikely to warrant such activity. They are however of significant importance in the provision of oil in the diet. In many countries the seeds of gourds and pumpkins are collected at the household level and incorporated in foods so providing much needed calories. It is only when large amounts of such materials are processed at one site that sufficient seeds would become available to warrant extraction. One example of this type that was identified was the extraction of passion fruit seed oil for use in medicinal preparations, the seeds being a by-product of a large passion fruit processing plant

in Sri Lanka.

Hopefully this document will prompt workers to provide further information and so build up knowledge of what appears to have been a somewhat ignored technical area for many minor oil crops are of vital dietary and economic importance to large numbers of poor people around the world and some it is suggested could prove of much wider application.

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Principals of extraction

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Principles of Oil Extraction

The extraction of oil from an oil bearing commodity involves some or all of the steps shown in the flow diagram shown overleaf, depending on the particular commodity to be processed, the scale of operation and the technical options available to the processor.

Decortication

The first stage of the process sometimes requires the separation of the oil bearing part of the plant be it a nut, fruit or seed. The process is generally referred to as decortication or dehulling. Seeds with thin testa similar to rapeseed or sesame seed can be processed without decortication.

Breaking

In most cases the oil bearing material is then broken into smaller pieces by pounding in a pestle and mortar or by manual or motorised grinding. When motorised oil expellers are used the decorticated or undecorticated material can often be fed directly to the expeller.

Cooking

The next step involves heating the oil bearing material, sometimes with the addition of a little water to assist in the rupture of oil bearing cells and in the liberation of oil. At small scale this is carried out in a pan over a fire but mechanised heaters or kettles are available and used in commercial plants small scale heater-Cecoco.

Figure 1 - Small Scale Heater (scorcher) Cecoco

Extraction

The oil bearing material is now ready for oil extraction. Five basic technical options exist; hot water floatation, ghanis, manual presses, powered expellers and solvent extraction.

Traditional Methods

1. **Hot water floatation is probably the simplest method and i" still used in many rural areas. The ground material is placed in boiling water and simmered for several hours. On removing from the fire and cooling the oil floats to the surface and is skimmed off. In general the oil is then heated in a shallow pan to drive off the last traces of water. This improve" the keeping quality of the oil as water has a catalytic role in the development of rancidity in oils. The extraction efficiency is generally low, and problems often occur with the formation of oil-water emulsions which makes the final separation difficult. In some cases salt is used to**

break such emulsions.

2. **In many countries a large rotating pestle and mortar system known as a ghani is used for oil extraction. Ghanis are powered by animals or motors (power-ghanis) although sometimes human power is used. The mortar is firmly fixed in the ground and as the pestle rotates oil is released by friction and pressure and runs out of a small aperture at the base of the mortar. A typical one bullock ghani can process 40 kg of material/day. In the case of power-ghanis either the pestle or mortar is fixed, the other rotating. Power ghanis usually are operated in pairs and have a typical capacity of 100 kg/day. The extraction efficiency is generally greater than animal units.**
   Figure 2 Traditional Animal Powered Ghani
   Figure 3 Power Ghani
3. **Other traditional methods are still used to extract oil from oil bearing materials. Such systems include the use of heavy stones, wedges, levers and twisted ropes to apply pressure to the material and so squeeze out oil. They are inefficient, of low capacity and labour intensive.**

Manual Presses

Traditional presses are now increasingly being replaced by better engineered, more efficient mechanical presses. Many different types of mechanical press are in use but they fall into two basic types, plate presses and ram presses. In the first type a plate or piston is forced into a perforated cylinder containing the oil bearing material by means of a worm. In some cases hydraulic jacks have been used, care is needed to make sure there is no leakage of hydraulic fluid that might contaminate the edible oil. In a ram press a piston forces the oilseed forward in a perforated cage fitted with an adjustable choke at the outlet, which controls the pressure. Ram presses provide a greater shearing action than simple screw presses and have been found to be considerably more efficient for some raw materials. It is important that when selecting a particular type of press its suitability for the raw material to be processed is confirmed.

Figure 4 -Plate Press

Figure 5 - Ram Press

Powered Presses

To obtain greater throughputs and extraction efficiencies it becomes necessary to use powered devices and the oil expeller is the most common of these. A whole range of expellers are available with capacities ranging from a few kg/hr up to tons/hr. They all work on the same basic principle. The raw material, which may have been previously heated to aid in the release of oil, is fed continuously to the expeller where it is fed by the wormshaft into a horizontal cylinder. A controllable pressure is built up in the cylinder by means of an adjustable choke at the cylinder exit. The internal pressure ruptures oil cells in the material and oil flows out through perforations in the cylinder cage. Some care has to be taken when selecting an expeller for a particular commodity. Many Have been designed for particular applications, in terms of internal pressure, amount of shearing action etc. Certain types tend to be more adjustable and hence less product specific than others.

Small scale expellers c 40 kg/hr

Figure 6 - Cecoco

Figure 7 - Mini 40

None of the above extraction systems are able to remove all of the oil from a material. In most small scale rural situations this is of little or no importance as the cake, that remains after the oil has been removed, finds uses in local dishes, in the manufacture of secondary products or for animal feed. Some raw materials however do not release oil by simple expelling; the most notable being rice bran. In order to remove oil from commodities that do not respond to expelling or to extract the final traces of oil after expelling it is necessary to use solvent

extraction. Solvent extraction is a high technology process that has to be carried out at comparatively large scale. Capital costs are high. Essentially the process is one of continuous countercurrent extraction with the raw material flowing in one direction against a solvent; usually hexane. After oil extraction the solvent passes to a recovery plant where the solvent is stripped off under vacuum. The crude oil then passes on for refining. Due to the large scale involved it would seem unlikely that solvent extraction would find much application in minor oil product processing.

Refining

The last stage in the processing of an oil is refining which includes some or all of the following treatments:- filtering, neutralisation, winterising, bleaching, deodorisation and degumming and filtering. In many cases refining is not a necessary stage in traditional processing systems as local palates are accustomed to the flavour of unrefined oils and in many parts of world these flavours are in fact preferred to the blandness of a fully refined oil. Many crude oils contain free fatty acids (FFA) which impart unpleasant odours and flavours. The FFA's are neutralised by treating the oil with a carefully controlled quantity of caustic soda solution. In larger oil refineries the caustic soda washes are sold on for soap manufacture and are known as soap stock.

Winterising involves allowing the oil to stand at low temperatures, during which time higher melting glycerides crystallise and are separated by filtration.

Some oils are rather dark in colour and are bleached by the addition of a small amount of bleaching earth or activated carbon prior to filtration. Many commercial plants in fact bleach crude oil as routine and then add a controlled amount of colour in order to produce a standard final product.

De-odourising involves sparging steam through the oil, usually under vacuum. The steam removes volatile odours, for example the coconut smell of coconut oil.

In some cases it is also necessary to treat oils with small amounts of water in order to remove gums and mucilages that are released along with oil as the plant cells rupture during extraction. These gums mainly consist of phospholipids. The above treatment, with heat, causes the gums to flocculate after which they may be removed by centrifugation or settling.

Oils produced at small scale in rural areas are rarely given all but a rudimentary level of refining, usually filtration. However clarity can be improved by filtration through cloth packed with fine sand or charcoal.

Vegetable food oils are of great importance in the diet, they are a concentrated form of energy vital to people all over the world. In developing countries poor people rarely have access to or can afford cooking oils from larger refineries and still rely on minor oil crops to meet their needs. In some cases viable and important local industry and trading is involved.

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Individual monographs

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Argan

I. GENERAL

COMMON NAME

Argan

BOTANICAL NAME

Argania sideroxylon, Argania spinosa

FAMILY

Sapotaceae

OTHER NAMES

Arga, Argaria, Arganier, Arjardin, Iron wood, Moroccon iron-wood tree

CULTIVATION CONDITIONS

The tree grows wild in south western Morocco over an area of some 740 000 Ha. It is well suited to calcareous soils and semi desert conditions. Modern developments have destroyed much of the previously extensive forests, protection is urged. The region has an annual rainfall of 100-m.

MAJOR PRODUCING COUNTRIES

MOROCCO

YIELD AND DESCRIPTION

The tree begins to bear fruit when it is five years old and has a life span of 125-150 years. The olive sized fruit are round to oval and turn bright yellow when ripe. Each fruit bears one to three oval brown smooth seeds,

about 2 cm long. The seeds contain up to 50% of a light brown oil (Farines). Inside each seed testa is a white, bitter oil rich kernel. Production is at its maximum when the tree is 60 years old. The average yield of fruit per tree is estimated to be 8 kg per annum. The Argan tree has the ability to retreat into a state of dormancy for a prolonged period in the advent of drought conditions and thus does not necessarily bear fruit every year (Mellado). The pulp of the fruit around the seed is reported to contain 20% sugars, 13% cellulose, 6% protein and 2% fat (Morton).

MAIN USES

In addition to its importance as a source of edible (cooking) oil the argan tree is also a major source of forage for sheep, goats and cattle. The timber is used as fuel. Protection areas have now been established to prevent this use of the tree. At a local level the wood is still used to make ploughs, wooden implements and utensils (Mellado).

II. AGRICULTURAL ASPECTS

CULTIVATION

The tree is not grown in plantations although its possible role in reforestation in Spain has been studied (Montoya). The seed" tend to germinate poorly without some assistance, those that survive having usually passed through the digestion tracts of grazing animals, particularly goats. Strict conservation measures have been implemented to prevent the threat of extinction caused by clearance, its poor germination quality and the fact that the timber is an excellent fuel (Mellado).

HARVESTING PERIOD

Harvesting takes place during September.

HARVESTING METHODS

Three main methods are used to harvest argan fruit, two of which involve the use of animals. Grazing goats sometimes eat the fallen fruits, spitting out the seeds which are then gathered up by hand. Camels are also fed the fruits, the seeds are indigestible and pass through the animal to be excreted. These seeds are then gathered from the dung. An alternative harvesting method is simply to shake the tree causing the fruits to fall to the ground for manual collection.

III. POST HARVEST TREATMENT. PRESERVATION AND STORAGE

PRE-TREATMENT

The fruits are sun dried until they reach approximately 50% of their original weight. The fruit is hit with a stone and the outer dry pulp separates cleanly from the inner nut.

IV. PROCESSING

PROCESSING METHOD

The nuts are cracked by hand using a stone hammer and anvil and the kernels removed.

OIL EXTRACTION

Traditional methods of processing involve the seed being roasted and then ground manually to a paste. Tepid water is added to the mixture and the oil which floats to the surface decanted off. More modern methods of oil extraction use small oil presses, typically olive presses. The first pressing produces edible oil, the second cooking oil. (Mellado).

MAJOR FATTY ACIDS OF OIL

Myristic acid	4.3%
Palmitic acid	13.5-13.9%
Linolenic acid	4.6%
Stearic acid	5.6-5.7%
Oleic acid	45.2-46.9%
Linoleic acid	31.5%

(Source: Mellado and Morton)

LOCAL PRODUCTS

The oil is mixed with almonds and honey to make an almond butter known locally as "amalou". Mixed with wheat germ and honey it makes a breakfast gruel locally called "sematar" (Mellado).

EQUIPMENT

Roasting pans, grinding mills, pestles and mortars and small expellers. There is a lack of identifiable information about the following areas: GENERAL, production; AGRICULTURAL ASPECTS, major pests and diseases; POST HARVEST, preservation, storage and equipment; PROCESSING, processing methods, by products,

nomenclature of products; OIL EXTRACTION, By products.

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Avocado

I. GENERAL

COMMON NAME

Avocado

BOTANICAL NAME

Persea americana

FAMILY

Laureacea

OTHER NAMES

Palta

HABITAT

Temperate to Tropical

MAJOR PRODUCING COUNTRIES

Native to Central and S. America. Now widely distributed in tropical and subtropical countries worldwide.

Mexico, USA, Brazil, Dominican Republic, Israel

YIELD AND DESCRIPTION

While only one species is usually recognized there are 3 ecological races; Mexican, Guatemalan and West Indian. The Mexican, the most hardy, has the highest pulp oil content, up to 30% but is of little economic importance except for its hybrids. The Guatemalan, which is less resistant to cold, has a medium oil content of 8-10% while the tropical West Indian has only 3-10% oil in the pulp. Inter-racial hybrids are grown

commercially (Purseglove).

The avocado tree grows to a height of 20m and bears the well known fruit which can weigh up to 1.5kg. The single seeded fruit 7-20cm long has a leathery skin which ranges from yellow-green to purple in colour. The edible mesocarp or pulp is yellow to yellow-green in colour and has a buttery consistency.

The tree starts to bear fruit when 3-6 years old and has a productive life of 25-35 years.

The pulp contains 65-80% moisture, 1-4% protein and 3-30% oil. The kernels contain little oil, about 1%. It has been shown that oil content increases dramatically in the last months of ripening (Human). In S. Africa fruit is picked for fresh consumption when the oil content is about 8% but at this stage of ripeness it is not suitable for oil extraction. Oil is generally extracted from culled fruit that are left to fully ripen after harvesting (Human).

In 1981 world production of avocado oil was 300 000 T.

MAIN USES

Avocado fruit is mainly for fresh consumption. It is also sold frozen with lemon juice and spices (Guacamole), as a cheese-like fermented food and as pulp for use in ice cream (Hilditch). (Jacobsberg).

Avocado oil is being strongly promoted for cosmetics and, after refining as a high price food oil. It has also been shown to be a most effective sun screen oil. In 1976 the US. FDA register recorded 240 cosmetic products containing avocado oil at levels of 0.1- 50% (Swisher).

II AGRICULTURAL ASPECTS

CULTIVATION

Avocado trees can be grown from seed but are better propagated vegetatively. The plants are transferred to orchards at 6-9 months. The normal planting distance is 20-40 ft. Maturity can be tested by oil content (Purseglove).

Yields are variable between 100-500 fruits per tree. Good orchards in California give 3-6 tons of fruit/ acre/annum (Purseglove).

HARVESTING PERIOD

As required

DISEASES AND PESTS

The most serious disease is root rot caused by Phytophthora cinnamomi. Other serious diseases are Cercospora spot, Anthracnose, and Scab. Scale insects, mealy-bugs and mites may cause damage. The sugar cane root weevil causes damage in Puerto Rico.

HARVESTING METHODS

Hand picking is most common.

III POST HARVEST PRE-TREATMENT. PROCESSING, STORAGE

PRE-TREATMENT

After harvesting the fruit should be allowed to ripen fully to give maximum oil yield. Depending on the method to be used for oil extraction the fruit may then be opened and, after removing the seed, sun dried.

IV PROCESING

OIL EXTRACTION

A number of methods have been proposed including mashing the pulp and after boiling skimming off the oil, high pressure pressing of dried slices, solvent extraction, expellers, presses and centrifugal extraction.

Another proposed method involves rendering; heating the pulp in avocado oil and evaporating off the moisture. The remaining slurry of oil and plant material is then pressed. Small scale trials showed that 57% of the oil could be decanted off after rendering and after subsequent pressing oil recoveries of 94% were achieved (Human). The addition of chalk, which precipitates the fruit pectins, has been found to improve oil release from the cells (Hilditch).

The crude oil is dark green/brown in colour, red under reflected light due to its high chlorophyll content and may be refined by alkali refining, bleaching, deodorizing and winterising. If very old rotten fruit is used as a raw material the oil may need alkali refining to remove FFA (Human).

Avocado oil has one major disadvantage in so far as it develops a bitter taste if heated. It is considered that treatment to overcome this defect would be very difficult (Human).

MAJOR FATTY ACID COMPOSITION OF OIL

The oil composition varies greatly,

Palmitic acid	7.2-26.1%
Oleic acid	64.8-80.9%
Linoleic acid	6.3-11.3%

(Source: Hilditch)

EQUIPMENT

Presses, expellers, centrifuges, solvent extraction plants, refining and filtering equipment.

NOMENCLATURE OF PRODUCTS

There is a lack of identifiable information on details of oil extraction methods and refining methods in use.

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Babassu palm

I. GENERAL

COMMON NAME

Babassu Palm

BOTANICAL NAME

Orbignya martiana

Orbignya oleifera

FAMILY

Palmaceae

OTHER NAMES

Babacu, Coco de macaco, Aguassu

CULTIVATION CONDITIONS

The crop requires a tropical climate, high temperature, plenty of sunshine, fertile soil and an adequate water supply. Q. martiana is best suited to a humid climate and is found in rainforest regions whilst Q. oleifera is found in drier, semi deciduous forests (Godin). Q. oleifera thrives under conditions sub-optimal for the cultivation of coconut (Godin), and appears to be restricted to the Sao Francisco River Basin in Minas Gerais, Brazil (Anderson).

MAJOR PRODUCING COUNTRIES

Babassu is widespread in Brazil, Mexico and Guyana. In Brazil alone it occupies an estimated area of 2-00 000 km which is concentrated in the states of Maranhao, Piaui and Gojas (May).

It is estimated that there are between 5 and 25 billion trees in Brazil (Ecky).

In 1980 Brazil harvested 254 000 tonnes of wild Babassu nuts (Bucher).

YIELD AND DESCRIPTION

The Babassu palm produces fruit in large bunches containing, on average, 200 individual fruits. However, bunches with up to 600 fruits do occur. The individual bunch weights range from 40-90 kg and the tree produces 1-4 bunches each year. Production starts at around 8 yrs old. (Anon). The individual fruits are 8-15 cm long and 5-9 cm broad and weigh 150200 g. Each contains 3-8 kernels with an oil content of 60-70% (1). The dry fruit is made up of 11-14% outer shell, 14-25% mesocarp, 50-67% woody inner shell and 610% kernels. (Peace). The outer fibrous portion of the fruit contains only about 1% oil (Ecky). Palms growing wild produce only 20 kg/ha compared to 1500 kg/ha in plantations. This is largely due to the greater tree density.

MAIN USES

In addition to its importance for the extraction of edible oil the Babassu palm can be used to make many products during its lifecycle. The leaves are used for thatch, basket work, construction and fodder, the trunks for bridges and building and the fruit for animal feed and charcoal (May). The palm is of considerable economic importance in rural Brazil and it is estimated that some 450 000 families collect and process Babassu.

II. AGRICULTURAL ASPECTS

CULTIVATION

Naturally growing forests are important ecologically as they possess a unique method of nutrient recycling which supports other forms of agriculture. While most palms grow in this way some plantations have been established in Brazil (Anderson).

The two species Q. martiana and Q. oleifera are often classed as different varieties.

HARVESTING PERIOD

In Brazil mature fruits begin to fall from their bunches between August and November and continue to drop until the rainy season begins in January and February.

When the tree is in flower all the year round it does not usually bear fruit.

Fruits lying on the ground at harvest are attacked by bruchid beetles (Pachymerus nucleanum) which enter the fruity and eat the kernels. After a period of three months some 70% of the fruits on the ground will have at least one kernel destroyed by the larvae. The larvae are known locally as "gongo" and are used for fish bait or fried for consumption (May).

HARVESTING METHODS

Harvesting occurs naturally, as the seeds ripen and mature they fall to the ground. They are then gathered by hand.

III. POST HARVEST TREATMENT, PRESERVATION AND STORAGE

PRE-TREATMENT

The nut is dried in the sun to facilitate the removal of the shell from the kernel. If protected from rain etc., babassu fruits can be stored without undergoing any signs of deterioration for some considerable time.

IV. PROCESSING

PROCESSING METHODS

The fruits have a hard thick shell (averaging 5cm in diameter) which is difficult to crack by machine. It is estimated that a pressure of approxi mately 1 tonne is needed to crack the shells open. While mechanical crackers have been developed their weight and power requirements have in general made them inappropriate for use in Babassu growing areas. As 1 tonne of nuts only yields 120 kg of kernels transportation of whole nuts to crackers has also proved impractical. In most areas the kernels are extracted locally by hand. The National Academy of Sciences estimates that this hand cracking accounts for 57% of the total processing cost. (Anon) It is important that the seeds are dried before decortication. If they have a high moisture content damage, occurring during the process, can initiate enzy matic activity and cause rancidity in the oil.

Decorticating is usually carried out at home although some women do remove the kernels in the forest. The fruit is placed on a hatchet blade or an axe and is hit with a wooden club until it splits. The broken pieces are in turn hit against the blade to dislodge the kernels. Most people can extract 3-5 kg kernels per day and a good worker can sometimes extract up to 10 kg.

A small proportion of the kernels extracted (0.7 kg per household during peak harvest period) is used domestically. The rest are sold immediately after cracking.

LOCAL PRODUCTS

The fruit's mesocarp can be ground into a meal for animal feed or human consumption.

The shells are suitable for fuel or can be made into charcoal. Husks are sometimes burnt in fields to protect crops against insect" or in some areas used to smoke rubber.

Local households produce charcoal on a weekly or biweekly basis. The husks are dried and then pushed

gradually into a pit about 1m diameter and 1m deep.

They are burnt for one hour after which time water is sprinkled on them. After being left overnight they are collected and stored in baskets. An average household uses 25 kg charcoal per week for cooking May).

Babassu charcoal is also being increas ingly sold to national and foreign buyers for fuel use in industry.

OIL EXTRACTION

Oil is removed by hot water floatation or mechanical expression.

Hot Water: Kernels are lightly roasted and then mashed in a mortar. Water is added and the mixture boiled. The oil released rises to the surface and is skimmed off (May).

Expression: After grinding, oil can be extracted from the kernels in simple presses. On a larger scale conventional screw oil expellers are used .

The kernel yields 60-70% of an oil which is somewhat similar to coconut oil. It is colourless and does not readily become rancid. Refined oil can be used for margarine production and general food purposes. The crude oil is suitable for soap production and detergents. It is also used for burning in lamps.

MAJOR FATTY ACID CONPOSITION

Caprylic acid	4-6%
Capric acid	6-7%
Lauric acid	44-46%
Myristic acid	15-20%

Palmitic acid	6-8%
Stearic acid	3-5%
Oleic acid	12-18%
Linoleic acid	1.4-2.8%

(Source: Echy)

At tropical ambient temperatures the oil is completely liquid but in temperate climates it solidifies, having a consistency similar to petroleum jelly and becoming white in colour (Peace).

LOCAL PRODUCTS

Dried residues of the kernels are used in coastal areas by fisherman to make a fish bait (May).

The cake remaining after oil extraction is somewhat similar to coconut oil cake, and is used in cattle feed. However, the irregular supply of this material has meant that it only occasionally used in formulations at levels of 5-10. (Lennerts).

EQUIPMENT

Nut Crackers, stones, axes, clubs. Mortars and Mills. Cooking pots and ladles for floatation extraction, Presses and expellers. There is a lack of identifiable information for the following areas: AGRICULTURAL ASPECTS, planting period and major diseases; POST HARVEST, pretreatment; OIL EXTRACTION, nomenclature of products.

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Balanites

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I. GENERAL

COMMON NAME

Balanites

BOTANICAL NAME

Balanites aegyptiaca

Balanites maughamii

FAMILY

Zygophyllaceae

OTHER NAMES

Desert Date, Lolab Tree H Heglig, Loba, Shashoba, Tau, Saronga, Q-og-g-ogat (Sudan)

CULTIVATION CONDITIONS

Balanites is particularly suited to arid regions and is widespread in African savannah areas.

MAJOR PRODUCING COUNTRIES

SUDAN, It is also found growing in neighbouring parts of East and West Africa, particularly Nigeria, and also in Arabia.

YIELD AND DESCRIPTION

The deep rooted Balanites tree lives for more than 100 years, for 75 years annually producing crop of 125 kg of ripe fruit. The ripe fruit resemble a date in size and appearance. The brown outer skin consists of a sticky pulp within which lies the oil bearing seed or nut. Analysis has shown that the fruit typically consists of 21.8% outer skin, 30.7% pulp, 36.7% shell and 10.8% kernel on a dry basis. The fat content of the kernels is high, levels of 40-46% edible oil having been reported (Abdel-Rahim).

It is estimated that there are a million trees growing in the Blue Nile province which could produce up to 100 000 tonnes of whole fruit annually and that some 14000 tonnes of oil could be extracted from existing Balanites resources in the Sudan (Anon).

MAIN USES

The Balanites tree is used locally for many products: the wood is used for making tools and furniture, the fruit for sweets and alcoholic beverages, and the kernels for cooking oil and medicines. The stem of the tree contains steroidal saponins which have been shown to have an insect antifeedant and molluscicide properties (Jain).

II. PROCESSING

PRE-TREATMENT

Shelling has been noted as a problem, one solution that has been used to improve efficiency is to simply saw the nuts in half to release the kernel (Hardman).

Every ton of whole fruit processed yields half a ton of hard woody shell which is highly combustible and produces a high quality charcoal (Anon).

OIL EXTRACTION

Oil is obtained by simple expression methods.

The kernel yields a highly stable, golden yellow oil suitable for cooking.

MAJOR FATTY ACID COMPOSITION

Saturated acids	24.0%
Oleic acid	31.0%
Linoleic acid	43-45%

(Source: Ecky)

BY-PRODUCTS

The oil extraction process produces an oilcake suitable for animal feed. It has a high protein (36.8%) and low fibre content (5.9%) (El Khindar).

EQUIPMENT

Camel driven ghanis or simple presses are used for oil extraction.

There is no identifiable information for the following areas: AGRICULTURAL ASPECTS planting material, varieties, planting period, major pests and diseases, harvesting period and harvesting methods; POST HARVEST, pretreatment, preservation, storage and equipment; PROCESSING, processing methods, nomenclature of products and equipment.

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Borneo tallow nut

I. GENERAL

COMMON NAME

Borneo Tallow Nut

BOTANICAL NAME

Shorea spp.

FAMILY

Dipterocarpaceae

OTHER NAMES

Tenka wang nut (Borneo), Enkabang illipe (Sarawak), Borneo Illipe

CULTIVATION CONDITIONS

The crop grows wild in the tropical rainforests of South East Asia, Indonesia and Borneo. A variety, Shorea robusta, occurs in North and Central India but is not generally regarded as source of Borneo Tallow. The Borneo Tallow tree grows in fresh water swamps, along river banks in alluvial soils and shallow peat (Godwin) .

MAJOR PRODUCING COUNTRIES

SARAWAK, Borneo, Java, Malaya, Philippines.

In peak years 41 000 tonnes may be exported, mainly from Indonesia (Godwin).

YIELD AND DESCRIPTION

The Borneo Tallow tree produces a egg-shaped winged fruit. The fruits vary in size between species but are typically about 4 cm long with a woody shell and brown or black in colour. The fruit contains the oil bearing kernel which has a typical fat content of 45-70%. Yields of 1,138 kg/ha of dried kernel have been reported.

The tree does not start to bear fruit until it is 18-25 years old.

MAIN USES

The tree provides a high quality timber. The fruit is processed to produce oil which is subsequently used as a substitute for cocoa butter, as well as in soap, candles, medicines and cosmetics.

II. AGRICULTURAL ASPECTS

CULTIVATION

The tree usually grows in the wild. The seed either falls and germinates under neath the mother plant or is carried away by flood streams to germinate in similar conditions elsewhere (Godwin).

Insect pests such as Lepidoptera and Coleoptera species may feed on the fruit during storage and spoil the quality of the oil by causing an increase in the free fatty acid content. Other species reported to be pest"

include: Poecilips gedeanus (Beaver), and Tirathaba spp. (Brady).

HARVESTING METHODS

Fruits are gathered when they fall from the tree, often helped by wind (Brady). In river areas bamboo fences and booms are constructed to trap the fruits flowing down stream" (Godwin).

An early monsoon can strip the tree of blossom and give rise to an immature fruit crop, the fruit are subsequently poor quality and not collected.

A good crop appears approximately once in every five years.

III. POST-HARVEST TREATMENT. PRESERVATION AND STORAGE

PRE-TREATMENT

The fruits are dried to a moisture content of 7% for protection against pests during storage. Fruits also deteriorate quickly due to their ability to germinate rapidly (Brady).

IV. PROCESSING

Shelling: a number of different methods are used including:

Initiating germination, the nuts are packed into cases and submerged in streams for 2-4 weeks, until the seed

begins to germinate. At which point the shell starts to crack and the seed can then be removed by hand.

A related method involves burying the nut in shallow pits. The fruits are first dewinged by beating them with sticks and the nuts are then buried in shallow pits which initiates germination and splits the shell.

Manual shelling: this involves breaking the shells directly with a sharp instrument or by heating the fruit in kilns at 55C to loosen the shell (Godwin) .

Drying: once the shells are split they can be removed by hand. The kernels are sun dried for a period of 5-7 days. If kiln shelling has been used sun drying is not necessary as the kiln also dries the kernels.

OIL EXTRACTION

In rural areas the oil is extracted using simple methods. The nuts are heated in a pan and then put into a rattan bag, which is placed between two hardwood boards and pressed by driving in wedges. (Anon).

At a commercial level the oil is removed by expelling and solvent extraction using hexane, followed by refining and bleaching.

An oil cake is produced which contains tannic acid and can be used ,at low levels, in animal feeds.

MAJOR FATTY ACIDS OF OIL

Palmitic acid	18.0%
Stearic acid	43.3%
Arachidic acid	1.1%
Oleic acid	37.4%

Linoleic acid	0.2%

EQUIPMENT

For pre-processing crates made of bamboo to hold nuts submerged in water, sharp spikes to split nuts and kilns. Simple plank presses. Oil expellers and solvent extraction plants.

There is a lack of identifiable information for the following areas: AGRICULTURAL ASPECTS, varieties, planting period, major diseases and harvesting period; POST HARVEST, pretreatment, storage and equipment; PROCESSING, nomenclature of products and by products.

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Brazil nut

I. GENERAL

COMMON NAME

Brazil Nut

BOTANICAL NAME

Bertholletia excelsa

FAMILY

Lecythidaceae

OTHER NAMES

Butter nut, Para nut (English), Nuez de pare, Nuez de Brazil, Castana. (Spanish) Noix de Brasil, Amande d'Amerique, (French) Castanha-do-Para, (Portuguese)

CULTIVATION CONDITIONS

The tree is found mainly in the Amazon basin of South America where it grows in deep, well drained alluvial

soils on high ground. It cannot tolerate flooding.

MAJOR PRODUCING COUNTRIES

BRAZIL, Venezuela, Guyana, Bolivia, Colombia, Peru.

YIELD AND DESCRIPTION

It is estimated that nuts are harvested from 250,000-400,000 trees annually. Many trees, however, are inaccessible as they are situated in dense rainforests (Brucher).

In Brazil 40,000-60,000 tons of inshell nuts are produced each year for internal use and export. It is reported that exports have declined since 1975 due to the migration of nomadic Indian collectors, low pay, post harvest losses and the overall destruction of virgin forest (Moritz). Brazil nut oil is a secondary product and extracted from low grade and broken material. It is reported that the State of Para, Brazil produces between 100 and 250 tonnes of oil per annum.

The Brazil nut tree is one of the largest of the Amazon forests standing up to 150 ft tall. The nuts are contained in large pods or fruits weighing 3 to 4 lbs and containing between 12-20 kernels. The whole nut consists of 51-57% shell and 43-49% kernel-. Most tree. produce 100300 fruits per year. However, a high yield in one year generally leads to a poor yield the next. Trees start producing nuts from 12-15 years old. The fruit containing the angular kernels takes one year to ripen. The ripe kernels contain 65% oil (Williams).

MAIN USES

Brazil nuts are mainly collected for export as a high value edible nut used in the confectionery and baking trades. Only surplus or damaged nuts are used for processing into Brazil nut oil. The pods are often utilised as a fuel source or are used to make cups and other household utensils. The residue, or cake, after oil extraction can

be used for animal feed.

II. AGRICULTURAL ASPECTS

CULTIVATION

Brazil nut trees essentially grow wild although they are cultivated from seed. Seeds are usually planted in a seed bed or special planting container and takes about 14 months to germinate. Plant ations are rare as it takes 12-15 years for a tree to reach maturity and bear fruit, and at least 30 years to become profitable (Williams).

A jungle rodent, similar to a squirrel, carries nuts away for food during the harvest period (Woodroof). Nuts lying on the forest floor are also subject to infestation caused by Carpophilus pilosellus and C. dimidiatus (Squire).

Leaf blight caused by Phytophthora heveae has been noted on newly grafted plants. It is characterised by spots and blight on young stems (Albeaquerque).

HARVESTING PERIOD

In Brazil mature nuts fall between November and early June.

HARVESTING METHODS

Harvesting is highly dependent upon casual labour. Mature pods fall to the ground and are collected in baskets or are thrown under trees for later collection. Harvesting also depends on the weather as pods will only be gathered if there is little or no wind, to minimise the danger of being hit by falling pods (Woodroof).

III. POST HARVEST TREATMENT: PRESERVAT1ON, STORAGE

PRE-TREATMENT

The nuts are washed and sometimes dried before storage or before being taken to trading posts or local processing.

Drying is usually carried out in a primitive shelter although this is often difficult as nuts are collected in the rainy season.

Nuts are often simply stored piled in heaps. However, due to high heat and humidity they tend to sweat and losses can occur if they are not turned regularly.

IV. PROCESSING

PROCESSING METHODS

The pods are cut open with a "tercado", a long sharp knife similar to a machete (Woodroof). Where large scale collection occurs the whole pods are dried in large, forced air driers that in some cases are fitted with automatic discharge.

Shelling is achieved by: soaking the nuts for 24 hours, boiling them for 5 minutes and then cracking them by hand.

Once shelled the nuts should be kept in cool, dark, unexposed conditions, which reduces the chances of the nuts becoming rancid (Williams).

Prior to export the nuts are graded according to size and may be artificially dried to an agreed moisture content.

OIL EXTRACTION

Brazil nut oil is extracted in hand presses or by expelling.

MAJOR FATTY ACID COMPOSITION OF OIL

Myristic acid	0.6%
Palmitic acid	15.4%
Stearic acid	6.2%
Oleic acid	48.0%
Linoleic acid	29.8%

(Source: Ecky)

EQUIPMENT

Pots/pans for boiling, sharp knives for cracking, hand decorticating machines, mechanical driers. oil presses, expellers.

There is a lack of identifiable information for the following areas: AGRICULTURAL ASPECTS, varieties;

POST HARVEST, pretreatment and equipment; PROCESSING, nomenclature of products.

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Caryocar spp

I. GENERAL

COMMON NAME

Caryocar spp

BOTANICAL NAME

Caryocar brasiliense

Caryocar villosum

FAMILY

Caryocaraceae

OTHER NAMES

Pequi, Piqui, Piqui-a (Brazil), Suari.

CULTIVATION CONDITIONS

The tree requires a tropical climate and is found growing in the Amazon basin of central Brazil and adjoining areas. There are 15 species, some of minor economic value.

MAJOR PRODUCING COUNTRIES

BRAZIL, Guyana.

YIELD AND DESCRIPTION

The fruit of the Caryocar tree is about the size of an orange and is surrounded by a fibrous husk or mesocarp. The fruit, which weigh up to 400 g have an outer shell and bear inside 1-4 kidney shaped brown kernels, similar to Brazil nuts, coated with a pale yellow fat that provides oil. The kernels have a thick shell that is very difficult to crack and also yield an oil that is highly prized by the local population.

MAIN USES

The pale yellow mesocarp oil is extracted and used for cooking. The kernels are eaten or used by the indigenous population to extract a highly prized oil. The shell can be used directly as fuel or processed into charcoal The timber from some species is extremely durable and is used for boat building. C. amygdaliferum, C. nuciferum and C. tomentosum produce an edible fat known locally as "suari and "butternuts" that are exported. The fruit is made into a liquor by the local populations of Brazil.

II. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

The fruit should be processed quickly after harvesting to prevent the activation of enzymes which cause oil rancidity to develop during storage.

III. PROCESSING

PROCESSING METHODS

The outer husk is easily removed but the shell of the kernel is, however, extremely difficult to crack.

IV. MAJOR FATTY ACIDS OF OIL

Both kernel and mesocarp oils contain glyceride esters of palmitic and oleic acids.

	Mesocarp oil	Kernel oil
Myristic acid	1.5%	1.4%
Palmitic acid	41.2%	48.4%
Stearic acid	0.8%	0.9%
Oleic acid	53.9%	46.0%
Linolenic acid	2.6%	3.3%

Source (Economic Botany).

EQUIPMENT

Knives for cracking, decorticators.

There is no identifiable information for the following areas: GENERAL, production and yield; AGRICULTURAL ASPECTS, planting material, varieties, planting period, major pests and diseases, harvesting period and harvesting methods; PROCESSING, nomenclature of products; OIL EXTRACTION, processing methods, nomenclature of products, by products and equipment.

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Cashew nut

I. GENERAL

COMMON NAME

Cashew Nut

BOTANICAL NAME

Anacardium occidentale

FAMILY

Anacardiaceae

OTHER NAME

Casa, Maranon, Merey (Spanish), Noix d'anacarde, Pomme de caju (French), Caju (Portuguese), Kaju (Hind))

CULTIVATION CONDITIONS

While the tree is native to central and South America it is now widely distributed throughout the tropics, particularly in many parts of Africa and Asia.

The cashew tree will tolerate a wide range of conditions including drought and poor soil, but cannot withstand cold or frost. In East Africa it grows between sea level and 1000m in areas of 500mm rainfall or more (Acland).

MAJOR PRODUCING COUNTRIES

TANZANIA, INDIA, Mozambique, Sri Lanka, Brazil, Kenya, Madagascar, Thailand, Malaysia, Indonesia, Nigeria, Senegal, Malawi, Angola.

Global production is estimated at 0.38 mt. World Bank data estimates that 97% of production is from wild trees and only 3% is from established plantations (Rosengarten).

YIELD AND DESCRIPTION

Yields of up to 7000 - 9000 kg/ha of cashews are possible, giving 150-300 kg shelled nuts per ha. Trees generally start producing in the third year after planting with full yields of 30 kg of nuts being obtained after 8-10 years. They then continue to yield for about 30 years. The cashew fruit consists of a peduncle and a seed. The peduncle, often called the false fruit, is pear shaped, yellow or red in colour and made up of a soft juicy pulp. The seed which develops below the peduncle is kidney shaped and resembles a large bean. Internally the seed contains the kernel or cashew nut of commerce surrounded by an oily liquid-cashew nut shell liquid. The kernels contain 47% oil.

MAIN USES

The main market is as a high value edible nut. Cashew yields two "oils". One of these, found between the seed coat (or pericarp) and the nut, is called cashew nut shell liquid (CNSL). It is not a triglyceride and contains a high proportion of phenolic compounds. It finds use in industry as a raw material for brake lining compounds, as a waterproofing agent, a preservative, and in the manufacturing of paints and plastics. It is toxic and corrosive to the skin. Cashew apples are sometimes made locally into drinks, wines and pickles. In some countries they are also osmo-sol dried to produce a date-like caramel.

An edible oil can be extracted from cashew nuts but no evidence of this being carried out commercially has been found. Due to the high value of cashew nuts even small pieces find a market in confectionery products.

II. AGRICULTURAL ASPECTS

CULTIVATION

Many trees are found growing wild. The plant germinates poorly, those that are cultivated are propagated by seed which are planted at a rate of 2-3 per hole due to poor germination rates (Gibbon).

A distinction is made between trees producing red apples and trees producing yellow apples (Woodroof).

Major pests attacking the cashew: In Tanzania and Sri Lanka the Helopeltis antonii or tea mosquito has been a problem. It causes inflorescence blight which damages the leaves and fruit. In Kenya Pseudotheraptus wayi, which is also a pest in coconut production, can cause the same problems as Helopeltis spp. The cashew stem and root borer damages causes damage during growth. Mites, thrips and leaf cutting ants may also cause economic damage (Acland).

Major diseases noted include: Pink disease (Corticium ,salmonicolor), has been noted in some areas to cause branch die back. Pythium, Fusarium, and Phytophthora spp may bring about damp off to seedlings. Colletotrichum gloeo-sporioides damages false fruits (Acland).

HARVESTING PERIODS

In East Africa harvesting starts in August and lasts until March. Peak harvesting is between October and December.

In India the main crop is ready for harvest between March and April. Some trees may produce an additional light crop between October and November (Woodroof).

In both cases, harvesting is preferable before the cashew apple has fully formed to reduce losses caused by

birds and animals attracted to the brightly coloured fruit.

HARVESTING METHODS

Ripe cashews can be picked from the tree but it is recommended that they are allowed to fall to the ground before they are gathered. This is to ensure that no unripe fruits are harvested.

The nuts rot quickly, therefore it is recommended that during fine weather harvesting should not be allowed to lapse for periods of more than one week. If nuts are left on the ground for longer than a week the seed coats become brown and rotten (Rosengarten). In wet weather nuts should be collected daily as they rot quickly.

III. POST HARVEST TREATMENT. PRESERVATION. AND STORAGE

PRE-TREATMENT

When the nuts are collected the cashew apple remains attached to the nut. This is removed by hand with a twisting action. Any pieces of the apple remaining on the nut are also removed (Acland).

Immediately after harvest, the nuts are sun dried for a few days until they have a moisture content of 8% or until the kernel is heard rattling inside the nut (Rosengarten). Drying also helps to mature the cashew seed.

After drying, the seeds can be stored in bags or bulk for a few days before processing. After processing the cashew nuts can be stored for up to a year in air tight containers.

Drying - the nuts are placed on bamboo mats or palm leaves and are regularly turned over using rakes. Raised barbecues are also used to hasten drying with the nuts being placed in layers on top of the barbecue not more

than 10cm thick and raked using wooden tools so that the nuts are uniformly spread for sun drying (Russell).

After drying, the seeds can be stored in bags or bulk for a few days before processing.

IV. PROCESSING

PROCESSING METHODS

CNSL removal - before the shell is removed from the nut the CNSL is extracted. The traditional method of removing CNSL in East Africa involves roasting the nut in drums or baths. The roasting process not only removes the corrosive CNSL but also makes the shell brittle, thereby aiding the cracking process. This method results in the loss of most or all of the CNSL. To extract and retain CNSL the nuts are roasted in baths at a temperature of 180-185 deg C. Vents in the equipment dispel the unpleasant fumes. This method recovers 85-90% of the liquid (Acland).

The traditional method of extracting CNSL in India involves roasting the nuts in a shallow pan over open charcoal fires. Constant agitation is required to prevent the nuts from becoming scorched. This method is extremely unpleasant as the shells burst releasing CNSL and fumes with resulting losses (Woodroof).

An improved method involves roasting the nuts in a perforated pan with troughs placed underneath to catch the liquid.

At a larger scale whole nuts are placed in rotating perforated cylinders inclined at an angle above a heat source. As the nuts fall downwards the shell liquid flows through the holes and is collected in troughs. The nuts are then water sprayed and set aside for cooling. (Solvent extraction can also be used to extract CNSL from the shells.)

Shelling - Shelling cashew nuts is unpleasant work and the hands of workers should be protected. The nuts and the shellers hands are commonly dusted in wood ash. This absorbs any CSNL remaining on the shell, preventing it from damaging the worker's hands and contaminating the kernels (Acland). In India skilled women crack the nuts. They use lime ash, linseed or castor oil to protect their hands. They squat on the floor, place the nut onto a hard stone and crack it open with a mallet (Woodroof).

Woodroof (1967) mentions a machine in Tanzania that is capable of shelling nuts whilst keeping the kernels intact. The operators hands are covered in oil for protection and the nut is placed inside a gripper. This moves against a circular saw and cuts a groove into the shell. A bladed instrument is then inserted within the grooves and the shell is removed.

A sheller designed by the Technology Development Unit of Thailand (See Appendix II), uses a lever operation to cut open the shell. Nuts are then removed by hand.

Commercial larger scale decorticators are available.

After shelling the kernels are dried to remove a thin skin which covers them.

After processing the cashew nuts can be stored for up to a year in air tight containers.

OIL EXTRACTION

No documentation of commercial oil extraction has been identified. Oil, however, can readily be extracted with simple presses and expellers.

V. MAJOR FATTY ACIDS OF OIL

OIL COMPOSITION

Palmitic acid	4.1-17.3%
Stearic acid	1.5-11.2%
Oleic acid	68.2-80.4%
Linoleic acid	0-21.7%

(Source: Ecky)

The oil is light yellow, sweet, odourless and can be stored for long periods without becoming rancid.

BY PRODUCTS

The press cake from the extraction process would be suitable for use in human and animal feed.

EQUIPMENT

Roasting baths/drums with troughs to catch the CNSL, water spraying equipment for cooling, and shelling machines.

There is a lack of identifiable information for the following areas: AGRICULTURAL ASPECTS, planting period, OIL EXTRACTION, processing methods, nomenclature of products and equipment.

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Chinese vegetable tallow

I. GENERAL

COMMON NAME

Chinese Vegetable Tallow

BOTANICAL NAME

Sapium sebiferum syn. Stillingia sebifera

FAMILY

Euphorbiaceae

OTHER NAMES

U-kau-shu (Cantonese), Arbol del sebo (Spanish), Tallowberry

CULTIVATION CONDITIONS

The Chinese Tallow tree, which requires a sub-tropical climate, is indigenous to China. It has been introduced to other countries, particularly North India (Godin) .

MAJOR PRODUCING COUNTRIES

China, India, USSR

YIELD AND DESCRIPTION

The deciduous Chinese Tallow tree produces two kinds of fat from the same fruit. The outer coating, or mesocarp, covering the seeds yields a solid fat known as Chinese Vegetable Tallow, while the kernels contain a drying oil known as stillingia oil. The fruit is a three lobed capsule some 15 mm in diameter which opens when

ripe and contains the kernel, about the size of a pea, surrounded by the solid fibrous and fatty mesocarp. Its structure allows the separation of the two oils with little contamination one with another. The fruit consists of 27-33% tallowy seed coat, 3641% shell and 29-35% kernel (dry basis). Both the outer seed coat and the kernel are very high in fat 55-78% and 53-64% respectively.

It is estimated that trees planted at a density of 370-395 per ha will produce 1340 kg fruit/ha. An average yield per tree is about 14-22 kg fruits which contain about 40% tallow and oil (Godin). The cake remaining after oil extraction is seldom used for animal feed. (Godin), (Bo Gohl).

MAIN USES

Tallow oil can be used to make soap, candles and an edible oil which is consumed in China. Stillingia oil is used as a drying oil in paints and varnishes. It is considered by some to be superior to linseed oil for these purposes (Godin). In addition, a black dye has traditionally been extracted from the leaves and used in the silk industry in China.

II. AGRICULTURAL ASPECTS

CULTIVATION

The tree can be grown from seed planted at 3-4 per hole with 5m spacings (Godin).

HARVESTING PERIOD

In China, harvesting takes place between September and November.

HARVESTING METHODS

The ripe fruits are plucked from the trees or branch ends. Chopping the fruits down causes severe damage to the trees (Godin).

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

The fruits are placed on mats and left to dry in the sun. This causes them to blacken and split open.

IV. PROCESSING

PROCESSING METHOD

After drying, the seeds are removed from the fruits by hand or with small threshers.

A traditional method used in China involves steaming the seeds in perforated cylinders and allowing the melted fat to run off, after which the seeds are crushed separately for the recovery of Stillingia Oil. Another method involves crushing the seeds between fluted roller" thereby stripping off the outer seed coat without breaking the kernel (Ecky).

An alternative process involves the removal of tallow and fibre stirring the fruits in warm water to disintegrate the seed coat. The slurry produced is washed over a screen which retains the seeds whilst the seed coat slurry

passes through. The slurry is then filtered using a vacuum filter to recover solid material which is dried at 100 deg C (Godin) .

OIL EXTRACTION

From the separated fibre Chinese Vegetable tallow is extracted by solvent extraction or expression in cage presses.

The seeds are then crushed and subjected to solvent extraction using hexane. The Stillingia oil released from the seed during this procedure is recovered from the hexane by a vacuum distillation process. Traces of solvent present in the extracted oil are removed in the final stage where the hot oil is sparged with carbon dioxide gas (Godin).

MAJOR FATTY ACID COMPOSITION OF OIL

Tallow oil

Lauric acid	0-2.5%
Myristic acid	0.5-3.7%
Palmitic acid	58-72%
Stearic acid	1.2-7.6%
Oleic acid	20-35%
Linoleic acid	0-1.6%

(Source: Hilditch)

EQUIPMENT

Small threshers, screening/washing equipment, filters, cage presses, expellers, solvent extraction equipment and driers.

NOMENCLATURE OF PRODUCTS

In China, vegetable tallow is known as "pi-yu" whilst stillingia oil is known as "ting-yu". A mixture of them both is called "mou-ieou".

Additional information was not identifiable for the following areas: GENERAL, production; AGRICULTURAL ASPECTS, varieties, planting period, major pests and diseases; POST HARVEST, pre-treatment, storage methods and equipment; PROCESSING, nomenclature of products and by products.

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Cohune palm

I. GENERAL

COMMON NAME

Cohune Palm

BOTANICAL NAME

Orbignya cobune

FAMILY

Palmaceae

OTHER NAMES

Corozo, Coquito, Coco de aceite

CULTIVATION CONDITIONS

The crop requires a tropical climate and grows well in areas of high rainfall. It is a characteristic species of the rainforests in South America (Godin).

MAJOR PRODUCING COUNTRIES

Mexico, Honduras, Belize, Paraguay, Guatemala, El Salvador, Nicaragua

YIELD AND DESCRIPTION

Approximately 20 000 tonnes of nuts per annum were produced in 1987 (Dransfield). Individual palms produce about 1000-2000 fruits per annum in large bunches yielding l 500 kg/ha. The individual fruits are egg shaped, about 5-8 cm long and up to 5 cm in diameter. The fruit has an outer husk and a pulpy fibrous mesocarp surrounding the nut. Inside the very hard nut shell is a kernel approx. 30 mm long, 18 mm in diameter and weighing 5 g. The kernel contains 65-72% oil (Godin). The outer pulpy portion of the fruit also contains about 13% oil. This pulp is, however, not considered to be of commercial interest (Private Communication).

MAIN USES

The oil contained within the kernel is somewhat similar to coconut nut oil. When refined the oil is suitable for margarine production, baking and biscuit making. Damaged kernels can be used as cattle feed. The shells are a good source of fuel. The cake remaining after oil extraction also finds use in animal feed.

II. AGRICULTURAL ASPECTS

CULTIVATION

Most palms grow wild at a density of 15 palms per ha.

III. PROCESSING

PROCESSING METHODS

The nuts have a hard shell which is difficult to crack and have a high ratio of shell to kernel. The pressure

required to crack the nuts is estimated at between 4 and 9 tonnes. Most nuts are cracked by hand, an extremely laborious task, machines have been developed to crack the nuts. One such mobile machine mounted on and powered by a truck has been developed in Belize, however, no data is available on its efficiency (Purseglove).

The oil is extracted by small expellers. It is recommended that the seeds be heated or scorched prior to expelling (Private Communication).

FATTY ACID COMPOSITION OF OIL

Caprylic acid	7.5%
Capric acid	6.5%
Lauric acid	46.5%
Myristic acid	16.0%
Palmitic acid	9.5%
Stearic acid	3.0%
Oleic acid	10.0%
Linoleic acid	1.0%

(Source: Godin)

EQUIPMENT

Sharp knives for cracking. Mechanical crackers, seed cooking kettles, Oil expellers or presses, filters.

There is a lack of identifiable information for the following areas: GENERAL, other names; AGRICULTURAL

ASPECTS, varieties, planting period, major pest" and diseases, harvesting period and harvesting methods; POST HARVEST, pretreatment, preservation, storage methods and equipment; PROCESSING METHODS, OIL EXTRACTION, nomenclature of products.

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Cucurbitaceae

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INTRODUCTION

The cucurbitaceae family include gourds, melons, pumpkins and squashes. They are characterized by their fleshy fruits. The seeds of many members of the group have been noted for their oil bearing properties. However, little information has been found that describes existing methods of oil extraction. In most cases the raw materials are grown primarily a" food, and the oil bearing seeds are used to make supplementary foodstuffs, thereby making dietary use of the oil. In such cases it would seem unlikely that it would be economically viable to extract oil from these raw materials, unless a large processing plant is involved that produces seeds in quantity. It has been suggested, however, that certain types of Curcubitacae, and in particular those that grow wild in arid areas, could be a potential source of oil. It is reported that the Arid Land Agricultural Development Institute, Lebanon, has carried out considerable research in this field (Anon).

Bottle gourd

I. GENERAL

COMMON NAME

Bottle Gourd

BOTANICAL NAME

Lagenaria siceraria

FAMILY

Cucurbitaceae

OTHER NAMES

White flowered gourd, Calabash gourd, Trumpet gourd; Calebassier, Courge bouteille (French); Cojombro, Guiro Amargo (Spanish); Upo, Talayag, Gucuzzi, Zucca melon (Philippines); Mokwa, Oo Lo Kwa (China).

CULTIVATION CONDITIONS

The vegetable is widely cultivated throughout the tropical regions of the world. It will tolerate a wide range of rainfall conditions but prefers moderate amounts with plenty of sunshine (Herklota, Tindall).

MAJOR PRODUCING COUNTRIES

India, Sri Lanka, Indonesia, Malaysia, Philippines, China, Hong Kong, Tropical Africa, Colombia, Brazil.

DESCRIPTION AND YIELD

The vegetable yields approximately 10-15 fruits per plant (Tindall).

MAIN USES

The fruits are generally eaten as a vegetable in Africa and Asia. The mature fruit is often scooped out and the skin used as containers, or in some cases, fishing floats. Shoots and leaves are also cooked and the seeds are

removed for oil extraction or for use in cooking (Herklots, Tindall).

II. AGRICULTURAL ASPECTS

CULTIVATION

The vegetable is grown from seed sown in mounds, ridges or prepared holes 120-180 cm apart. After germination and emerg ence, the crop is thinned to leave one seedling per space (Tindall).

Planting in India takes place at monthly intervals from February until August. In Hong Kong the operation usually takes place between March and April (Herklots).

The following major diseases occur in some areas, although they are not often very serious:

Cucumber Mosaic virus

Powdery Mildew

Anthracnose

Fusarium wilt (Tindall).

HARVESTING PERIOD

The fruits are ready for harvest 100 - 120 days after sowing.

IV. PROCESSING

No information has been encountered on the commercial extraction of oil from the seeds of this plant.

Based on experimental work carried out in Southern France, oil was extracted from Lagenaria and its composition analyzed by the Station Onenologique de 1'; Herault, Laboratoire Inter-regional de Montpellier in 1987. According to the results of the analysis, this oil is similar to gourd seed oil both in its composition in fatty acids (high content in essential fatty acids: Linoleic acid, absence of linolenique acid) and in the composition of sterolic compounds (high content in spinasterol). This oil is, therefore, comparable to semi-siccative oils such as sunflower oil or grapeseed oil. However, it has not been possible to have access to any toxicological studies. The amino acid composition is given in Table 1 below. The fatty acid composition is given in Table 2 and competed to that of sunflower.

Table 1 - Amino acid composition of Lagenaria Siceraria grain

Amino acid composition of the whole seeds			Amino acide composition of the oileeed cake	
AMINO ACIDS	**gr. per 100 g seeds**	**gr. per 160 of N.**	**gr. per 100g seeds**	**gr. per 160 of N.**
Aspertic acid	2.41	7.49	5.22	7.38
Threonine	0.85	2.64	1.93	2.73
Serine	1.24	3.85	2.91	4.12
Glutamic acid	4.71	14.64	10.58	14.97

Boline	0.83	2.58	1.98	2.67
Glycine	1.44	4.47	3.33	4.71
Alaine	1.22	3.79	2.77	3.92
Cystine	0.49	1.52	0.88	1.24
Valine	1.33	4.13	3.14	4.42
Methionine	0.70	2.18	1.56	2.21
Isoleucine	0.99	3.08	2.23	3.15
Leucine	1.80	5.59	3.99	5.64
Tyrosine	0.80	2.49	1.85	2.62
Phenylalanine	1.72	5.34	3.85	5.45
Histidine	0.72	2.24	1.64	2.32
Lysine	0.87	2.70	1.93	2.76
Arginine	4.77	14.82	10.63	15.04

Table 2 - Comparative fatty acids composition of Lagenaria siceraria and Sunflower

FATTY ACIDS	LANGENARIA SICERARIA	SUNFLOWER
C14:0	0.1	-
C16:0	13.8	6.6
C16:1	0.1	0.1
C18:0	6.6	4.5

C18:1	17.4	26.4
C18:2	61.4	60.8
C18:3	0.1	0.4
C20:0	0.4	0.2
C20:1	0.1	0.5
C22:0	-	0.5

There is a lack of identifiable information for the following areas: GENERAL, production; AGRICULTURAL ASPECTS, varieties, major pests and harvesting methods; POST HARVEST, pretreatment, preservation, storage methods and equipment; PROCESSING, processing methods, by products, nomenclature of products and equipment; OIL EXTRACTION, processing methods, nomenclature of products and by products and equipment.

Buffalo gourd

I. GENERAL

COMMON NAME

Buffalo Gourd

BOTANICAL NAME

Cucurbita foetidissima. C.maxima, C.palmata. C.digitada

FAMILY

Cucurbitaceae sp.

OTHER NAMES

Chilicote, Mock orange (C.palmata), Hubbard squash (C.maxima), Wild gourd (C. digitada),

CULTIVATION CONDITIONS

These species of wild gourds grow particularly well in arid regions and disturbed soils. They are suited to desert environments. For optimum growth the crop requires long periods of warm, dry weather and well drained soils. It cannot tolerate frost or waterlogging (Anon).

MAJOR PRODUCING COUNTRIES

MEXICO, USA - historically, the crop has been used by the North American Indians as a source of food and to produce soap. There are no details of production as the crop is still being examined for its agricultural and economic potential.

DESCRIPTION AND YIELD

The plant (Buffalo gourd) produces yellow, hard shelled fruit up to 8 cm in diameter which contain a white pulp and flat seeds 12 mm long. The fruit dries out so completely that the seeds can be threshed out. The large starchy roots can weigh 30kg but contain bitter glycosides. They can however be used for starch production. Yields differ greatly between plants, some being barren whilst others are prolific producers of seed. An average fruit will contain 150-200 seeds. Yield is thought to be in the region of 2 000 kg/ha. The seeds contain approximately 34% oil (Anon).

It is thought that the plant can match the performance of groundnuts and sunflowers as an oil producer (Anon).

The other species listed above contain edible oil in the seeds ranging from 2538%

MAIN USES

The plant is becoming increasingly recognised as a potential commercial crop. The seeds can be pressed to obtain an edible polyunsaturated oil for food and industrial use and the roots to produce starch. The use of the oil cake in animal feed requires further examination.

The oil extracted is bland in odour and taste. It varies from dark reddish brown - light yellow green in colour (Bucher). It has been reported that a high quality edible oil results after refining. (Vasconcellos).

II. AGRICULTURAL ASPECTS

CULTIVATION

Buffalo gourd and related species grow wild in desert wastelands, as a perennial vine. Research has shown that it can be asexually propagated using root nodules or planted directly from seed.

The crop has a high resistance to pests such as the cucumber beetle and the squash bug.

HARVESTING METHODS

Research has shown that the crop can be mechanically harvested. In arid environments the fruit dries up allowing the seed to be threshed out during the harvesting process.

III. PROCESSING

No information has been encountered on the extraction of oil from Buffalo gourd.

FATTY ACID COMPOSITION OF OIL

Palmitic acid	7.8%
Stearic acid	3.6%
Oleic acid	27.0%
Linoleic acid	61.5%

(Source: Bucher)

There is a lack of identifiable information for the following areas: AGRICULTURAL ASPECTS, varieties, planting period, major diseases and harvesting period; POST HARVEST, pretreatment, preservation, storage methods and equipment; PROCESSING, nomenclature of products; OIL EXTRACTION, equipment and nomenclature of products and by products.

Fluted pumpkin

I. GENERAL

COMMON NAME

Fluted Pumpkin

BOTANICAL NAME

Telfairia occidentales

FAMILY

Cucurbitaceae

OTHER NAMES

Fluted gourd, Telfairia nut; Calabaza, Costillada (Spanish); Iroko (Nigeria); Krobonko (Ghana); Pondokoko, Oroko, Gonugbe (Sierra Leone).

CULTIVATION CONDITIONS

The crop is grown across the lowland humid tropics of West Africa. It is partially drought resistant and is tolerant to a wide range of soils (Okoli).

MAJOR PRODUCING COUNTRIES

Nigeria, Ghana, Sierra Leone.

DESCRIPTION AND YIELD

The fruits of Fluted Pumpkin can be very large. Lengths of up to 105 cm and 9 cm diameter having been recorded. They are outwardly marked by 10 longitudinal ridges. When ripe they are a bright yellow. Embedded in the fibrous mesocarp are a large number of seeds, 196 were recorded in one fruit. The seeds are dark red and up to 5 cm in length. 2-5 fruits per plant are produced although this fluctuates as many female flowers do not

reach full maturity (Tindall). The ripe fruit contains up to 13% oil. No data was encountered on the oil content of the seed alone (Okoli).

MAIN USES

The crop is primarily grown as a leafy vegetable and is used for human con sumption and animal fodder. The seeds are either roasted or ground for other food preparation. A good cooking oil can be extracted from the seeds. It has been suggested (Irvine) that the oil could be used for making soap. A related species T. pedata is recorded as being grown commercially for its oil rich seeds in E. Africa (Okoli).

II. AGRICULTURAL ASPECTS

CULTIVATION

The pumpkins are planted solely from seed, often close to fences and walls so that the shoots have a support to climb against (Okoli). In other cases they are planted in mounds measuring approximately 75-90 cm each way.

The major pest attacking the Fluted pumpkin is the larvae from the cotton leaf roller (Sylepta derogata) which feeds on the leaf edges of the plant causing them to curl and fall. The pest is usually controlled by hand picking (Tindall).

The major noted diseases include: Leaf spot caused by Cercospora citrullus which attacks the leaves of the pumpkin, causing them to drop off. Other species affecting the crop are: Corynespora spp, Fusarium spp, and the Mosaic virus (Tindell).

HARVESTING PERIOD

Harvesting takes place 120-150 days after sowing.

III. PROCESSING

No information has been encountered on methods of processing of Fluted pumpkin seeds.

There is no identifiable information for the following areas: GENERAL, production; AGRICULTURAL ASPECTS, varieties and harvesting methods; POST HARVEST, pretreatment, preservation, storage methods and equipment; PROCESSING, processing methods, by products, nomenclature of products and equipment; OIL EXTRACTION, oil composition, processing methods, nomenclature of products, by products and equipment.

Marrow

I. GENERAL

COMMON NAME

Marrow

BOTANICAL NAME

Cucurbita pepo

FAMILY

Cucurbitaceae

OTHER NAMES

Marrow, Vegetable marrow, Summer Squash; Citrouille (French); Calabaza (Spanish; Pumpkin (Philippines); Calabacilla, Calabacilla (Mexico).

CULTIVATION CONDITIONS

The marrow is grown throughout South East Asia, Tropical South America and Africa. It does not like high temperatures and high humidities, preferring well drained soils with plenty of organic matter (Herklots).

MAJOR PRODUCING COUNTRIES

India, Malaysia, Philippines.

YIELD AND DESCRIPTION

Numerous varieties of C.pepo of different fruit sizes exist. They contain numerous seeds 1.1 - 2.6 cm long, 0.9-1.5 cm wide and 2-4 mm thick. The seed kernels constitute 75% of the seed weight. It is possible to harvest 20 t of fruit per ha. The seeds have an oil content of 48% of the weight of the kernel.

MAIN USES

The plant is primarily used as a vegetable. It has been estimated that some 1200 tons of seed could be obtained from large commercial pumpkin canning operations in the USA. It is said that pumpkin oil has been commercially extracted in Eastern Europe and Russia.

II. AGRICULTURAL ASPECTS

CULTIVATION

The crop is sown directly from seed in ridges 75 -90 cm apart, trailing varieties are spaced 2.0-2.5 m apart. When the seedlings emerge they are thinned out to two plants per spacing.

Three main varieties are used:

Pepo - Field pumpkin

Medullosa - Vegetable marrow

Melopepo - Bush summer squash (Tindall).

The major pests attacking marrow are listed below:

Aphis gossypii - Glover aphid causes wilting by sucking cell sap.

Aulacophora spp. - Red pumpkin beetle, the adults of this species shred the plants leaves whilst the larvae attack the roots and the fruits.

Dacus ciliatus - Fruit fly, the larvae tunnel into the fruit introducing rotting organisms in the process.

Diabrotica spp. - Cucumber beetle, contains Erwinia spp. which causes bacteria wilt.

Epilachna spp. - beetles, causes damage by eating the leaves.

Meloidogyne spp. - Root knot nematodes, stimulate the formation of root galls which interfere with the uptake of water (Tindall).

The major diseases attacking the marrow are:

Pseudoperonospora cubensis (downy mildew) attacks the leaves of the plant which in turn affects fruit set and flavour. Erwinia tracheiphila or bacterial soft spot has been noted to cause bacterial wilting (Tindall).

HARVESTING PERIOD

Mature fruits of the Medulosa variety are ready for harvesting 80-100 days after sowing (Tindall).

The fruit can be safely stored for up to 7 days after harvesting at temperatures below 10 deg C and 95% humidity (Tindall).

III. PROCESSING

OIL EXTRACTION

No data encountered.

FATTY ACID COMPOSITION OF OIL

Palmitic acid	7.0-12.0%

Stearic acid	6.0-7.0%
Oleic acid	24.0-41.0%
Linoleic acid	46.0-57.0%

(Source: Ecky)

BY-PRODUCTS

When extracting oil from seeds on a relatively large scale, the flesh from the fruit is sometimes used as animal fodder or for industrial alcohol production (Nartonffy). The meal produced during the processing operation is used as a constituent for animal feed (Hamid).

There is a lack of identifiable information for the following areas: GENERAL, production; AGRICULTURAL ASPECTS, harvesting methods; POST HARVEST, pretreatment, preservation, and storage; PROCESSING, processing methods, by products, nomenclature of products and equipment; OIL EXTRACTION, processing methods, nomenclature of products and equipment.

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Smooth loofah

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I. GENERAL

COMMON NAME

Smooth Loofah

BOTANICAL NAME

Luffa cylindrica

FAMILY

Cucurbitaceae

OTHER NAMES

Dish cloth gourd, Sponge gourd, Rag gourd, Vegetable sponge; Thinga, Turai, Dhundal, Mozhuku, Peerkankai (India); Ketola, Mains (Malaysia); Pikku, Pichukku (Sri Lanka); Loffa, Sponge gourd, Patola (Philippines); Shui kwa (China) (Herklots).

CULTIVATION CONDITIONS

The loofah grows in tropical Asia and China. It tolerates a wide range of climatic and soil conditions, although excessive rainfall during flowering and fruiting period can cause damage to the yield (Tindall).

MAJOR PRODUCING

China, India, Japan, Indonesia, Malaysia, Philippines, Hong Kong, Brazil, Caribbean.

DESCRIPTION AND YIELD

The fruits, between 1 and 2 ft long, become dry and fibrous. It is estimated that one plant, on average, will produce 20-25 fruits. The black seeds inside the fruit contain 37- 46% oil (Ecky, Tindall).

MAIN USES

The vegetable produces a number of different commodities. The fruit is often eaten fresh by local populations. More importantly, however, the internal tissue is extracted to produce the domestic loofah, during this process the seeds are often extracted and used to produce an edible oil (Herklots).

II. AGRICULTURAL ASPECTS

CULTIVATION

The crop is grown from seed, sown in ridges measuring 75-90cm. Seeds may also be sown in containers and then trans planted at a later date (Tindall).

Planting in Hong Kong takes place between mid May and mid September. In Japan the season takes place earlier, from March until April (Tindall).

Major pests; The plant is sometimes attacked by the Daccus spp. whose larvae tunnel through the fruit, contaminating it with rotting organisms (Tindall).

Diseases noted to affect the vegetable are, Powdery mildew and Downy mildew.

HARVESTING PERIOD

Harvesting usually takes place 100-120 days after sowing.

III. PROCESSING

The seeds used for oil extraction are often taken from the fruit during the manufacture of loofahs. The mature fruit is left on the vine to dry in the sun.

After a few days the outer layer is removed and the remaining fibrous skeleton is rested in water. The pulp can then be removed by hand, before the fruits are rested again. Drying then takes place, at which time the oil seeds are removed for extraction. Loofahs are bleached in the sun before being packed for export (Herklots). No information has been encountered on the methods used to extract the oil.

MAJOR FATTY ACID COMPOSITION OF OIL

Palmitic acid	9.6%
Stearic acid	18.9%
Oleic acid	6.9%
Linoleic acid	64.6%

(Source: Ecky)

EQUIPMENT

Drying equipment, tanks or containers to hold water for resting stages.

There is a lack of identifiable information for the following areas: GENERAL, production; AGRICULTURAL ASPECTS, varieties and harvesting methods; POST HARVEST, pretreatment, preservation, storage methods and equipment; PROCESSING, processing methods, by products, nomenclature of products and equipment; OIL EXTRACTION, oil composition, processing methods, nomenclature of products, by products and equipment.

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Grapeseed

I. GENERAL

COMMON NAME

Grapeseed

BOTANICAL NAME

Vitis vinifera

FAMILY

Vitaceae

OTHER NAMES

HABITAT

Temperate. Little growth takes place below 10C (Kinsella).

MAJOR PRODUCING COUNTRIES

France, Spain, Italy, Chile, USA, Australia

YIELD AND DESCRIPTION

Grapeseeds are available as by products of the raisin, wine and juice industries. In general the seeds make up 3.5-4.5 of the fresh fruit weight. Each fruit contains, on average, 4 or 5 seeds. The oil content varies considerably between 6-21%, the average value being 15% (Ecky). Sweet wine grape seeds yield up to 20% oil while some black varieties are at the lower end of the range (Kinsella). Despite these low figures the total quantity of grapes produced is so huge that there is considerable potential for grapeseed oil extraction. The kernel is reported to make up 54-56% of the whole seed weight. World production is considerable. In 1983 Italy, France and Spain alone produced 42,000 tons (Casao).

MAIN USES

The oil has found use in soaps, paints and for food use. In recent years grape seed oil has become rather a nutritional speciality, it is recommended to be included in diets designed for lowering serum cholesterol (Godin). The cake remaining after oil extraction is used for combustion or animal feed. It has a fibre content of 25-45% and a protein level of 8-12% (Casao).

II. AGRICULTURAL ASPECTS

CULTIVATION

The cultivation of grapes is widely covered in the appropriate literature.

HARVESTING PERIOD

The harvesting period depends on the country of production.

HARVESTING METHODS

Most commonly by hand.

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

The seeds are best separated and dried quickly after the fruit has been processed in order to produce an oil with a low acid value. The grape residues are either subjected to wet de-seeding or dried and then de-seeded. In the wet process the wine pomace is run through revolving cylinders with a 3mm screen, which removes pulp then dried in rotary driers (Kinsella). Equipment is available for the extraction, cleaning and conservation of grape seeds.

A decorticating machine has been developed which worked with reasonable efficiency (Kinsella). However in 1983 it was reported that no viable method had yet been developed to separate the kernel from the seed coat, and so increase throughputs (Cacao).

IV. PROCESSING

OIL EXTRACTION

Traditionally the milled and heated seeds were pressed to extract the oil. Pressing of whole seeds in screw presses has been reported as unsatisfactory (Ecky) The older methods of oil extraction by pressing have now been almost totally replaced by solvent extraction after crushing in roller mills and heating to 100 C for 20mins. Oil yields of 65-75% are obtained with 5-6% oil remaining in the meal.

The crude oil is neutralised, bleached with activated carbon and clay and finally deodorized under vacuum. It has been suggested that refining can simply be limited to decolorization as the FFA's are low.

MAJOR FATTY ACID CONPOSITION OF OIL

Palmitic acid	4-11%
Stearic acid	2.5-5%
Oleic acid	12-33%
Linoleic acid	45-72%

(Ecky)

EQUIPMENT

Decorticators, rotary washers, presses, solvent extraction equipment, refining equipment

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Illipe

I. GENERAL

COMMON NAME

Illipe

BOTANICAL NAME

Maduca longifolia

Maduca latifolia

FAMILY

Sapotaceae

OTHER NAMES

Mowha, Mahua, Mahwa (Hind)), Illipi, Illupai (Tamil), Mowrah butter nut

CULTIVATION CONDITIONS

The medium sized Illipe tree is found growing mainly in India. The two species have different growing conditions, M. logifolia grows in tropical monsoon forests while M. latifolia grows in N. India and has a degree of frost tolerance (Godin). The trees can withstand drought well and are often found in inaccessible places on land unsuitable for other crops ((Ecky) .

MAJOR PRODUCING COUNTRIES

INDIA: It is estimated that India could produce 400 000 tons of oil p.a. Actual production (1976-1984) ranged from 19 000 to 30 000 tons p.a.

DESCRIPTION AND YIELD

The tree produces between 9-45 kg of seeds or nuts and under good conditions will begin to bear fruit after 8-10 years and continue to do so for about 60 years. The fleshy fruits, between 2.5 and 5 cm long, contain 1-4 seeds. Each seed contains two kernels approx. 2.5 cm by 1.75 cm. The fruit to kernel ratio is 70% on a dry basis. The seed contains 55-60% fat.

MAIN USES

The kernels are not edible as they contain poisonous saponins. Crude Mowrah butter is used as a fat for spinning wool, for making candles and soap (Bring)). Mahwa flowers are either directly used for human consumption or as a raw material for the production of alcohol. The refined fat is used as an edible fat and vegetable ghee in India.

II. AGRICULTURAL ASPECTS

CULTIVATION

The tree can be planted from seed or stump plantings (Godin). M. longifolia is a large deciduous tree with a dense spreading crown. M. lati folia is often regarded as a variety of M. longifolia. (Godin). Planting from seed takes place between July and August. If the plants are transplanted they are placed in the ground during the first rainy season (Godin).

Major pests are various species of caterpillars, including, Achea jarsata, Angua multipilcans, Bombotelia nugatrix and Metanastria hyrtaca, which eat the leaves of M. Latifolia. M. longifolia is attacked by the sap sucker (Unaspis acuminate) and white ants (Optotemes ceylonicus) (Godin).

Major diseases affecting M. latifolia include: rust (Scopella echinulata), white spongy rot (Polystictus steinheilianus), white heart rot (Fornes caryophylli) and root and but rot (caused by Polyporus giluus) (Godin).

HARVESTING PERIOD

In northern India harvesting takes place between April and July.

In southern India the harvesting period is between August and September.

HARVESTING METHODS

The fruits are collected by shaking the tree or waiting until they have fallen naturally.

III. POST HARVEST TREATMENT: PRESERVATION, STORAGE

PRE-TREATMENT

The seeds are separated by pressing and are then sun dried.

During storage the kernels are susceptible to fungus and insect attack. Aspergillus flavus and Rhizopus have been recorded together with the insect pest Oryzaephilus surinamensis. To prevent extensive damage the kernels should have a moisture content of 8% and if possible be treated with a persistent insecticide. Oil quality is much related to storage conditions. The FFA content of fresh kernels lies between 1 and 2% but can rise to 30% in poorly stored material. (Bring)).

IV. PROCESSING

The fruit's shell is removed by hand or by beating it with a mallet. Roller mills are also sometimes used for decortication. If solvent extraction is to be used to obtain the oil, the seeds are flaked beforehand (Godin).

V. OIL EXTRACTION

In rural areas, the oil is extracted using traditional Ghanis. Industrial processing involves the use of expellers with or without solvent extraction of the cakes. The yields obtained by each method are shown below.

Ghanis	20-30%
Expellers	34-37%
Solvent	40-43%

After extraction, the oil is refined using alcohol. The oil may be hydrogenated to produce a product similar to cocoa butter (Godin).

The press cake containing saponins is unsuitable for animal feed and is used as a fertiliser (Bring)).

MAJOR FATTY ACIDS OF OIL

Palmitic acid	23.7%
Stearic acid	19.3%
Oleic acid	43.3%
Linoleic acid	13.7%

(Source: Ecky)

EQUIPMENT

Roller mills, flaking machines.

Ghanis, Expellers ,Solvent and refining equipment.

Further information is required for the following areas: GENERAL, production; There is a lack of POST HARVEST, pretreatment; PRIMARY AND SECONDARY PROCESSING, nomenclature of products.

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Kusum

I. GENERAL

COMMON NAME

Kusum

BOTANICAL NAME

Schleichera triguga

FAMILY

Sapindaceae

OTHER NAMES

Macassar, Lac tree, Ceylon oak

HABITAT

Tropical

MAJOR PRODUCING COUNTRIES

India, Burma, Sri Lanka, Java

YIELD AND DESCRIPTION

The Kusum tree grows to a height of 35-45 ft. and bears a fruit with a pulpy edible aril containing one or two almost round seeds some 1.5cm in diameter and weighing between 0.5 and 1.0g. The fruit pulp is much appreciated by local people for its refreshing acid taste. The kernels comprise 60-65% of the seed weight and contain between 59% and 72% fat (Ecky).

The kernels also contain cyanolipids that can produce HCN up to 0.5% of the kernel weight. The presence of

these uncommon compounds has been found in most members of the Sapindaceaea family (Ecky).

In the past Kusum oil was exported from India to Germany. This market has now fallen away. Current (1979) production in India is 4000-5000 tons (Bring)). The tree has economic import-ance as it is a host to the insects that produce a laquer gum of high quality (Nasirullah).

MAIN USES

The oil is used in the localities where it is extracted as a medicinal oil, a hair dressing and for soap. Conventional saponification is not favoured due to the presence of up to 1.2% HCN in the effluent. Despite its toxic nature in some areas of Mexico its use as an edible oil has been reported. Mexico has been reported (Kundu). A number of references exist describing analytical methods to detect adulteration of edible oils with Kusum Oil (Nasirullah).

II. AGRICULTURAL ASPECTS

CULTIVATION

No information identified.

HARVESTING PERIOD

In India June/July

HARVESTING METHODS

The fruits are hand plucked from the trees.

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

Harvested fruits are depulped by soaking in water and hand rubbing the pulp after which they are dried. One person can produce 7-11 kg. of pulped seed /day.

IV. PROCESSING

OIL EXTRACTION

Oil is extracted in ghanis and small village expellers with yields of 25-27% and 36% respectively (Bring)).

MAJOR FATTY ACID COMPOSITION OF OIL

EQUIPMENT

Expellers, ghanis

NOMENCLATURE OF PRODUCTS

Macasser oil, Lac.

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Macadamia nuts

I. GENERAL

COMMON NAME

Macadamia Nuts

BOTANICAL NAME

Macadamia intergrifolia

Macadamia tetraphylla

FAMILY

Proteaceae

OTHER NAMES

Queensland nut, Australian nut, bopple nut, bauple nut, popple nut, kindal kindal, boombera, burrawang (Aboriginal)

CULTIVATION CONDITIONS

Macadamia is indigenous to coastal rainforests of South Queensland and the northern river districts of New South Wales, Australia (Cavaletto). It has since been introduced to many- other countries, particularly in Africa.

The trees cannot tolerate frost and are suited best to areas where there are alternate wet and dry seasons (Cavaletto).

MAJOR PRODUCING COUNTRIES

HAWAII, AUSTRALIA, USA, Kenya, Guatemala, Costa Rica, Malawi, Zimbabwe, South Africa, Brazil, Fiji.

In 1978 Hawaii, for example, produced 9 500 tonnes of inshell nuts (Rosengarten).

DESCRIPTION AND YIELD

Two species of the family produce edible nuts, M. tetraphylla known as rough shell macadamia and M. intergrifolia known as smooth shelled macadamia. The fully mature nut consists of a nearly round nut in hard spherical brown testa, or shell, about 25 mm in diameter and 2-3 mm thick which is in turn surrounded by a fibrous green pericarp some 2 to 4 mm thick. Normally only one nut develops in each fruit. The tree begins to bear fruit when it is about 6-7 years old and has a lifespan of approximately 60 years. Trees can yield between 27 - 68 kg of nuts per year (Cavaletto). Nuts have an oil content of 60% (Maefalane).

MAIN USES

The kernels are mainly sold whole as high value edible nuts. Macfalane and Harris (NRI, 1981) show that reject kernels can be processed to yield an edible oil. The shell is used as a mulch or, if mixed with pineapple and molasses, for animal feed (Woodroof). It can also be used as a source of fuel. Some industrial units use the shell to fire their boilers. (calorific value 10,000 BTU/lbs) (Rosengarten). The oil extraction process produces an oilcake which is suitable as a feed for non ruminant animals (Macfalane). The hull powder is used as a filler in the plastics industry (Woodroof).

II. AGRICULTURAL ASPECTS

CULTIVATION

Macadamia trees are usually grown in plantations, especially in Hawaii where there has been extensive research into the crop.

Trees can be grown from seedlings but it is suggested that this type of planting yields low oil content as there are too many variations in productivity and kernel quality.

A preferred method of planting is by grafting trees of selected varieties. New grafting methods have reduced propagation from 2 years to 1 year and have also increased success from 66.8% - to 94.8% (Campo-Dall'Orto).

VARIETIES

10 Spp of Macadamia have been identified, M. intergrifolia and tetraphylla are the only two that produce edible oil nuts. In Hawaii 9 selections of intergrifolia have been used for creating varieties. The rough shelled M. tetraphylla has less desirable processing characteristics than intergrifolia.

It is not really grown for commercial purposes. The varieties used are: (HAES 246) Keauhou, (HAES 333) Ikaika, (HAES 508) Kakea, (HAES 660) Kcaau, (HAES 344) Ka'u, (HAES 741) Mauka, (HAES 800) Makai, (HAES 294) Purvis, and (HAES 788) Pahala (Cavaletto).

Listed below is a summary of insect pests which attack Macadamia, taken from different sources.

Peoudotheraptus wayi

Maladera matrida

Monolepta australis

Cryptoblabes gnidiella larvae

Spectrobates ceratoniae

Crvtophlebia leucotreta

Nezara spp.

Erysichton lineata

Ulonemia spp.

Toxoptera aurantii

Amblypelta nitida

Cryptophlebia ombrodelta

Damage from rats can also be serious, cases have been noted where 50% of the crop has been lost as a result of rat infestation.

Major diseases noted: In Taiwan 1982, extensive root decay in macadamia was noted, caused by Ganoderma tucidum and Kretzschmania clavus (Ann). Phytophthora cinnamomi has been noted to cause trunk canker disease in Australia (Pegg).

HARVESTING PERIOD

About 215 days after flowering, the nuts mature and fall to the ground. Harvesting extends over a seven month

period, therefore several harvests are required.

In general, harvesting in the northern hemisphere occurs between August and February while harvesting in the southern hemisphere takes place between March and September (Cavaletto). During the main harvest, nuts are gathered at intervals of 2 weeks. For the rest of the harvest period they are collected once a month (Woodroof).

HARVESTING METHODS

Harvesting is usually by manual collection of the nuts from the ground. Picking is generally avoided as there is great difficulty in distinguishing between immature and mature fruits (Grimwood). In Hawaii, to provide a smooth surface for the nuts to fall upon, some areas are covered with volcanic cinders. Mechanical harvesting methods have been developed. For example, an inexpensive tractor mounted nut recovery attachment has been designed. Experiments show that it is 90% efficient and can replace 30 hand pickers (Paquin). Other methods use nets hung between trees to catch the falling nuts. This is not often used as the nets are expensive and are often contaminated with fallen leaves (Cavaletto).

III. POST HARVEST TREATMENT. PRESERVATION, STORAGE

PRE-TREATMENT

The husks are removed and the nuts are dried within 24 hours of harvest. Failure to do so initiates undesirable physiological activity which causes fermentation and spoilage.

For the production of edible nuts it is important to dry the nuts from an initial moisture content of 45% to between 5% - 1.5%. This is done by passing air through the nuts for a week, followed by an application of low

heat (38 deg C - 54 deg C), for an additional 7-10 days (Cavaletto). At a smaller scale nuts are placed 2-3 deep in trays which have good air circulation and these are left to dry for about 2-3 weeks (Rosengarten).

If stored in bulk, respiratory activity results in increased temperatures and creates high relative humidity. In such conditions lipolysis and moulds become storage problems. The nuts should be stored in a rainproof shelter or drying shed (Rosengerten).

Simple drying racks can be made from 1.27-0.635 cm meshed cloth stapled to a light wooden frame (Rosengarten).

IV. PROCESSING

PROCESSING METHODS

A range of technical options exist for shelling, or decorticating, the nut". These range from simple hand methods, through to machines that apply pressure with a rotating rubber tyre (Cavaletto), to large commercial crackers. Walnut decorticators have teen used with some success in Hawaii, but are expensive (Woodroof). Other machines use counter rotating steel rollers. Experiments in Hawaii have been successful in showing that flame drying can be used to decrease the macadamia nutshell moisture below that of the kernel so causing it to become brittle and easy to crack (Tang).

After the nuts have been removed from their shells they are graded. Fresh nuts are placed into a saline bath of specific gravity 1.024.

If they float they are placed into a water bath. The nuts that rise to the surface are classed as grade I nuts and are packaged as "Top Quality Edible Nuts". Those that sink are classed as grade II nuts and are sold whole for

edible purposes.

The nuts that sink during the first immersion are placed into another saline bath which has a specific gravity of 1.15. If they float they are graded as Grade III and are used for oil extraction. The debris, such as shells, usually sink at this stage.

Those nuts falling into Grade III can account for about 25% of the nuts processed (Macfalane).

OIL EXTRACTION

Oil is extracted from reject grade III nuts using small expellers and finds use as cooking oil, and by the cosmetic industry. (Anon). It has been shown that it is necessary to add a proportion of fibre in the form of press cake to the feed of kernels to obtain good extraction rates (Macfalane). In Malawi the oil is made into soap.

MAJOR FATTY ACIDS OF OIL

Myristic acid	0.7%
Palmitic acid	9.1%
Palmitoleic acid	21.9%
Stearic acid	2.2%
Oleic acid	59.9%
Linoleic acid	1.9%
Arachidonic acid	1.8%
Eicosenoic acid	2.0%

(Source: Cavaletto)

A high oleic acid to low linoleic acid ratio suggests that the oil is quite stable to oxidative deterioration (Macfalane).

The oil extracted using expellers is pale yellow in colour and has a taste and smell similar to unprocessed macadamia nuts (Macfalane).

EQUIPMENT

Decorticators, driers, Saline bath. An expeller with a throughput of about 25 kg/hr has been recommended for small scale production (Macfalane).

Additional information was unidentifiable for the following areas: AGRICULTURAL ASPECTS, planting period, major pests and diseases; PROCESSING AND OIL EXTRACTION, nomenclature of products.

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Mango seed

I. GENERAL

COMMON NAME OF THE OIL

Mango Kernel Oil

BOTANICAL NAME

Mangifera indica

FAMILY

Anacardiacae

OTHER NAMES HABITAT

Tropical

MAJOR PRODUCING COUNTRIES

India

YIELD AND DESCRIPTION

While considerable variations occur depending on variety on average the dry stone makes up some 10% of the fruit weight. The -kernel makes up 75% of the seed weight and contains, on average, 10% oil (Bring)).

It has been estimated that in India alone some 30,000 tons of oil could be extracted from 4 million tons of the total annual harvest of 7 million tons (Bring)). Some mango kernel oil has been commercially extracted in India with 150 tons being exported in 1976 rising to 850 tons in 1978 (Bring)).

MAIN USES

The main use of mango is as a fresh fruit and as an ingredient in a wide range of fruit products. The kernels are

edible, have a protein content of about 9% and are eaten, particularly in times of food scarcity. Oil is commercially extracted from the kernels in India and finds use as a cocoa butter substitute. The cake remaining after oil extraction is used in animal feed.

The mango tree yields a gum, a tannin and a yellow dye. The bark, leaves and seeds are used to prepare a range of traditional medicines (Narasiahachar).

II. AGRICULTURAL ASPECTS

CULTIVATION

See standard agricultural texts

HARVESTING PERIOD

In India, April to September.

HARVESTING METHODS

The fruit is generally harvested by picking from the trees. The major constraint to mango kernel oil production lies in the procurement of stones. These are to be collected by hand for income in a similar way to waste paper etc.

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

Mango stones have to be dried, usually in the sun, so reducing the kernel moisture content from about 48% to 13%. In India the collection period coincides with the monsoon making drying a problem. Good drying is essential to prevent the growth of the fungus Aspergilla niger and to avoid the development of FFA rancidity. FFA levels in raw stones can rise from 2% to 7% after 20 days and to 46% after 120 days (Bring)).

After drying the stones are decorticated, usually by hand. A continuous mango stone decorticator has been designed (Narasiahachar).

IV. PROCESSING

OIL EXTRACTION

The following system has been used in India. Prior to oil extraction the mango kernels are sieved to remove foreign matter and broken in a hammer mill. The broken kernels are further reduced in size by use of a roller breaker. The material is heated to soften it and finally feed to flaking rollers. The final flakes, which should be very thin and have a moisture content of 10-12% are solvent extracted with hexane (Bring)).

MAJOR FATTY ACID COMPOSITION OF OIL

Mango kernel oil is pale yellow in colour. The fatty acid composition varies with both variety and climatic conditions. Typical values are:

Palmitic acid	5.1-8.0%

Stearic acid	42-48%
Oleic acid	35-42%

(Bring)

EQUIPMENT

Driers, decorticators, hammer mills, roller mills, solvent extraction plant.

There is a lack of identifiable information on methods of oil extraction, particularly pressing and expelling are required.

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Noog abyssinia

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I. GENERAL

COMMON NAME

NOOG ABYSSINIA

BOTANICAL NAME

Guizotia abyssinica

FAMILY

Compositae

OTHER NAMES

Ramtil (Hind)), kalatil, sarguia, tilangi, karala (India), neuk, noog, nug (Ethiopia), niger

CULTIVATION CONDITIONS

Niger is of African origin and occurs from Ethiopia to Malawi. It has been extensively introduced to India.

The species is a short day, temperate region plant which has been adapted to a semi-tropical environment, particularly at high altitudes. It grows well on poor soils and has good resistance to waterlogging (Weiss).

MAJOR PRODUCING COUNTRIES

ETHIOPIA, INDIA, Pakistan, Bangladesh, South Africa, Zaire, West Indies

It is estimated that Ethiopia produces 101 600 - 203 200 tonnes of Niger per annum, whilst India produces 762 000 tonnes/annum (Purseglove).

DESCRIPTION AND YIELD

Niger is a stout, erect annual herb about 1 metre high with yellow flowers that produce the oil bearing seed. In plantations it is estimated that yields are about 400-450 kg/ha. The oil content of the seed varies greatly between 25% and 45% for unimproved varieties and 50% to 60% for improved strains.

Each plant will yield between 15-30 mature seeds per head (Weiss). The black glossy seeds are small; 1000 weighing 5-7 g.

MAIN USES

The main use is for the extraction of an edible oil: in India often as an extender for Sesame seed oil. It also find use for making soap and as an illuminant. The remaining plant matter is often used as a green manure (Weiss).

II. AGRICULTURAL ASPECTS

CULTIVATION

In India the crop is grown either from seed mixed with finger millet, or as a pure stand. It is mostly broadcast sown (Weiss).

In India the varieties Oota Cammund 1GP- 76 and N5 are used in Maharashtra, Madhya Pradesh, Bihar and Orissa states (Kaul).

In Ethiopia, the crop is sown to avoid frost. In Mysore, India, it is sown between July and August after heavy rains (Weiss).

The list below is a summary of a detailed investigation of pests which attack Niger. It gives the botanical and common name of the pest along with the region where it is most commonly found (Weiss).

Acherontia atropes - Hawk moth, India.

Calidea dregii - Shield bug, Africa.

Chrontononus spp - Grasshopper, Asia.

Cyrtancanthacris tatarica - Grasshopper, Africa.

Diacrisia obligua - Hairy caterpilla, India.

Diacrisia sorocula - Fruit fly, Africa.

Frankliniella schultzei - Thrips, East Africa.

Heliothis spp - Bullworm, Cosmopolitan.

Larinus spp - Weevil, East Africa.

Macrosiphum spp - Aphis, Cosmopolitan.

Melanagromyza spp - Stem borer, Africa.

Nezara viridula - Shield bug, Africa.

Perigea capensis - Safflower caterpilla, India.

Sphaerocoris annulus - Stink bug, East Africa.

Spodoptera spp - Leafworms, Widespread.

Noted diseases include: leaf spots caused by Cercospora spp and Altemaria spp in Africa and in India; Bacterial blight due to Pseudomonas spp in India; Powdery mildew caused by Sphaerotheca spp in India (Weiss).

HARVESTING PERIOD

Harvesting begins about 4-4.5 months after sowing. The correct harvesting time should be accurate to avoid yield losses which result from the shedding of ripe seeds. (Weiss, Kaul)

HARVESTING METHODS

The crop is cut with a sickle and is usually cut in the morning when humidity is relatively high (Weiss).

III. POST HARVEST TREATMENT: PRESERVATION. STORAGE

PRE-TREATMENT

The crops are dried in the sun for 2-3 days, bundled, and taken to the yard or are threshed in the field (Kaul). The seeds are removed by threshing. The simplest method is by hand which does little damage to the seed, but is time consuming. In Ethiopia, oxen are sometimes used to tread out the seeds or to pull small threshing sledges. Small pedal operated threshers, similar to those used in S.E. Asia for rice, are also used (Weiss).

After threshing, the seeds are cleaned by winnowing and sieving. The seed is sometimes dusted with insecticide prior to storage (Weiss).

Clean Niger seed can easily be stored in 200 litre oil drums fitted with lids (Weiss).

IV. OIL EXTRACTION

The oil is most commonly extracted with expellers in India while in Bangladesh ghanis are more commonly used. The expressed oil is pale yellow, odourless and has a nutty taste. Due to the high linoleic acid content it has poor keeping properties. (Kaul, Weiss).

MAJOR FATTY ACID COMPOSITION OF OIL

Myristic acid	1.1-3.3%

Palmitic acid	5.0-12.4%
Stearic acid	2.3-11.6%
Oleic acid	7.0-39.4%
Linoleic acid	51.6-72.6%
Linolenic acid	0.9-3.0%
Arachidic acid	0.5-2.8%

(Source: Hilditch)

EQUIPMENT

Small threshers, winnowers and sieves. The main types of equipment used for extracting oil are: Ghanis, expellers and hydraulic presses. An improved one bullock ghani designed by the All India

Village Industries Association can extract about 25 - 27 kg oil/day and produce 65 - 68 kg of oilcake (Charan).

There is a lack of identifiable information for the following areas: PROCESSING AND OIL EXTRACTION, nomenclature of products.

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Nutmeg

I. GENERAL

COMMON NAME

NUTMEG

BOTANICAL NAME

Myristica fragrens

FAMILY

Myristicaceae

OTHER NAMES

Oil of Mace

HABITAT

Grows well on rich volcanic soils in hot humid tropics at altitudes up to 1500 feet.

MAJOR PRODUCING COUNTRIES

Indonesia, Grenada

YIELD AND DESCRIPTION

The nutmeg tree grows to a height of 50-60 feet and produces globular to pear shaped fruits. Two distinct types are recognised, E.Indian and W. Indian. Seeding trees begin to bear fruit when 5-8 years old, attaining full production at 15-20 years and continuing to bear fruit until 30-40 years old. A tree may produce 15002000 fruits and yields per acre vary from 500-1000 lbs of nutmegs and 100-200 lbs of mace. (Purseglove).

When the fruit ripens it splits open revealing the crimson aril, which surrounds the nut. When the nuts are harvested this aril, which is the spice mace, is carefully removed. The nuts contain 24-30% oil which includes essential oil. (Ecky).

Nutmeg butter contains about 73% of trimyristin and 13% essential oil. Volatile nutmeg oil comprises 7-12% of the seed and contains about 4% myristicin (Purseglove).

MAIN USES

Nutmegs yield a number of products. The red aril mace and the nutmeg are used widely as a food flavouring. Essential oil of nutmeg is distilled from reject, usually infested, material and finds use in the food , pharmaceutical and cosmetic industries. The pulpy outer husk or pericarp is made into sweetmeats and jellies. Nutmegs also yield a fixed oil nutmeg butter which is used in ointments and perfumery (Purseglove). Both butter and oil contain myristicin which is narcotic and toxic. Nutmegs must thus be used sparingly, 4-5g produce symptoms of poisoning in man. (2) An integrated utilisation method for reject nutmegs has been proposed (private communication) involving distillation of the essential oil, extraction and refining of the butter followed by hydrolysis of the main component tri-myristin and conversion of the myristic acid to iso-propylmyristin which is used in a number of cosmetic preparations. The main problem appears to lie in the production of a butter free of nutmeg odour.

II AGRICULTURAL ASPECTS

CULTIVATION

Cultivation is mainly restricted to islands. The tree cannot tolerate waterlogging. Nutmegs are normally propagated by seed and transplanted to the field when about 6 months old. After removal of excess male trees an irregular spacing of about 40 feet is achieved (Purseglove).

HARVESTING PERIOD

There are two peaks of harvest each year although some fruits are ripening all the time (Purseglove).

HARVESTING METHODS

Usually harvested from the ground as the fruits fall from the trees.

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

IV. PROCESSING

After harvest the mace is removed and the nutmegs carefully shade dried. Second grade infested nuts are separated by floatation in water. Sound nutmegs are then size graded.

OIL EXTRACTION

Traditionally nutmeg butter is extracted by hot manual pressing, usually from reject material.

MAJOR FATTY ACID COMPOSITION OF OIL

Lauric acid	1.5%
Myristic acid	76.6%
Palmitic acid	10.1%

(Ecky)

EQUIPMENT

Presses

There is a lack of identifiable information on nutmeg oil extraction, utilisation and integrated nutmeg processing systems.

NOMENCLATURE OF PRODUCTS

Nutmegs, Mace, Essential oil of nutmeg, Nutmeg butter, nutmeg jelly.

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Perilla

I. GENERAL

COMMON NAME

Perilla

BOTANICAL NAME

Perilla frutescens

FAMILY

Labiatae

OTHER NAMES

Su-tzu (China), Green Perilla

CULTIVATION CONDITIONS

The crop is annual and is native to India and China (Godin).

MAJOR PRODUCING COUNTRIES

CHINA, INDIA, Japan, Korea

DESCRIPTION AND YIELD

Perilla seeds are small end globular weighing about 4 g per 1000. They contain 30-51% oil (Ecky).

MAIN USES

The seed is processed in the country of origin as an edible food oil. It is exported to the USA and used as a substitute for linseed oil in paint manufacture.

II. AGRICULTURAL ASPECTS

CULTIVATION

The crop is grown from seed. In China the crop is sown in May.

HARVESTING PERIOD

Harvesting is usually between the end of September and the beginning of October.

HARVESTING METHOD

The seeds do not all ripen at the same time, and those that ripen early tend to shed. When the majority of the fruits are mature the plants are cut.

III. POST HARVEST TREATMENT: PRESERVATION. STORAGE

PRE-TREATMENT

After harvesting the plants are either bundled or spread on the ground to dry. (Godin). When the bundles have been dried they are placed on level ground and threshed.

IV. PROCESSING

The seeds are crushed using a stone roller and the shell manually winnowed off (Godin).

BY-PRODUCTS

The seed cake produced can be used as an animal feed.

V. MAJOR FATTY ACIDS OF OIL

Saturated acids	6.7-7.6%
Oleic acid	14-23%
Linoleic acid	11-16%
Linolenic acid	50-70%

(Source: Hilditch 1964)

There is no identifiable information for the following areas: GENERAL, production; AGRICULTURAL ASPECTS, varieties, major pests and diseases; POST HARVEST, pretreatment, storage methods and equipment; OIL EXTRACTION, processing methods, nomenclature of products, by products and equipment.

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Pili nut

I. GENERAL

COMMON NAME

Pili Nut

BOTANICAL NAME

Canarium ovatum

FAMILY

Burseraceae

OTHER NAMES

Anangi (Philippines)

CULTIVATION CONDITIONS

The crop is tropical and is found mainly growing in the warm, low elevated regions of the Philippines. It requires abundant rainfall and cannot tolerate frost (Martin, Private communication).

MAJOR PRODUCING COUNTRIES

PHILIPPINES

DESCRIPTION AND YIELD

The tree begins to bear fruits ready for harvest when it is between 7-10 years old. Yields are not well reported but it is estimated that 33 kg nuts/tree can be harvested. The Pilli fruit is 6-7 cm long with a thin oily pulp containing one triangular seed. The seed or nut has a hard shell inside which is the oil bearing kernel. The kernels have a very high fat content of 71% (Martin).

MAIN USES

The pulp is edible and is consumed by local populations. An edible oil is also produced which is used for cooking. The oil is also used locally for burning in lamps (Martin, Rosengarten). The shell finds use as a fuel for many small industries (Private communication).

II. AGRICULTURAL ASPECTS

CULTIVATION

Most trees occur naturally although some have been planted near to coconut plantations (Rosengarten).

HARVESTING METHODS

The fruits are knocked or shaken from the tree and then gathered from the ground (Rosengarten).

III. PROCESSING

No information identified on processing and oil extraction. There is no identifiable information for the following areas: GENERAL, production; AGRICULTURAL ASPECTS, varieties, planting period, major pests and diseases; POSTHARVEST TREATMENT, PROCESSING AND OIL EXTRACTION, processing methods, oil composition, nomenclature of products, by products and equipment.

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Rice bran

I. GENERAL

COMMON NAME OF THE OIL

Rice Bran Oil

BOTANICAL NAME

Oryza sativa

FAMILY

Graminaceae

OTHER NAMES OF THE OIL

Aceite de Salvado de arroz, Riz, Huile de sonde, Riso, Olio di crusca

HABITAT

Tropical

MAJOR PRODUCING COUNTRIES

Asia, Africa, Americas

YIELD AND DESCRIPTION

Rice bran is a by product of the pearling process of rice and comprises the pericarp, aleurone layer, embryo and some endosperm. The bran forms about 8% of milled rice and contains 15-20% oil, 0.4-1.5% wax, 5-8% protein, 40-50% soluble carbohydrates and 5-8% fibre (Godin). Refined low acid rice bran oil is pale yellow in colour and very similar to corn and cottonseed oil. As the FFA content increases so does the oil colour, high acidity oil being brown.

Rice bran contains a powerful lipolytic enzyme system which causes a rapid release of free fatty acids (FFA), up to 30% of the oil being converted to FFA in one week under tropical storage conditions. Freshly milled bran has a FFA of 3%. Oil with more than 10% FFA cannot be economically refined. A major constraint to rice bran oil extraction in developing countries is the practice of one stage milling which results in a mixture of hulls and bran with an oil content too low for economic oil extraction. The use of two stage mills provides a bran with an economic oil content. It has been estimated that 700 000 t per year of rice bran oil could be extracted from the 20% world paddy production currently processed in two stage mills (Enochian.)

The bran from parboiled rice is more stable to FFA development. Well processed parboiled rice bran can be stored for up to 6 months with little deterioration. Existing parboiling techniques, however, are directed to improving rice quality rather than bran quality. Optimum parboiling conditions have been established as 48 hrs steeping, 12 mins. steaming at 60 psig steam and drying to 12% moisture (U Myint).

Rice bran oil production was 110,000 t in India in 1979 but there is increasing interest in overcoming the production problems of edible rice bran oil to meet shortfalls in national oil needs (Pillaiyar). India's production of refined, food grade oil was a meagre 5000 t. Japan, with only 20% of India's production of paddy, produced 90,000 t. Of oil, of which 55,000 to 60,000 t was used for edible purposes (Pillaiyar). A pilot rice bran oil refinery has been established in the Philippines (Anon).

MAIN USES

Refined rice bran oil is a high quality cooking oil and finds uses in many manufactured foodstuffs. It has been used as a carrier for insecticides, after sulphonation in textile and leather treatments, and for a range of industrial purposes. Crude rice bran oil, which is not economically refinable, is mainly used in soap manufacture and for the production of industrial fatty acids (Godin). Its use, after de-waxing, to replace oleic acid as a cheap anti-foamer for chemical industries has also been investigated (Zanati).

Extracted rice bran, which contains 1-3% residual oil is a good cattle feed and also finds use in human foods, as a soil conditioner and in pharmaceuticals.

Rice bran oil milk is used in the production of bean paste and soy sauce due to its high amylase content (Anon).

Rice sugar is a residue of alcoholic oil extraction and finds use in pharmaceutical industries. Another by-product, rice wax can replace carnauba wax in polishes, carbon paper and other products.

II. AGRICULTURAL ASPECTS

CULTIVATION

The agricultural aspects of rice production are covered in the relevant literature.

III. POST HARVEST PRE-TREATMENT, PROCESSING. STORAGE

PRE-TREATMENT

The lipolytic enzymes in rice bran can be inactivated by heating, the time and temperature required depending on the bran moisture content (at 30% moisture, 90-100 C for 5-10 mins; at 10% moisture 130-140 C for seconds) (Enochian). In recent years much work has been carried out on rice bran stabilisation by heating, particularly in the area of small extrusion cookers that could be linked into small rice mills. It has been estimated that an extrusion cooker costing $6200 (1981 prices) would yield an annual return of 50% on the capital investment by producing 200-300 t of stabilised rice bran/annum (Enochian).

Extrusion equipment is currently being installed by many large rice milling companies in the USA and has also been installed at several locations in India.

Rice bran can also be stabilised by treatment with hydrochloric acid and it is reported that this technique is now being evaluated in Indian mills (Personal communication).

Rice bran may be subjected to a cooking process to eliminate very fine particles prior to extraction.

IV. PROCESSING

OIL EXTRACTION

Solvent extraction is used. Hexane and isopropanol are good solvents. If alcohol is used as a solvent rice sugar is produced as a by-product. Oil expellers have been examined (Yokochi).

After extraction crude rice bran oil is filtered at room temperature to remove solids and high melting point waxes and then treated with a small amount (0.1-0.6%) of phosphoric acid to remove gums. It is then alkali refined to remove FFAs, washed and any moisture removed in a vacuum drier. The refined oil is then decolorized and filtered, deodorized and winterized to remove high melting point waxes (U Myint).

MAJOR FATTY ACID COMPOSITION OF OIL

Myristic acid	0.4-1.0%
Palmitic acid	13-18%
Stearic acid	1-3%

Oleic acid	0-50%
Linoleic acid	29-42%
Linolenic acid	0-1%

(Godin)

EQUIPMENT

Extrusion cookers, Driers, Solvent extraction plant, filters, refining equipment

NOMENCLATURE OF PRODUCTS

Rice sugar, Rice wax, Oil cake, Oil.

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Sacha inche

I. GENERAL

COMMON NAME

Sacha Inche

BOTANICAL NAME

Plukenetia volubilis, Tetracapidium conophorum

FAMILY

Euphorbiaceae

OTHER NAMES

Inca peanut, N'gart

HABITAT

Highland tropical jungles,

MAJOR PRODUCING COUNTRIES

West Africa, Central and S. America.

YIELD AND DESCRIPTION

The Inca peanut is a legume with branched nitrogen fixing root nodules. The white flowers develop into 4 pods,

each with 4 seeds. The pods sun dry on the vine. The seeds or nuts are flattened spheres about the size of a penny (Personal communication). The individual seeds weigh 6.6g and the kernels make up 63% of the seed weight. The seeds contain a heat labile substance which gives them a bitter taste if not roasted. The oil content is 35-60% of which 70% is unsaturated.

The rather viscous oil is yellow to orange in colour. The oil is mainly interesting for its drying properties and has been considered to have potential for the manufacture of paints, varnishes and linoleum (Mensier).

The cake, after oil extraction, has a good quality protein content of some 45-60% and finds use in animal feeds.

Yields are estimated at 2 tons of seed/ Ha. Sacha Inche is closely related to the African oilseed Cumbaza.

MAIN USES

The Inca peanut has been used traditionally by the Chancas Indians of Peru as a food and in Africa the oil is traditionally extracted for food use. In Peru the crop is being promoted for edible oil extraction and the oilcake as an animal feed.

II. AGRICULTURAL ASPECTS CULTIVATION

No information identified

HARVESTING PERIOD

No information identified

HARVESTING METHODS

Hand harvesting

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

Seeds are removed from pods and dried

IV. PROCESSING OIL EXTRACTION

No information identified

MAJOR FATTY ACID COMPOSITION OF OIL

Palmitic acid	4.4%
Stearic acid	3.2%
Oleic acid	9.6%
Linoleic acid	36.8%
Linolenic acid	45.1%

(Personal communication)

EQUIPMENT

NOMENCLATURE OF PRODUCTS

There is a lack of identifiable information on cultivation, oil extraction and uses of Inca Peanut.

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Seje

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I. GENERAL

COMMON NAME

Seje

BOTANICAL NAME

Jessenia bataua

Jessenia polycarpa

FAMILY

Palmae

OTHER NAMES

Batana, pataua, sejen, coumou, unamo, coroba, milpesos (Spanish)

CULTIVATION CONDITIONS

The tree is found in the tropical rainforests of South America and has a wide range of growing conditions, from swampy lowlands to mountainous regions (Anon) .

MAJOR PRODUCING COUNTRIES

VENEZUELA, Colombia, Brazil, Peru, Panama, Caribbean Islands.

DESCRIPTION AND YIELD

Adult palms produce two fruit bunches per annum. These weigh between 8-35 kg and can contain up to 1 000

fruits (FAO).

MAIN USES

The kernels yield an edible oil somewhat similar to olive oil. It is also made into soap and is used in the cosmetic industry. The fronds of the palm also find use for thatching.

II. AGRICULTURAL ASPECTS

CULTIVATION

The trees have never been cultivated commercially, all palms occur naturally.

HARVESTING PERIOD

The fruit is collected between April and November.

HARVESTING METHODS

The bunches are harvested by climbing the trees and picking the crop or by felling the palm if the leaves are needed for thatch (FAO).

III. PROCESSING

Oil is extracted by simple floatation methods. The pounded fruit coat is boiled with water, the oil separates to the top and is scooped off.

The oil extraction process leaves behind a milky white residue which is consumed locally as a beverage known locally as "yucuta" (Anon).

FATTY ACID COMPOSITION OF OIL

Palmitic acid	8.8%
Stearic acid	5.6%
Oleic acid	76.5%
Linoleic acid	3.4%

(Source: FAO)

The oil is yellow and does not easily turn rancid.

EQUIPMENT

Boiling pans/pots, ladles or similar items for skimming oil away.

There is a lack of identifiable information for the following areas: GENERAL, production; AGRICULTURAL ASPECTS, varieties, planting material, major pests and diseases; POST HARVEST, pretreatment, preservation, storage methods and equipment.

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Shea nut

I. GENERAL

COMMON NAME

Shea Nut

BOTANICAL NAME

Butryospermum parkii

FAMILY

Sapotaceae

OTHER NAMES

Karite (French), Nku (Ghana), Shea butter tree, Bambuk butter tree

GEOGRAPHICAL DISTRIBUTION

The tree can be found growing naturally in the southern regions of the Sahel and the northern regions of the Guinea zone. It thrives in savanna areas where oil palm cannot grow due to low rainfall (GTZ). Temperatures range from 24 - 32 deg C, and rainfall is between 800 - 1400 mm per annum (Godwin).

MAJOR PRODUCING COUNTRIES

WEST AFRICA, Mali, Baukina Fassau, Bennin, Senegal, Ivory Coast, Ghana, Gambia, Nigeria.

PRODUCTION

Using landstat remote sensing images in Mali, 18 million shea butters trees were counted over a distance of 200 km (Fleury). It is also estimated that Mali produces 150 000 - 200 000 tons of nuts per annum (Anon).

YIELD

In general, trees do not usually yield fruit until they are 20 years old, and do not reach full maturity until they are 45 years old. However, once productive, they will continue to bear fruits up until their 200th year (Fleury). An average of 25 - 55 kg of berries can be expected each year from one tree, although one tree in three will be productive each year (Godwin).

MAIN USES

The nut is processed to produce shea butter which is a very important vegetable oil in West Africa. The high allantoic content in the butter also makes it a useful base for local pharmaceutical preparations. The butter is also used to make soap and in the construction industry it is used on the walls of houses to prevent them from being washed away during the rainy season. Shea butter can also be used to form a coco butter substitute (Fleury).

II. AGRICULTURAL ASPECTS

PLANTING MATERIAL

Trees are not usually grown in plantations due to the long period it takes before reaching maturity. As most trees grow in the wild therefore, long distances are often incurred for collection (Fleury). In a few examples where plantations have been established, trees are grown from seed in nurseries and are then transplanted (Godwin).

PLANTING PERIOD

Transplantation of the seedling takes place during the second dry season after sowing. Two years later the saplings are replanted before being moved again to their final position during the following year -4 1/2 years after sowing. The final spacing is at 1.5 - 2m intervals in rows 8m apart (Godwin).

MAJOR PESTS

Damage to foliage is caused by the larvae of Cirina butryrospermi and Anacridium moestum. Muissida nigriveriella and Ceratitis silvestrii larvae may develop inside the pulp of mature fruit and also cause damage (Godwin).

MAJOR DISEASES

Trees may suffer from feat spot which is caused by Pestalotia heterospora and Fusidadium butyrospermi (Godwin).

HARVESTING PERIOD

Harvesting generally takes place between June and August, peaking during July (Fleury).

HARVESTING METHODS

Berries ripen and fall to the ground. They are gathered by women and children and stored in ditches for collection (Fleury).

III. POST HARVEST PRETREATMENT, PRESERVATION AND STORAGE

PRESERVATION AND STORAGE

The harvest is piled into pits one meter square by 1.5m deep. Up to 600 kg of berries can be stored in four pits using this method. When the pits are full, the nuts are covered with leaves and earth. An opening is left in the centre which lets rain seep through. As a result the berries ferment and the pup disintegrates. The increase in temperature caused by this procedure also prevents germination occurring, which affects the amount of fat produced (Fleury, Godwin).

IV. PRIMARY PROCESSING

PROCESSING METHODS

After fermentation the harvested berries are crushed underfoot to remove pulp. The berry (almond) sticks to the shell wall. To separate them, the nuts are immersed in boiling water and then sun dried for a few days. During the drying stage, the berries become detached. Nuts can now be stored for months without deterioration.

Shelling is carried out at village level using stones, hammers or pestles. Winnowing is achieved by holding baskets filled with nuts at arms length and gradually emptying them. If there is a strong wind the pieces of shell will be blown away, if not, then the operation is repeated many times (Fleury).

The day prior to oil extraction, the shelled almonds are dried again from a moisture content of 40-50% to 6-7% (Godwin). This process usually takes up to a day and a night, or until the oil begins to "sweat" from the almond (Fleury). Alter-natively, the kernels are broken in a mortar and pestle after winnowing and are then fried in clay pots to remove moisture. After 2-3 hours complete dryness has occurred and a hard black mass is formed (Tettey).

EQUIPMENT

Pans for boiling water, drying mats, hammers, pestles, winnowing baskets, clay pots.

V. SECONDARY PROCESSING

OIL CONPOSITION

Palmitic acid	5.0- 9.0%
Stearic acid	30.0- 41.0%
Oleic acid	49.0-50.0%
Linoleic acid	4.0-5.0%

(Source: Godwin)

Shea butter is soft and solid at tropical ambient temperatures. It is yellowish white in colour and has a strong smell (Tettey).

PROCESSING METHODS

There are two methods for oil extraction, a traditional village process and a mechanical procedure.

In Mali, the traditional process involves many time consuming stages. After drying, the kernels are crushed by three women using simultaneous strokes, in a mortar. The paste that is gradually formed needs to be kept at a temperature of about 40 deg C. Shea butter tends to solidify between 34- 38 deg C. Once the paste becomes a fluid, it is strained and heated in a pan. A kneading process using a polished stone takes place to break up oil cells and ease oil extraction. The paste is then mixed with water to separate the remaining oil.

Afterwards it is rapidly mixed by hand until it starts to cover itself with a white emulsion of fat. Once this is achieved, the paste is left to rest. The oil that floats to the surface is scooped off, and poured into a container filled with luke warm water for decantation.

During decantation, a white film forms over the top of the surface, this is shea butter. It is separated and heated in a cauldron to evaporate remaining water and allow heavy impurities to settle at the bottom. The butter is left

overnight to rest. Traditionally it is then divided and wrapped in leaves for selling or for storage. The butter will last for many years if kept away from light and heat as it is resilient to oxidative rancidity (Fleury).

A less time consuming method of preparing shea butter has been developed by The Royal Tropical Institute in the Netherlands. This process has only four stages. The kernels are pounded to a fine powder which is then heated to a temperature of 100 deg C. It is kept hot in a hot air oven for one hour before being pressed in a hydraulic hand press. The fat which is obtained is cleared of all other residues by boiling with okra, lemon juice and water (UNIFEM).

It should be noted that using a shea nut press, not only alleviates a time consuming process but also improves the fat output. For example, using a shea press fat output will be between 40-45% whereas fat output using the traditional method will be about 25% (Niess).

EQUIPMENT

Traditional method - Mortar and pestle, pots and pans, ladles, strainers, polished stone (one hand wide by 3-4 ft long) cauldron. Mechanical method - Hydraulic press (as shown below), hot air oven, grinding mill.

BY-PRODUCTS

The remainder of the pressed material can be used as fuel (GTZ).

Further information is required for the following areas: AGRICULTURAL ASPECTS, varieties; POST HARVEST, preservation; PRIMARY PROCESSING, main uses; SECONDARY PROCESSING, nomenclature of products.

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Teased

I. GENERAL

COMMON NAME

Teaseed

BOTANICAL NAME

Camellia sasanqua

FAMILY

Theaceae

OTHER NAMES

Chah (Hindi), (Japan), Tsubaki (Japan)

CULTIVATION CONDITIONS

The crop grows in the tropical rainforest and humid subtropical areas of China, Assam, and North Vietnam (Ecky).

MAJOR PRODUCING COUNTRIES

CHINA, North Vietnam, Assam, Hong Kong

Annual production of teaseed oil in China has been recorded as between 25 000 and 28 000 metric tons.

DESCRIPTION AND YIELD

The pruning applied to normal tea plants discourages the formation of seed. Certain varieties, however, are allowed to produce seed for the extraction of an oil which is so similar to Olive oil that it has been used as an adulterant. Teaseeds are contained in capsules. Each capsule usually contains one seed. Inside the shiny dark brown seed coat lies the kernel. The kernel makes up some 70% of the seed weight.

MAIN USES

The oil from the seed can be refined for edible purposes. The oilcake produced as a by-product of oil extraction is unsuitable as animal feed due to its saponin content. It is used as an insecticide in China.

II. AGRICULTURAL ASPECTS

CULTIVATION

The crop is grown from seed and is planted at a depth of 4-8 cm.

HARVESTING PERIOD

Harvesting occurs between October and December.

HARVESTING METHODS

When the fruits are mature they fall to the ground and are gathered.

III. POST HARVEST TREATMENT: PRESERVATION, STORAGE

PRE-TREATMENT

The seeds are spread in the sun to dry prior to storage.

IV. PROCESSING

The outer husks are removed by hand. They are then ground to produce a fine meal.

OIL EXTRACTION

Two methods can be used to extract the oil: pressing and solvent extraction.

The meal is steamed prior to pressing, or, if it is to be solvent extracted using petroleum ether, dried in an oven at 50 deg. C. The crude oil obtained by traditional methods is unsuitable for edible purposes and requires refining by vacuum deodorisation and bleaching.

FATTY ACID COMPOSITION OF OIL

Saturated acids	6-12%
Oleic acid	72-78%
Linoleic acid	2-15%

(Source: Ecky)

The oil is similar chemically and physically to Olive oil.

EQUIPMENT

Oil presses, driers, vacuum and deodorising equipment, solvent extraction plants.

There is a lack of identifiable information for the following areas: GENERAL, production and yield; AGRICULTURAL ASPECTS, varieties, planting period, major pests and diseases; POST HARVEST, pretreatment, storage and equipment; PROCESSING METHODS, nomenclature and by products.

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Appendix I - Summary of various applications of minor edible oil groups

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The following Table 1 shows various known applications of oils extracted from those minor edible oil crops reviewed in this section. Such applications are listed below:

A. MAJOR APPLICATIONS

- **Edible oil**
- **Cosmetics**
- **Soap**
- **Substitute for cocoa butter**
- **Medicine**
- **Candle and lighting**
- **Paints and varnishes**

B. OTHER APPLICATIONS

- **Brake lining**
- **Water proofing agent**
- **Preservative**
- **Plastics**
- **Siccative oil**
- **Margarine production**
- **Baking and biscuit production**
- **Industrial fatty acids**
- **Anti-cholesterol**
- **Wool spinning**
- **Hairdressing**

- **Essential oil and perfumery**
- **Food flavouring agent**
- **Textile and leather treatment**
- **Antifoaming agent**

Table- 1 Sumnary of Various Applications of Minor Edible- Oil Crops

	FOOD	SUBSTITUTE FOR COCOA BUTTER	COSMETICS	SOAP	MEDICINE	CANDLE AND LIGHTING	PAINTS VARNISHES AND OTHERS
1. Argan		x					
2. Avocado seed		x	x				
3. Babassu	x						
4. Balanites	x				x		
5. Borneo Tallow	x		x	x	x	x	
6. Brazil Nut	x						
7.Caryocar Spp.	x						
8. Cashew Nut	x						x
9. Chinese Vegetable Tallow	x			x		x	x
10. Cahune palm	x						
11. Bottle Gourd	x						

12. Buffalo Gourd	x						x
13. Fluted pumpkin	x			x			
14. Marrow	x						
15. Smooth Loofah	x						
16. Grapeseed	x			x			x
17. Illipe	x			x		x	x
18. Kusum	x			x	x		
19. Macadamia nuts	x						
20. Mango seed							
21. Noog abyssinia	x			x		x	
22. Nutmeg	x		x		x		
23. Perilla	x	x					
24. Pili nut	x						x
25. Rice bran	x			x	x		x
26. Sacha Inche	x						
27. Seje	x		x	x			
28. Shea nut	x	x		x	x		x
29. Teaseed	x						

Appendix II - Research and development institutions

BABASSU PALM

- **Institute of Intermediate Technology, Belo Horizonte, Brazil.**
- **University of Maranhao, Sao Luiz, Maranhao, Brazil.**

BRAZIL NUTS

- **Embrapa, Brazilian Agricultural Research Station, Belem, Brazil.**

BUFFALO GOURD

- **The Arid Lands Agricultural Development Programme, The Ford Foundation, Beirut, Lebanon.**
- **Centro Nacional de Investigacion pare Desarrollo de Zonas Aridas, Saltillo, Coahuila, Mexico.**
- **Department of Biochemistry, University of Arizona, Tuscon, Arizona, 85721, USA.**
- **LC Curtis and Son Inc. Watkinsville, Georgia, 30677, USA.**
- **USDA, Southern Regional Research Centre, P.O. Box 19687, New Orleans, Louisiana, 70179, USA.**

JESSENIA SPP

- **Jardin Botanico, "Joaquin Antonio Uribe", Medelin, Colombia.**
- **Ministerio de Agricultura, Bogota, Colombia.**

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I. Individual monographs

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Allanblackia

I. GENERAL

COMMON NAME OF THE OIL

Allanblackia

BOTANICAL NAME

Allanblackia stuhlmannii, A.floribunda

FAMILY

Guttiferae

OTHER NAMES OF THE OIL

Mkanyi fat, Kagne butter,

HABITAT

Tropical

MAJOR PRODUCING COUNTRIES

E. Africa, Congo, Cameroons

YIELD AND DESCRIPTION

Trees of the genus bear large fruits, up to 12 inches long which may contain 40-50 seeds. The seed kernels amount to 60-80% of the whole seed weight. A hard white fat can be extracted from the kernels. Allanblackia fats are unusual in that they consist almost entirely of stearic and oleic acids, and even more unusual in that the stearic acid proportion is very high, above 50%. Allanblackia has thus had considerable attention, based on its unusual fat composition, rather than its commercial importance (Ecky).

In 1958 E.Tanganyika was reported to have produced 68 tons of Kagne butter (Tang).

MAIN USES

The use of the fat in soap has been suggested (Foma). The timber is suitable for use under damp conditions and finds use in Ghana for bridge piers and pit props. The pounded bark is used for medicinal purposes, in Ghana for example as a pain reliever, for tooth ache, and to treat diarrhoea (Abbiw).

II. AGRICULTURAL ASPECTS

CULTIVATION

No information identified

HARVESTING PERIOD

No information identified

HARVESTING METHODS

No information identified

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

No information identified

IV. PROCESSING

OIL EXTRACTION

No information identified

MAJOR FATTY ACID COMPOSITION OF OIL

Palmitic acid 2-3%

Stearic acid 52-58%

Oleic acid 39-45%

(Hilditch)

EQUIPMENT

No information identified

NOMENCLATURE OF PRODUCTS

No information identified

There is a lack of identifiable information for the following areas: GENERAL, production, uses: AGRICULTURAL ASPECTS, cultivation, harvesting periods and methods; PROCESSING, primary processing, oil extraction, by products.

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Almond

I. GENERAL

COMMON NAME OF THE OIL

Almond Oil

BOTANICAL NAME

Prunus communis, P. americana P. . amygdalus

FAMILY

Rosaceae

OTHER NAMES OF THE OIL

Amandier, Mandelbaum, Almendro, Mandorlo HABITAT Temperate, Mediterranean

MAJOR PRODUCING COUNTRIES

Italy, Spain, Morocco, France ,Greece, Iran

YIELD AND DESCRIPTION

The Almond tree grows to a height of 10-25ft. and bears a peach like fruit. The outer pulpy portion of the fruit is thin and inedible. The fruit becomes tough and leathery and splits open when ripe. Many varieties of almonds are grown but they can broadly be divided into two types, Bitter and Sweet.

Sweet almonds do not contain amygdalin and are widely used as nuts and food ingredients. Bitter almonds contain amygdalin and an enzyme which causes its hydrolysis to glucose, benzaldehyde and hydrocyanic acid.

When ground, moistened bitter almond kernels are subjected to steam distillation a volatile oil is obtained. This is Oil of Bitter Almond and mainly consists of benzaldehyde and hydrocyanic acid. It should not be confused with the fixed oil, Sweet Almond Oil.

The fixed oil is known as Sweet Almond Oil to distinguish it from the steam volatile Bitter Almond Oil. This does not imply however that sweet almond oil is made from sweet almonds, in fact most is extracted from bitter almonds as sweet almonds are too valuable for oil extraction. Bitter almonds are thus used for both fixed and volatile oil extraction (Ecky). The oil content of dried sweet almond kernels is 50-60%. That of bitter almonds is lower, 40-45%, and sometimes as low as 20% (Ecky).

Almonds are also grouped by shell type in hard shell, soft shell and paper shell types.

MAIN USES

Sweet hard shell almonds are sold as shelled nuts while the soft and paper shell types may be sold with or without the removal of the shell. Shelled almonds are sold both blanched and unblanched. Blanching removes the very thin skin around the inner kernel. Sweet Almonds find use in a wide range of food products.

Sweet Almond oil is used in many cosmetic products. Due to its high value Sweet Almond Oil is subject to

adulteration, particularly by the far cheaper peach oil which has very similar fatty acid characteristics. In one survey in Brazil it was found that 77% of almond oil samples had been adulterated (Badolato). Much research has been carried out on analytical methods to detect such adulteration (Salvo).

The cake of sweet almond remaining after oil extraction contains 39-47% protein and 10-18% oil. It is used in animal feed and also ground to a fine powder which finds use in some toilet preparations. Bitter almond press cake, due to its toxic components cannot be used for feed (Mensier).

The Indian Almond, Terminalia catappa, find wide use amongst tribals. The kernel is eaten and the tree provides medicines and dyes. The wood is used for construction (Sen).

II. AGRICULTURAL ASPECTS

CULTIVATION

The commercial cultivation of almond is covered in the appropriate literature.

HARVESTING PERIOD

Varies depending on country

HARVESTING METHODS

The fruits are either picked from, or knocked down from, the trees.

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

After removing the hulls from harvested fruit the nuts are dried. If the nuts are to be sold whole they are sometimes treated with sulphur dioxide to bleach them (Ecky).

IV. PROCESSING

OIL EXTRACTION

Bitter almonds are pressed at a low temperature, generally about 30C to prevent destruction of the hydrolytic enzyme, generally about 30C. The press cake is then used for the production of bitter almond oil (Ecky).

MAJOR FATTY ACID COMPOSITION OF OIL

Palmitic acid 7.5%

Stearic acid 1.8%

Oleic acid 66.4%

Linoleic acid 23.5%

(Garcia Olmedo)

EQUIPMENT

Presses, filters

NOMENCLATURE OF PRODUCTS

Almond nuts, Bitter oil of Almond, Sweet almond oil. There is alack of identifiable information on oil extraction methods, refining and uses.

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Chaulmoogra

I. GENERAL

COMMON NAME OF THE OIL

Chaulmoogra oil

BOTANICAL NAME

True Chaulmoogra oil comes from Taraktogenos kurzli. Other closely related species include Hydnocarpus wightiana, Oncoba echinata; native to West Africa and Carpotroche brasiliensis; Brazil (Ecky).

FAMILY

Flacourtiaceae

OTHER NAMES OF THE OIL

Maroti, Hydnocarpus oils, Gorli seed oil (Ecky).

HABITAT

MAJOR PRODUCING COUNTRIES

India, Sri Lanka, Burma, Bangladesh, Nigeria, Uganda.

YIELD AND DESCRIPTION

Trees of the species that yield Chaulmoogra oil grow to a height of 12-15 m. and in India bear fruits in August and September. The fruits are ovoid some 10 cm in diameter with a thick woody rind. Internally they contain 10-16 black seeds embedded in the fruit pulp. The seeds account for some 20% of the fruit weight. A typical tree produces 20 kg of seed/annum. The kernels make up 60-70% of the seed weight and contain 63% of pale yellow oil (mukherjee). The oil is unusual in not being made up of straight chain fatty acids but acids with a cyclic group at the end of the chain.

MAIN USES

Chaulmoogra oil has traditionally been used for thousands of years in the treatment of leprosy. Its use has now however been largely replaced by modern drugs. The expeller cake is a useful manure and is reported to ward off ants and other insect pests. It cannot be used for animal feed due to its toxicity.

The oil has been shown to be highly active against fungal plant pathogens including aspergillus niger and rhizopus nigricans (Mukherjee).

II. AGRICULTURAL ASPECTS

CULTIVATION

No information identified

HARVESTING PERIOD

In India August to September.

HARVESTING METHODS

No information identified

III. POST HARVEST PRETREATMENT. PROCESSING, STORAGE

PRE-TREATMENT

The seeds require decortication prior to oil extraction. This is reported to be a simple process (Bring)).

IV. PROCESSING

OIL EXTRACTION

The oil is extracted from the kernels using traditional ghanis and small expellers (Bring)).

MAJOR FATTY ACID COMPOSITION OF OIL

No information identified

EQUIPMENT

Ghanis, expellers

There is a lack of identifiable information on most areas of current production, extraction methods and uses.

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Cuphea spp.

I. GENERAL

COMMON NAME

Cuphea spp

BOTANICAL NAME

C. carthagenensis. C. painter)

FAMILY

Lythraceae

OTHER NAMES OF THE OIL

HABITAT

Temperate and sub tropical

MAJOR PRODUCING COUNTRIES

Occurs naturally in Central and South America. Has been grown in trials in Germany and USA

YIELD AND DESCRIPTION

The genus Cuphea comprises some 260 herbaceous or perennial species. The seeds of Cuphea sp. weigh about 2 mg. They have been reviewed by Graham. Yields of one ton/acre of seed is estimated.

MAIN USES

Industry has always made use of short chain fatty acids and C8, C10 and C12 saturated acids are mainly produced from coconut and palm kernel oils. C8 and C10 acids are only found at levels of 6-10% in these commodities. Recent price rises have caused interest in alternative sources of short chain fatty acids, of which various members of the genus Cuphea have been shown to contain high levels. The seeds of Cuphea studied contain 30-36% oil (Kaliangilee).

II. AGRICULTURAL ASPECTS

CULTIVATION

Propagated from seeds or vegetatively by cuttings.

HARVESTING PERIOD

No information identified

HARVESTING METHODS

Indeterminate flowering and seed shattering are wild type character istics that cause difficulties (Princen).

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

No information identified

IV. PROCESSING

OIL EXTRACTION

No information identified

MAJOR FATTY ACID COMPOSITION OF OIL

C. carthagenensis		C. painteri	C. ignea	C. llavea
C8		73%	3%	
C10	18%	24%	87%	83-86%
C12	57%			

There is a lack of identifiable information for most aspects of Cuphea cultivation, processing, production and market potential.

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Jatropa curgas

I. GENERAL

COMMON NAME

Pourghere

BOTANICAL NAME

Jatropha curgas

FAMILY

Euphorbiaceac

OTHER NAMES

Barbados nut, Physic nut, Tuba, Taua taua, Saboo dam, Jarak butte, Awla.

HABITAT

Hot dry tropical

MAJOR PRODUCING COUNTRIES

The Physic nut originated in S. America and is now find worldwide in tropical countries. It grows wild in many tropical regions, especially W. Africa. Grown commercially in Cape Verde Islands and Malagasy Republic.

YIELD AND DESCRIPTION

The tree grows to a height of 8m. and can survive long dry periods by shedding its leaves. It begins to yield at 4-5 months and can live for up to 50 years (Godin).

The tree bears round fruits with a soft brownish skin, 1.5-3 cm in diameter that weigh 1.5-3 g. The fruits contain up to 3 black/ yellow striated oval seeds. One litre of seed weighs 450-500 g.

The seeds contain about 33% oil, the kernels 50%. The oil is pale yellow to brown in colour. The oil contains a toxic substance, curcasin, which has a strong purging effect, a few drops of the oil being equivalent to a large spoonful of castor oil.

MAIN USER

It has been strongly recommended that J.curgas is cultivated as a drought resistant plant in marginal areas to prevent soil erosion.

The seeds yield a semi-drying oil that has been commercially used for lighting oil, lacquer, soap and as a textile lubricant. It is also used for medicinal purposes for its strong purging effect; from which the name purging nut stems. The sap has blood clotting properties and the leaves find use in the treatment of malaria (Henning).

Products useful as plasticizer, hide softeners and hydraulic fluid have been obtained after halogenation (Godin). Dye extraction has been proposed (Aide) (Gonzales). The wood is used for fuel.

The cake, after oil extraction, cannot be used for animal feed due to its toxicity but is a good organic fertilizer. In Mali it is widely used for hedging, it is estimated that there are 1500 kms and that the yield is 2 kg of seed/km (Henning). In Madagascar the plant is used as a support for Vanilla (Ecky).

The wood is very flexible if thinly split and is used for basket making. A water extract of the whole plant has molluscicide effects against various types of snail, and has insecticidal properties (Ecky).

Recently there has been considerable interest in the use of the oil in small diesel engines. Vegetable oils can only be directly utilized in pre-chamber engines (such adapted engines are commercially available or existing motors may be easily adapted). Jatropha oil may however be modified by transesterification; heating with alcohol and a catalyst; after which it can be directly substituted for diesel fuel. Zaske summarises vegetable oil/ engine technology thinking. In the Cape Verde Islands this is at the limit of commercial viability, Jatropha oil being 138 CFA franc/litre against diesel at 142 CFA francs. It is suggested Jatropha oil could be economically viable in Mali with diesel costing 210 CFA francs/litre and up to 400 CFA francs in remote areas (Henning). A recent survey in Mali indicates that the potential of 3000 t. Of seeds/annum represents a monetary value of 55 million CFA francs and that equally importantly the purchase of seed would inject substantial amounts of money into lower income families' budgets (Henning).

J. curgas has also been the subject of investigation in Thailand for powering single cylinder country diesel engines. (Betang).

The integrated use of C. curgas has been surveyed recently by GTZ, Germany. (Hunch).

II AGRICULTURAL ASPECTS

CULTIVATION

May be grown from seeds or cuttings

HARVESTING PERIOD

In Cape Verde there are two harvests, June/July and October/November. In Mali from August to September.

HARVESTING METHODS

Generally fruits are allowed to ripen and fall to ground although sometimes trees are climbed to harvest them.

III POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

The seeds are cleaned, decorticated, ground and heated prior to pressing or expelling.

IV PROCESSING

OIL EXTRACTION

Traditionally, in Thailand, the ground seeds are boiled with water and the oil floated off. In Mali the oil is trad itionally extracted in manual and hydraulic presses which are also used for the extraction of Shea butter.

Small expellers, with a capacity of 30-70 litres oil/hr. can also be used powered by electricity or diesel engines running on Jatropha oil (Henning).

The crude oil may be semi-refined by degumming and alkali treatment.

MAJOR FATTY ACID COMPOSITION OF OIL

Myristic acid 0-0.5%

Palmitic acid 12-17%

Stearic acid 5-6%

Oleic acid 37-63%

Linoleic acid 19-40%

(Ecky)

EQUIPMENT

Mills, pestles and mortars, heating pans, driers, presses, expellers, filters.

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Karanja seed

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I. GENERAL

COMMON NAME OF THE OIL

Karanja Seed Oil

BOTANICAL NAME

Pongamia glabra

FAMILY

Leguminaceae

OTHER NAMES OF THE OIL

Pongam oil, Honge oil

HABITAT

Pongamia is widely distributed in tropical Asia. The tree is hardy, reasonably drought resistant and tolerant to salinity.

MAJOR PRODUCING COUNTRIES

East Indies, Philippines, India

YIELD AND DESCRIPTION

The Karanja tree is of medium size, reaching a height of lam. The tree bears green pods which after some 10 months change to a tan colour. The pods are flat to elliptic, 5-7 cm long and contain 1 or 2 kidney shaped brownish red kernels. The yield of kernels per tree is reported between 8 and 24 kg. (Bring)).

The kernels are white and covered by a thin reddish skin. The composition of typical air dried kernels is:

Moisture 19%, Oil 27.5%, Protein 17.4%. The oil content varies from 2739%. The oil contains toxic flavonoids including 1.25% karanjin and 0.85% pongamol. After refining, and removal of these flavonoids, the oil still produced retarded growth in rat feeding studies. (Mandal). In the 1970's India was producing 4000-6500 tans of oil per annum.

MAIN USES

As a lighting oil, in pharmacy particularly for skin problems, in tanning and soaps. Soap made from crude oil tends to darken due to a component, Isolonchocarpin, which gives a wine red colour in the presence of alkali. In rural areas the leaves are used to prevent infestation of grains. The cake after oil extraction may be used as a manure. The presence of a hypotensive principle and a substance producing uterine contraction has been reported (Bring)).

Much research has been carried out on secondary processing of Karanja oil to overcome some of its shortcomings. All parts of the plant have also been analyzed due to its reported medicinal importance (Bring)).

Karanja oil, like Neem oil, has been widely tested for piscidal, insecticidal, nematicidal and bactericidal activity.

II AGRICULTURAL ASPECTS

CULTIVATION

Essentially the Karanja tree occurs naturally although its use for reforestation in dry waste land in Karnataka, India has been reported (Bring)).

HARVESTING PERIOD

As required.

HARVESTING METHODS

The most common method involves climbing the tree and beating off the pods with sticks.

III POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

The dried pods are struck with hammers and sticks to open them after which the seeds are winnowed out.

IV PROCESING

OIL EXTRACTION

Carried out in Ghanis and small expellers. The oil is dark in colour with a disagreeable odour and difficult to refine.

MAJOR FATTY ACID COMPOSITION OF OIL

Oleic acid 71.3%

Linoleic acid 10.8%

(Hilditch)

EQUIPMENT

Harvesting sticks, hammers, ghanis, oil expellers.

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Neem

I. GENERAL

COMMON NAME

Neem

BOTANICAL NAME

Mellia azadirachta

FAMILY

Meliaceae

OTHER NAMES

Margosa, Veppam, Cho do, Nilayati nimb.

HABITAT

Dry tropical forests

MAJOR PRODUCING COUNTRIES

India, Sri Lanka, Burma, Pakistan, Tropical Australia, Africa

YIELD AND DESCRIPTION

The Neem tree is a large glabrous evergreen growing up to 60 ft high. It bears an ovoid fruit, 2cm by 1cm, that has a pericarp containing a resinous substance with a garlicky odour. Each seed contains one kernel. The seed kernels, which weigh 0.2g constitute some 50-60% of the seed weight and 25% of the fruit. The fat content of the kernels ranges from 33-45% (Ecky). The fruit yield per tree is 37-55 kg.

It is estimated that India alone has a theoretical potential to produce 350,000 tons of oil per annum. Production in the late 1970's was 30,000 tons but this dropped dramatically to 14,000 tons in 1979.

MAIN USES

Soaps, medicinal, insecticide and repellent. Neem twigs find use as tooth brushes. In recent years the insecti cidal and anti-feedant properties of Neem oil have prompted a considerable amount of research. Some Neem based insect repellents are now commercially marketed.

Neem oil is usually opaque, bitter and inedible but it has recently been shown that it can be processed into a non bitter edible oil with 50% oleic acid and 15% linoleic acid. Rat feeding studies on this refined oil indicated that it was suitable for use as an edible oil (Rumkini).

The bitter cake after extraction of oil has no value for animal feeds although it has been reported that after solvent extraction with alcohol and hexane a meal suitable for animals is produced.

II AGRICULTURAL ASPECTS

CULTIVATION

Normally occurs as a natural forest tree

HARVESTING PERIOD

June-August in India

HARVESTING METHODS

No information identified

III POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

It has been found that between 2 - 5 months after harvesting the oil content of neen seeds rises to a maximum. The main problem is that neem is a forest product, making collection difficult.

Its harvest also coincides with the monsoon in India, making drying difficult. After collection the fruits are depulped, usually manually, although small mechanical pulpers are available. In some areas the fruits are buried for a few days to facilitate pulping.

The pulped seeds are then either sun dried or piled in heaps and turned periodically (Bringi). Small artificial tray driers are also used.

The dry seeds are de-corticated, usually manually. Hand and powered decorticators have been developed by the Khadi & Village Industry Commission of India as has a machine that processes dry fruit right through to kernels.

The importance of good drying and storage to extraction efficiencies in ghanis where yields can fall from 35% oil to 20% has been demonstrated (Bring).

IV PROCESSING

OIL EXTRACTION

Neem seeds are usually crushed prior to extraction in ghanis. Whole dried fruits may be directly passed to expellers. Good quality kernels (50% oil) yield 40% oil in ghanis. In expellers whole dried fruits, depulped seeds and kernels, yield 4-6%, 12-16% and 30-40% oil respectively (Bring)). The cakes, which contain 7-12% oil are sold for solvent extraction.

MAJOR FATTY ACID COMPOSITION OF OIL

Palmitic acid 19.4%

Stearic acid 21.2%

Oleic acid 42.1%

Linoleic acid 14.9%

Arachidic acid 1.4%

(Bringi)

Neem oil is unusual in containing non-lipid associates often loosely termed as "bitters" and organic sulphur compounds that impart a pungent, disagreeable odour.

EQUIPMENT

Depulpers. Driers, Ghanis, Expellers, Solvent Extraction plants, Decorticators

NOMENCLATURE OF PRODUCTS

Neem oil, Neem insecticides

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Papaya

I. GENERAL

COMMON NAME

Papaya

BOTANICAL NAME

Carica papaya

FAMILY

Caricaceae

OTHER NMAES

Papaw, Lechosa, Mamon.

HABITAT

Tropical to sub-tropical

MAJOR PRODUCING COUNTRIES

Native to S. America, now widely distributed throughout the tropics.

YIELD AND DESCRIPTION

The short lived, rapidly growing papaya is in reality not a true tree having no lignified tissues. Papaya starts to bear fruit at 9-14 months but although it can live for up to 25 years the normal productive life is only 3 years. The trunk reaches a height of 3-8 m and is covered with conspicuous scars from leaf petioles. Papaya occurs as male and female plants. The fruits vary in colour from green-yellow to almost red. The size of fruit varies, some varieties from Venezuela can be 60-100 cm long and weigh up to 10 kg. but more common varieties have fruits 15-30 cm long. The average number of fruits per plant is 50 and yields can reach 30-50 t/Ha.

The small black seeds which comprise about 15% of the fruit weight are attached in 5 rows to the interior wall of the fruit. They are some 5 mm in diameter. About 20 dry seeds/g (Purseglove). The seeds contain oil, 25.3% has been reported from Florida varieties and 28.8% from Senegal (Ecky, Mensier). The oil is pale yellow and almost odourless and flavourless.

The protein content of the defatted seed is 44.4% (Godin). The oil contains mainly unsaturated fatty acids. 70.7% is reported (Godin). Results from rat feeding trials that caused enlarged livers and kidneys indicated that

the oil may contain toxic components that would make it unsuitable for use in human foods (Godin).

MAIN USES

The main uses of papaya are as a fresh fruit and for the production of drinks, jams etc. Green papaya also finds use in pickles and chutneys. Native Indian tribes are reported to use the seeds a" a treatment for worms, and the leaves to wrap meat in to make it tender. Papayan produces this effect (Brucher). The seeds also find use as counter irritants and to promote abortion (Purseglove).

It has been suggested that oil extraction from the seeds could improve the viability of industry in countries where papaya is cultivated for papain production and processing (Marfo). In Hawaii for example the seeds constitute 22% of the waste from papaya puree plants and oil extraction has been examined as a possible method of utilization (Marfo).

The green fruit is also a commercial source of the proteolytic enzymes papain and chymopapain, the former finding use in a wide range of industries, particulary brewing for haze removal, the latter in medicine.

Traditionally the enzyme is obtained by making cuts in the trunk and fruits and collecting the exuded latex. World demand for papain varies from 200-400 l/annum (Brucher).

II AGRICULTURAL ASPECTS

CULTIVATION

Normally propagated by seed and then grown on until sex can be determined on flowering. They are then thinned to provide one male plant per 25-100 female (Purseglove).

HARVESTING PERIOD

Varies according to country of production.

HARVESTING METHODS

Both hand and mechanised harvesting are used. In Hawaii mechanised harvesting able to handle 50 tons/day has been developed. The fruit is then rapidly sprayed and wax applied to control decay (Brucher).

DISEASES AND PESTS

A serious disease is "bunchy top" transmitted by the white fly Bemisia tabaci. Leaf mosaic virus is also transmitted by various aphids and leafhoppers (Brucher). Pythium, collar and foot rot are common diseases.

Colletotrichum gloeosporioides, Arachnose. Mites Tetranychus, Tenuipalpus and Hemitarsonemus are serious pests in Hawaii.

III POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

The seeds will normally be available after fruit processing, either scraped by hand from the opened fruit or removed by a pulper finisher.

IV PROCESSING

OIL EXTRACTION

No information encountered on methods used.

MAJOR FATTY ACID COMPOSITION OF OIL

Oleic 79.1%

Palmitic 16.6%

(Mensier)

EQUIPMENT

No information on oil processing equipment.

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Tonka bean

I. GENERAL

COMMON NAME

Tonka Bean

BOTANICAL NAME

Dipteryx odorata

FAMILY

Leguminacea

OTHER NAMES

Gaiac de Guyane, Camaru, Sarrapia (Mensier)

HABITAT

Tropical

MAJOR PRODUCING COUNTRIES

Guianas, Venezuela

YIELD AND DESCRIPTION

The tonka bean is the seed of a large tree which produces purple flowers. The seeds are almond shaped and some 3-4 cm long with a dark brown skin and a pale interior. The kernel contains up to 46% oil on a dry basis. The bean contains .

MAIN USES

The oil is used in perfumery and as a flavouring material. The beans are placed for 24 hrs in rum or alcohol after which time crystals of coumarin appear on their outer surface. This was the coumarin of commerce but has now been replaced by synthetics. Tonka extracts have found use in the American tobacco industry to impart a particular aroma.

II AGRICULTURAL ASPECTS

CULTIVATION

No information identified

HARVESTING PERIOD

No information identified

HARVESTING METHODS

No information identified

III POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

No information identified

IV PROCESSING

OIL EXTRACTION

No information identified

MAJOR FATTY ACID COMPOSITION OF OIL

Palmitic acid 6.1%

Stearic acid 5.7%

Oleic acid 59.6%

Linoleic acid 51.4%

(Echy)

EQUIPMENT

There is a lack of identifiable information on agricultural aspects, harvesting, pre-treatment, oil extraction and commercial application.

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Tung

I. GENERAL

COMMON NAME OF THE OIL

Tung Oil

BOTANICAL NAME

Aleurites fordii, A .montana

FAMILY

Euphorbiaceae

OTHER NAMES OF THE OIL

China Wood Oil, Lumbang oil, Noix d'abrasin

HABITAT

A. fordii grows well in cooler climates but will survive sub-tropical conditions. A. montana prefers a more tropical climate.

MAJOR PRODUCING COUNTRIES

China, Argentina, Paraguay, Brazil, USA.

YIELD AND DESCRIPTION

The deciduous Tung tree bears a globular to pear shaped fruit 3-5cm in diameter which changes from green to brown when ripe. A. fordii starts to bear after 4 years and continues fruiting to 40 years. The fruit contains 1-15 nuts or seeds, although 5 nuts per fruit is most common. The nuts are about one inch long and one inch wide and contain an oil rich kernel enclosed by a thin shell (Ecky). The kernel makes up 60% of the seed weight and has an oil content of between 40-60%, depending on the moisture content. The oil content of the air dried fruit lies between 14.7 and 19.5%.

The USA began to produce tung oil as a commercial crop in the early part of this century. Average yields in the USA are 0.5 tons/acre (Ecky). World production was 100,000 tons (1971) and 121,000 tons (1972) (Plank).

MAIN USES

Tung oil, which has good drying pro perties is used in paints, varnishes etc. It also finds use in the pro duction of linoleum, resins and chemical coatings. It has been used in motor fuel in China (Ecky). The seed cake after oil extraction is used as a fertilizer and cannot be used for animal feed as it contains a toxic protein (Godin).

II AGRICULTURAL ASBECTS

CULTIVATION

Grown from seed or grafted cuttings. A special plate to adapt a corn planter has been developed for sung. Seeds are planted at 8" intervals. A fully mechanised transplanter has been investigated (Godin). Selection and orchard trials in China have demonstrated that oil yield" can be increased by 41-101% (Wu).

HARVESTING PERIOD

Depends upon region of cultivation

HARVESTING METHODS

In China the fruit is harvested from the trees before maturity while in the USA it is allowed to ripen and fall to the ground from where it is mechani cally gathered.

III POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

When the fruit falls from the tree its moisture content is about 65%. It should be allowed to dry in the orchard to 25% the safe level for storage. The dried fruits are mechanically de-hulled (Ecky). In China the fruits are kept moist in piles to loosen and soften the hulls, after which the nuts are removed by hand and sold, usually without drying.

IV PROCESSING

OIL EXTRACTION

Traditional methods of oil extraction in China involve drying over slow fires followed by milling in primitive stone mills. The meal is then steamed over hot water for a short while before being moulded into large cakes which are then pressed in a wedge press. The pressed meal is usually re-pressed after further grinding and heating (Ecky).

In the USA the fruits are mechanically de-hulled and after drying passed to continuous oil expellers. The efficiency of extraction depend'; on the moisture content of the nuts and the percentage of shell present. The best yields are obtained with 4.2% moisture and 20% shell.

The crude oil is filtered, but is not usually subjected to alkali refining.

MAJOR FATTY ACID COMPOSITION OF OIL

Palmitic acid 5.5%

Oleic acid 4.0%

Linoleic acid 8.5%

Eleostearic acid 82.0%

(Ecky)

EQUIPMENT

De-hullers, driers, wedge presses, expellers. Information on oil extraction methods currently in use is required together with production, market and usage data.

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Ucuuba

I. GENERAL

COMMON NAME

Ucuuba

BOTANICAL NAME

Virola surinamensis, V.sebifera

FAMILY

Myristicacea

OTHER NAMES

Muscadier du Para, Yagamadou, Ocuba,

HABITAT

Tropical swampy forests

MAJOR PRODUCING COUNTRIES

Brazil, Guianas

YIELD AND DESCRIPTION

V. sebifers trees are of medium height with regular branches. At an early age the trees begin to bear spherical fruits that split easily and enclose a seed with a thin delicate shell. Inside the seed lies a kernel, 8-12mm in diameter, which makes up 82-88% of the seed weight. A typical tree can produce 60-90 litres of oil each year (Ecky).

The seeds of V. surinamensis are somewhat different and average 15mm in diameter and have a dark green to black furrowed brittle shell. The kernel comprises 86% of the seed weight and contains 65-76 % fat. The yellow-brown aromatic smelling oil from both varieties is very similar.

Other related species such as V. otoba, which grows in Colombia and Peru, yields a fat similar to ucuuba which

is known as Otoba butter or American Nutmeg Butter.

MAIN USES

Virola fat has been used traditionally in candle manufacture. Native tribes also use the seeds, impaled on sticks, as candlelights (Brucher). The fat and pulverised kernels find use in tradi tional medicines. Ucuuba has been proposed as a potential source of isopropyl myristate, used in cosmetic manufacture.

II. AGRICULTURAL ASPECTS

CULTIVATION

The trees grow wild

HARVESTING PERIOD

No information identified

HARVESTING METHOD

As many of the trees grow close to rivers the seeds tend to fall into the water and are collected as they float downstream.

III POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

No information identified

IV PROCESSING

OIL EXTRACTION

No information identified

MAJOR FATTY ACID COMPOSITION OF OIL

Lauric acid 15.0-17.6%

Myristic acid 72.9-73.296

Palmitic acid 4.4- 5.0%

Oleic acid 5.1- 6.3%

(Ecky, Hilditch)

EQUIPAMENT

NOMENCLATURE OF PRODUCTS

There is a lack of identifiable information for the following areas: Harvesting period; Post-harvest treatment

and storage; equipment and nomenclature of products.

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Appendix I - Summary of various applications of minor non-edible oil crops

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The following table shows the distribution of various known applications of extracted fatty materials from those minor nonedible oil crops reviewed in this section. Such applications are listed below:

a. MAJOR APPLICATIONS

- **Medicine**

- **Soap**
- **Cosmetics**
- **Flavouring for liquors**
- **Lighting**
- **Pesticide (piscidal, insecticidal, nematicidal and bactericidal)**
- **Motor fuel**
- **Paints and varnishes**

B. OTHER APPLICATIONS

- **Essential oils**
- **Tanning**
- **Lubricant for textiles**
- **Plasticizer**
- **Repellent**
- **Refinement into edible oil**
- **Resins**
- **Chemical coating**
- **Lacquer**

Table 1 Various applications for a few minor non-edible oilseed crops

	MEDICINE	SOAP	COSMETICS AND FLAVOURING	LIGHTING	PESTICIDE	MOTOR FUEL	PAINT AND VARNISHES	OTHER
Allanblackia	x	x						

Almond			x					
Chaulmoogra	x							
Cuphea spp.								
Jatropha curgas		x		x		x		x
Karanja seed	x	x		x	x			x
Neem	x	x			x			
Papaya	x				x			
Tonka bean			x					
Tung						x	x	
Ucuuba	x		x	x				

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I. Introduction

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Essential oils are generally high value, low volume commodities. This makes them attractive crops to grow and process for smallholder farmers and remote communities in the LDCs, where transport problems prevent them from marketing high volume cash crops.

Fourteen monographs on essential oil crops which are capable of yielding an income in a relatively short space of time have been prepared. The oils featured in the monographs have been selected for one of two reasons: i. there is an existing commercial market for the oil with room for new producers to enter, e.g. patchouli oil. ii. the oil contains a major ingredient for which shortages may occur in the future, e.g. safrole from sassafras oil.

The essential oil from a particular species of plant may vary depending on where it has been grown and how it has been processed. New producers should be prepared to meet with some resistance when attempting to market oils from new sources. They may be offered lower prices than expected and, initially, sales may be slow. In order to be successful a new supplier must satisfy buyers that his oil(s) will meet the following requirements. i. uniform good quality ii. stable price iii. continuity of supply

Building up buyer confidence will, of necessity, take some time and new producers of essential oils are encouraged to take this into account when beginning to distil commercially essential oils.

II. Distillation of essential oils

Essential oils are aromatic materials of vegetable origin, which are used in perfumery and flavourings. They represent the "essential aroma" of the plant from which they are obtained. The majority of essential oils are produced by the process of steam distillation.

2.1 Raw materials / processing

Essential oils occur in many different parts of plants, e.g. roots (vetiver), bark (cinnamon), heartwood (sandalwood), leaves (bay), herb (peppermint), seeds (nutmeg), flowers (cananga and jasmine).

The essential oil of a plant consists of many compounds which generally boil between 150 300 C. If attempts are

made to remove these compounds by dry distillation many will decompose and the oil will be ruined. However, the compounds are steam volatile and can be distilled out of the vegetal materials at around 100 C.

When plant materials are steam distilled chemical changes inevitably occur and the oil obtained will not have an identical aroma to that of the original plant material.

Preparation of material for distillation varies with the material to be distilled. Some material must be distilled immediately after harvesting, whereas others can be (and are best) stored for a day or two before distilling and finally there are materials which can be stored indefinitely before distillation. In general, flowers should be distilled immediately, whereas herbaceous material often benefits from wilting for one or two days before distillation. Woody materials may need to be ground and/or soaked before distillation.

The preparation of the raw material, the packing of the still and the rate/type of distillation can be determined for a particular essential oil crop from the literature or from experimental trials.

2.2 Types of distillation

There are three basic types of essential oil distillation:

i. **water or "hydrodistillation"**
ii. **water and steam or "wet steam"**
iii. **steam or "dry steam"**

i. "Hydrodistillation" - in this method the charge (which is usually comminuted) is immersed totally in water which is boiled. The stills are of the simplest type (see Figure 1: Simple still hydrpdistillation) and are used extensively by smallholder producers of essential oils. Often they are heated over an open fire. The disadvantages are that the heat is difficult to control and hence the rate of distillation is variable. Also the

possibility exists for local overheating and "burning" of the charge which can lead to a poorer quality oil. Improved distillation control can be obtained by using steam from a separate boiler, which is passed into a jacket around the still or through a closed coil in the bottom of the still, to heat the contents of the still. A further disadvantage of this system is that it requires the heating of a large quantity of water adding to costs and time needed for each distillation. However, it is necessary for certain flower distillations e.g. rose and ylang. It is also necessary for the efficient distillation of certain woody materials e.g. sandalwood and cinnamon bark.

ii. Water/steam distillation this is an improved method, the still contains a grid which keeps the plant material above the water level (Fig. 2. Water/Steam still) The water is boiled below the charge and "wet" steam passes through the plant material. Consequently, if an open fire is used the plant material is protected from direct heat. In Fig. 2 the still is heated by a steam jacket. It is important in both water/steam and steam distillation that the still is packed evenly and not too tightly so that steam can extract from the complete charge efficiently. Over packing of the still can cause the steam to force "rat holes" through the charge and leave other parts of the charge unextracted.

iii. Steam Distillation - the most advanced type of distillation is by direct steam provided from a separate boiler. The still contains a grid plate under which an open steam pipe is fitted (see Fig. 3. Steam distillation unit).

The advantages of this type of "dry" steam distillation are that it is relatively rapid, therefore charging and emptying the still is much faster and energy consumption is lower. The rapid distillation is also less likely to damage those oils which contain reactive compounds, e.g. esters

As a general rule all stills should be insulated ("lagged") to reduce heat losses. Their design and losses . Their design and construction should also facilitate loading and unloading.

Condensers and Separators

The steam containing essential oil vapour leaves the still and passes into a condenser by way of a "gooseneck" (Fig. 4. Btillhead/Gooseneck). Some sort of gauze or screen is often fitted at the mouth of the gooseneck to prevent plant material being blown over into the condenser.

In the condenser the vapours are cooled and condense. The simple form of condenser is shown in Fig. 5. (see Fig. 5. Coil condenser). The vapours pass through a coiled tube contained in a water bath and condensate is obtained at the bottom of the condenser tube. It is important that condensation is complete or oil may be lost by evaporation.

A more efficient type of condenser is the multi-tubular type shown in Fig. 6 (see Fig. 6. Multi-tubular condenser) in which a series of parallel tubes are mounted inside a cylindrical jacket through which cooling water is passed. This design provides a large surface area for cooling in relation to its volume.

The mixture of water and essential oil leaves the condenser and flows into a separator, called a florentine flask, in which they separate into two layers.

The essential oil will generally be lighter than water, the oil floats to the surface and the distillate water drains away.

Fig. 7. Lighter-than-water separator

It is important that the oil separators should be large enough in volume to minimize turbulence because significant amounts of oil can be lost with the distillate water if the oil is not allowed to separate completely. In addition, the temperature of the distillate may have an important bearing on the efficiency of separation of essential oil and water. The optimum temperature for obtaining the best separation can be found by trial and

error. Sometimes when separation of oil is difficult, the distillate water is run back into the still (cohobation) and redistilled.

Fig. 8. Heavier-than-water separator

Condensers and separators should be constructed of materials which do not react with essential oils or water. Mild steel rusts and is not suitable. However, copper has been used successfully for many years tend tinned copper were cooper reacts with the oil). The optimum material for stills, condensers and separators is stainless steel which is resistant and durable but is relatively expensive.

2.3 Storage and packaging

Most essential oils can be stored for long periods under suitable conditions: they should be dry, not in contact with the air or direct sunlight and kept cool.

It is important that essential oils do not come into contact with materials with which they might react, e.g. rubber or plastic bungs.

Glass containers are often used for smaller amounts of oil but larger quantities are invariably stored in metal drums. Mild steel drums lined with epoxy resin are very popular for essential oils. If secondhand drums are to be used, it is important that they are thoroughly cleaned and dried before being filled with essential oil. Plastic containers, e.g. polythene, should not be used because the oil may be absorbed by the plastic and contamination may occur. To ensure that the oil is not wet it should be left to stand for some time before being filtered into its container. Oils generally show no cloudiness when thoroughly dry.

Freshly distilled oils often possess some "still odours" which are unpleasant. These generally disappear after several weeks storage. Some oils gradually improve in storage and acquire a fuller more rounded aroma, e.g.

vetiver and patchouli.

III. Individual monographs

Cajuput

I. GENERAL

COMMON NAME

Cajeput

BOTANICAL NAME

Melaleuca minor sm

FAMILY

Myrtacae

OTHER NAMES

Cajuput, Cajuputi, Kaju-Puti,Ti-Tree (not to be confused with Melalecua alternifolis or Melalecua viridiflora)

CULTIVATION CONDITIONS

Occurs in natural stands and with associated species in the Far East, principally Indonesia and the Philippines.

The tree grows to a height of 10 - 12 metres, but only the shrub growth is used for the oil production. The oil is produced all year round from the young leaves and terminal branches (Guenther).

MAJOR PRODUCING COUNTRIES

Indonesia (Moluccas) (production fluctuates between 70 150 tonnes / pa) and Vietnam (2 tonnes).

YIELD AND DESCRIPTION

The young leaves yield approximately 1% pale green to yellow oil. The oil has a powerful fresh 'mildly medicated' odour. The taste is harsh and burning.

MAIN USES

For the inhabitants of South East Asia this oil which has several names (Cajuput oil, Cajuputi oil, Kaju-Puti oil, Ti-Tree oil, Cajaput oil), is a complete all-purpose home medicine. The

Vietnamese hail the oil for its antibacterial properties. Elsewhere it is widely used as an expectorant, for throat preparations, such as gargles and for stomach upsets. It is used in

Indonesia as an insecticide. Total production is estimated to be between 75 and 200 tons annually (Arctander).

It has not been fully considered outside S.E. Asia. The smoothness of this cajuputol containing oil, compared to the harshness of Eucalyptol oils for blending with other flavours, has yet to be exploited.

II. AGRICULTURAL ASPECTS

CULTIVATION

Natural cultivation and reforestation is sufficient for the present demand. It could be readily cultivated in a plantation provided the usual precautions are taken against tropical diseases and pests (Evans).

HARVESTING PERIOD

The leaves are collected all year round.

HARVESTING METHODS

By hand, however plantations could be harvested mechanically.

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

There are no particular requirements

PRESERVATION AND STORAGE

There are no particular requirements

IV. PROCESSING

PROCESSING METHOD

By water/steam distillation in mobile field stills. The stills are carried by two men on bamboo poles. The spent leaf is used as the fuel. Modern equipment, in particular the collecting system, would improve the yield, as the oil does have some solubility in water.

COMPOSITION OF OIL

Terpenes

Cajeputol (Cineole) 50 - 60%

Terpineol

Linalol

EQUIPMENT

Simple distillation apparatus

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Clausena anisata

I. GENERAL

COMMON NAME

Clausena

BOTANICAL NAME

Clausena anisata, Hook

FAMILY

Rutaceae

OTHER NAMES

Various local native language names are used

CULTIVATION CONDITIONS

Clausena is a small tree that grows abundantly in tropical countries

MAJOR PRODUCING COUNTRIES

East Africa, Indonesia and the Philippines

No commercial production reported.

YIELD AND DESCRIPTION

Oil of Clausena anisata is a mobile yellow clear liquid with a strong anise odour. On a dry weight basis the yield is reported as 4.32% (Guenther).

MAIN USES

In Indonesia and the Philippines the oil is used as a medicinal flavour and in the Philippino local brandy "Anisdos". While the world interest in this oil was wiped out with the availability of synthetic anethole for aniseed, it has remained in use to save foreign currency. In East Africa the dried leaves are used as an insect repellent and the oil has been reported to be toxic to the grasshopper "Zonecerus variegate" (Okunade).

II. AGRICULTURAL ASPECTS

CULTIVATION

The shrub can be propagated from seed t Guenther) or more easily as grafts on Clausena excavate.

HARVESTING PERIOD

This has not been investigated but is considered to be "as required".

HARVESTING METHODS

By hand, no commercial mechanical harvesting is known.

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

None specified

PRESERVATION AND STORAGE

The oil is susceptible to oxidation and, therefore, should be stored in full, airtight containers in a cool dark place.

IV. PROCESSING

PROCESSING METHOD

Water/steam or steam distillation is satisfactory

COMPOSITION OF OIL

Nineteen components have been identified in the leaves, with phenylpropanoids making up 96%, methyl havicol

(estragole) being the most abundant at 92% (Ekundayo).

EQUIPMENT

Distillation retorts with heat exchangers made from stainless steel

There is no identifiable information for the following areas: PROCESSING oil extraction, and nomenclature of products

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Davana

I. GENERAL

COMMON NAME

Davana or Davanum

BOTANICAL NAME

Artemisia pollens Wall

FAMILY

Compositae

OTHER NAMES

CULTIVATION CONDITIONS

Davana is an indigenous herb of Southern India but does not grow wild to any great extent and is cultivated mainly for the leaves and flowers used in Indian garlands (Arctander). It is an annual, grown from seed and it reaches maturity in four months.

MAJOR PRODUCING COUNTRIES

India (1 tonne)

YIELD AND DESCRIPTION

Yields have been reported ranging from 0.13 - 0.58% with an average value of 0.2%. The oil is brown in colour with a fine herbaceous sweet foliage odour which becomes balsamic on drying. Because of the price it has caused little interest outside the Indian sub continent.

The herb is susceptible to nematodes (Haseeb).

MAIN USES

As a perfumery material. Antifungal and antibacterial properties have been widely reported for the oil (Alankara Rao, Alankara Rao).

II. AGRICULTURAL ASPECTS

CULTIVATION

The plants are readily cultivated from seeds. These are planted in December and the seedlings are planted out after 4 - 6 weeks. Artificial irrigation is used. Davana farming has been very labour intensive, i.e. the propagation, planting out, weed control and harvesting (Kumar).

HARVESTING PERIOD

This is usually 4 months after planting and just prior to inflorescence. Artemisia pallens Wall.

HARVESTING METHODS

Reports indicate this has been by hand (Gowda). The herb is dried for a week in the shade.

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

Nematodes have to be combatted (Arctander).

PRESERVATION

None required

STORAGE

In clean airtight drums

IV. PROCESSING

PROCESSING METHOD

Normal herbage distillation techniques are used (Denny). The herb is dried, as above. The spent herb can be used as fuel.

COMPOSITION OF OIL

The early reports were summarised by Lawrence (Lawrence). More recently the ketone and furan have been discussed with interest (Akhila). The main component is davanone and this, and related compounds, have been used to identify Davana Oil (Sandra).

EQUIPMENT

Usual primitive distillation apparatus suffices.

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Galbanum natural oleoresin

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I. GENERAL

COMMON NAME

Two types:

Levant or Soft Galbanum

Persian or Hard Galbanum

BOTANICAL NAME

Ferula galbaniflua

Ferula rubricaulis

Ferula ceratophylla

FAMILY

Umbelliferae

OTHER NAMES

Galbanum, Resinoid

CULTIVATION CONDITIONS

These tall herbs have not been cultivated but grow in Northern Iran (Ferula galbaniflua), Southern Iran (Ferula rubricaulis) and Turkestan (Ferula cera tophylla) (Guenther).

MAJOR PRODUCING COUNTRIES

Iran (15 tonnes)

YIELD AND DESCRIPTION

Galbanum is the air dried extruded gum resin. The soft galbanum exists as tears, viscous, translucent and yellow

to red in colour. The hard galbanum occurs as lumps and can be broken readily. The crude gum contains 'foots' consisting of sand, water, insects and chips of wood. In the heat of the summer it can be purified by straining. The natural material on steam distillation yields an oil, 15 - 25%. The strained gum can be extracted by solvent to form a resinoid. A 40 - 50% extract is obtained. Pourable grades of the resinoid are obtained by extracting the crude gum with a perfumery diluent such as diethyl phthalate, benzyl benzoate etc. The yields depend on the cleanliness of the gum.

MAIN USES

The oil is pale in colour with a powerful woody balsamic green fragrance and is used in classical perfumes to give a 'green' floral note.

The resinoid has a deeper fragrance than the oil and also has fixative properties skilfully used in some well known perfumes.

II. AGRICULTURAL ASPECTS

CULTIVATION

As yet this is entirely natural.

HARVESTING PERIOD

There is a lack of identifiable information.

HARVESTING METHODS

By women, when the crude extruded gum is required, usually in the winter. They collect for the exporters.

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

PRESERVATION AND STORAGE

IV. PROCESSING

PROCESSING METHOD

Apart from the straining, most of the processing is carried out by European and American raw material processors.

Distillation is best carried out in stainless steel stills with direct steam. Water/Steam distillation can be done at source but the oil quality is poor. The extractions are to 'in house' requirements.

COMPOSITION OF OIL

A review of the published analysis of the oil has been given by Lawrence and by McAndrew and Michelkiewicz The oil has been frequently adulterated with pine oil distilled fractions.

EQUIPMENT

There is no identifiable information for the following areas: GENERAL, Other names, Major producing countries and Main uses; AGRICULTURAL ASPECTS, Harvesting period; POST HARVEST PRE-TREATMENT, PRESERVATION & STORAGE; PROCESSING, oil extraction, and nomenclature of product.

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German chamomile

I. GENERAL

COMMON NAME

German Chamomile

BOTANICAL NAME

Matricaria chamomilla Linn. (Camomilla recutita L.)

FAMILY

Compositae

OTHER NAMES

Blue chamomile, Matricaria, Hungarian Chamomile, Raushert Chamomile, Mother Herb

CULTIVATION CONDITIONS

The herb is indigenous to Europe and was extensively cultivated in Germany, still the major user, where the name originates. It is also widespread in the remainder of Central Europe, particularly Hungary and Czechoslovakia. It has been successfully introduced to many other countries (Guenther).

This oil is not to be confused with Roman Chamomile (Arthemis nobilis) or Moroccan Chamomile (Ormims multicaulis). These are entirely different plants (Singh).

MAJOR PRODUCING COUNTRIES

Egypt (1 tonne), France (1 tonne), Hungary (1 tonne), Bulgaria (700 kg), Portugal (500 kg), Czechoslavakia (100 kg) and the herb also in India, Brazil and Argentina.

YIELD AND DESCRIPTION

The oil is contained in the flower. The yield and quality are very dependent on the correct selection of harvest time, the location, the use of fertilizer (El-Hamidi) and the climatic conditions. The dried flowers are reported to contain between 0.3 and 1.3% oil, a typical figure being 0.65%.

The oil is a brilliant dark blue.

This colour is indicative of the freshness and age of the oil. Old oil will lose the liquid sheen, turning dark gray-green. The oil on ageing, and during distillation tends to form a deposit on the walls of metal containers.

The odour and the flavour are characteristically aromatic and camphoraceous; pharmaceutical as opposed to medicinal.

MAIN USES

Infusions are prepared from the herb flowering tops that are used as mild sedatives and digestive aids. The essential oil has several names (Oil of German Chamomile, Oil of Blue Chamomile, Oil of Matricaria, Oil of Raushert Chamomile and Mother Herb Oil) and is used in alcoholic beverages and as a general flavouring agent.

Pharmaceutical use of the oil for its anti-inflammatory, anti bacterial and fungicidal properties is well documented (Cardia Effects...). These properties have been attributed to both the chamazulene and bisabolol constituents.

In the 16th century Chamomile was used for the treatment of fevers. Chamomile drinks are today reported to be used for Cardiac conditions as well as for chronic gastritis, stomach spasms and diarrhoea (A). The medical properties are attributed to both the chamazulene and (-) alpha bisabolol contents.

II. AGRICULTURAL ASPECTS

CULTIVATION

In Europe and Argentina the herb is a summer crop. In India and Egypt it is a winter annual and is used as a fill-in between cereal crops (Atal). Where the oil is produced the flowers, after drying, are graded for export and the rejects become the essential oil raw material. Greater day length is reported to increase oil content and quality as well as chamazulene content.

Chamomile is grown from seed.

After 6 weeks the seedlings can be planted out in ridges 0.75 m x 0.25 m apart. Chamomile has shallow roots and so the plants have to be frequently irrigated. The soil has to be moist, but not flooded. Constant weeding is necessary until the chamomile 'mat' takes over. Chamomile is a very adaptable plant and responds to the local climate or altitude, growing from 300 to 1500 metes. Experiencing some freezing temperatures will not harm the plants, merely reducing the 'bloom' period. It is suitable for planting in saline soils (Singh). It has a high sodium uptake, thus regenerating the soil.

Insects - Aphids are a spring problem, while mildew, which would cause plant loss, is combatted by spraying with kerosene fractions or wettable sulphur (Reichling).

HARVESTING PERIOD

This is a continuous procedure once the chamomile is in bloom. In Egypt, it is picked by children on a 7 - 10 day rotation during January to April. Harvesting is best during temperatures of 22 - 25 degrees centigrade.

HARVESTING METHODS

By hand as indicated above. This is labour intensive and the harvesting method is adapted to suit the size of the operation.

Flower forks are used to pick the flowers and these have been converted for mechanical operation in Hungary

and South America. The yield of flowers can be 4000/Ha.

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

The flowers have to be dried immediately on picking. This cannot be done in the sun, but in the shade, turning occasionally to prevent browning. For large operations they are dried in a heated tunnel.

PRESERVATION

Preservation of the flowers is controlled by the moisture content reached during drying.

STORAGE

The herb, whether for use as such, or for oil production, should be stored in dry polyethylene lined bags. The oil must be stored cool, in full containers out of contact with light. When the oil is to be decanted the flasks or bottles should be well agitated.

IV. PROCESSING

PROCESSING METHODS

The flowers are usually graded before packing. The best quality whole flowers are sold as exportable herb,

while the siftings and broken flowers are used for oil production.

Distillation of the flowers in modern steam stills takes between 4 -5 hours at 7 bar pressure. The Specific Gravity of the oil is very similar to that for water and the separation can be difficult with heavy emulsions formed. Some distillers add solvent to the receivers and later remove the solvent under vacuum.

COMPOSITION OF OIL

The principal component is chamazulene. This does not occur naturally in the oil but is formed during the steam distillation (Sandra). Typical analysis is given by Lawrence but this does indicate the wide variations obtained in the oil (Franz).

EQUIPMENT

Planting machinery for seedlings

Flower forks or adapted flower harvesters

Stainless steel distillation

Steam boiler

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Hexastylis

I. GENERAL

COMMON NAME

Hexastylis

BOTANICAL NAME

Hexastylis arifolia

FAMILY

Aristolochiaceae

OTHER NAMES

Snakeroot, Snakeweed

CULTIVATION CONDITIONS

This is an evergreen herb found in North America, widely reported in North Carolina, occurring with associated species H. minus: H. virginica (Gonzales).

MAJOR PRODUCING COUNTRIES

North America

No commercial production reported.

YIELD AND DESCRIPTION

A pale yellow oil with a strong aromatic odour. The leaf oil is reported to contain 70% safrole and the root oil 58% safrole

MAIN USES

The oil of Hexastylis arifolia has potential safrole uses as food flavour and is extracted both from the leaves and from the roots.

This material is closely related to the Japanese HETEROTROPA species (Hayashi).

II. AGRICULTURAL ASPECTS

CULTIVATION

None reported

HARVESTING PERIOD

As Hexastylis arifolia is an evergreen, harvesting is expected to be continuous.

HARVESTING METHODS

Not investigated

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

Leaves can be dried. Roots triturated.

PRESERVATION

Not required, the oil is an antioxidant.

STORAGE

No special requirements other than for handling safrole (carcino genic).

IV. PROCESSING

PROCESSING METHOD

Steam distillation

COMPOSITION OF OIL (Hayashi)

Leaf Oil:

Safrole 70%

Methyl Eugenol

Methyl Isoeugenol

Root Oil:

Safrole 58%

Methyl Eugenol

Methyl Isoeugenol

EQUIPMENT

Normal steam distillation

There is no identifiable information for the following areas: PROCESSING, oil extraction, and nomenclature of products

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High-geraniol monarda

I. GENERAL

COMMON NAME

High-geraniol Monarda

BOTANICAL NAME

Monarda fistulosa var. menthaefolia

FAMILY

Labiatea

OTHER NAMES

"Sweet" Monarda, Monharda fistulosa

CULTIVATION CONDITIONS

The genus Monarda is native to North America ranging from the Canadian prairies to the plateau of Michoacan in Mexico with Monarda fistulosa being the most widespread complex in this genus.

This is found in Quebec and across to British Columbia and then southwards to the Atlantic coast into Northern

Mexico. In 1967

Scora examined 19 different species and varieties. These oils proved of little commercial interest, the major constituents being thymol and carvacrol. In 1972 Marshall and Scora examined two dissimilar forms of Monarda fistulosa var. menthae falia. The "normal" form contained thymol as the major constituent while the "sweet" form had geraniol as the major component. In 1977 Lawrence using modern analytical techniques confirmed these findings for "Sweet" monarda.

Cultivation of two strains was undertaken by Marshall and Chubey at the Research Station, Agri culture Canada, Morden, Man.

MAJOR PRODUCING COUNTRIES

Canada (Full commercial production yet to be exploited - 2.0 tonnes / p.a.)

YIELD AND DESCRIPTION

A very pale sweet rose smelling oil is produced. Yields vary depending on the time of the harvest and the amount of wilting (Marshall, Mazza) with an average figure of 0.9% on a fresh weight basis with geraniol contents in excess of 90%. Yields of oil are reported at between 100 125 Kg/Ha.

MAIN USES

The oil is called Oil of Monarda fistulosa. It can be used as a perfumery material in its own right but is ideally fractionated for the production of natural geraniol. This geraniol will be competitive with synthetic geraniol.

II. AGRICULTURAL ASPECTS

CULTIVATION

Two hybrids, identified as Morden No. 3 and Morden No. 82-IT have been cultivated (Masse). Morden No. 3 is a triploid hybrid and can only be propagated asexually. Morden No. 82-IT is a tetraploid and can be propagated from seed.

The plants are established in June and have a life of 5 - 7 years. It grows best in fertile, well drained soil. It is drought tolerant.

HARVESTING PERIOD

Reportedly between 15 - 20 July during full bloom.

HARVESTING METHODS

As the oil is located in all parts of the plant harvesting is under taken using a forage harvester.

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

The plants are managed in the same way as for mint, with the weeds controlled using the same mint herbicides.

PRESERVATION

When distilled the oil has a shelf life in excess of two years with out the addition of antioxidants.

STORAGE

Ideally stored in a cool, dark place, in well filled epoxy-coated containers.

IV. PROCESSING

PROCESSING METHOD

By hydrodistillation or hydro diffusion. The material can be distilled fresh, or wilted. Baled material gives a lower yield than expected (Simon). Hydrodiffusion was seen as an alternative to crude field distillation stills. Monarda fistulosa

COMPOSITION OF OIL (Lawrence)

Geraniol 90% (+/-2%) Other Alcohols 5% Aldehydes and Ketones 3.4% Esters 0.4%

EQUIPMENT

Forage Harvester

Field stills or Hydrodiffuser (a)

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(a) Hydrodiffuser supplied by Hydrodiffusion Services Ltd., 222 Shepherds Bush Road, London, W6 England

Juniapa-hinojo sabalero

I. GENERAL

COMMON NAME

Juniapa. Hinojo Sabalero

BOTANICAL NAME

Piper auritum H. B. K.

FAMILY

Piperaceae

OTHER NAMES

Juniapa, Piper auritum

CULTIVATION CONDITIONS

Grows wild in abundance in open areas in tropical Central and Southern America. Has teen cultivated in Mexico, Vera Cruz State in trial plots by the Institute Nacional de Investigaciones Sobre Recursos Bioticos.

MAJOR PRODUCING COUNTRIES

Panama and Brazil. No commercial production reported

YIELD AND DESCRIPTION

On steam distillation leaves give a mobile clear liquid with a characteristic odour of "root beer". Yield of oil has been reported at 0.17% with a safrole content of 70% (Gupta).

MAIN USES

As an alternative to sassafras oil or as a source of essential oil containing Safrole, the chemical raw material for the manufacture of Heliotropin (Fragrance material) and Piperonyl Butoxide (Pyrethum synergist).

In Panama it is used as a food condiment and as a fish bait (Joly). In Mexico it is used as a house plant because of the heart shaped colourful leaves.

II. AGRICULTURAL ASPECTS

CULTIVATION

Natural cultivation as secondary vegetation after clearing the high perennial evergreen forest.

HARVESTING PERIOD

Not reported

HARVESTING METHODS

By hand

III. POST HARVEST TREATMENT, PRESERVATION, STORAGE

PRE-TREATMENT

Wilting prior to distillation is required

PRESERVATION

None required

STORAGE

In good quality drums

IV. PROCESSING

PROCESSING METHOD

By hydrodistillation of the dried herb. Water/steam or steam distillation is satisfactory. The temperature of the condensate is critical as emulsion or top/bottom separation can result.

The sun dried exhausted herb can be utilized as a fuel.

COMPOSITION OF OIL

Safrole up to 90%

Terpenes

Forty components have been identified (Gupta)

EQUIPMENT

Harvesting equipment

Stills

Boiler

There is no identifiable information for the following areas: PROCESSING, oil extraction, equipment and nomenclature of products.

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