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NON-WOOD FOREST PRODUCTS

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Edible nuts

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by

G.E. Wickens

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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FOREWORD

Forests offer a variety of edible products, of which edible nuts form a distinct group.

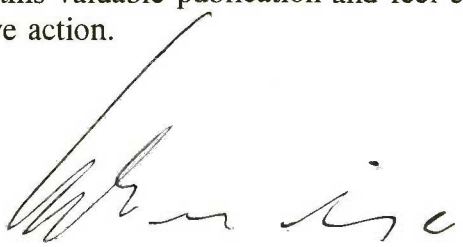
Nuts are among the most nutritionally concentrated of human foods and are an important food source for rural communities and forest dwellers. While some of the edible nuts support subsistence, others are of considerable commercial importance.

However, the role and importance of edible nuts as a Non-Wood Forest Product is not adequately recognized or appreciated. An attempt is made here to address this deficiency.

The document deals with a representative selection of major edible nut producing plants, minor edible nut producing plants, and potential edible nut producing plants. The purpose is to bring the importance of edible nuts into sharp focus, to highlight their immense potential, to encourage further studies and research relating to edible nuts and to promote their development.

The draft of this publication was prepared by G.E. Wickens, previously of the Royal Botanic Gardens, Kew (UK), and it benefitted from the detailed comments of G. Blaak, E.H. Sène and P. Vantomme. Laura Russo undertook light editing of the text and organized the illustrations. Format editing and proof reading was done by Elisa Rubini. Overall guidance and supervision for the preparation and publication of the document was provided by C. Chandrasekharan, Chief of the Non-Wood Products and Energy Branch. I wish to express my thanks to all of them.

I have great pleasure in releasing this valuable publication and feel confident that it will provide necessary impetus for positive action.



Karl-Hermann Schmincke
Director
Forest Products Division

CONTENTS

GLOSSARY OF TECHNICAL TERMS

abscision scar	adhesion scar
accrescent	inflated
achene	1-seeded, coriaceous (*q.v.*) fruit
acuminate (of a leaf)	apex tapering gradually or abruptly into a narrow point
acute	pointed
adaxial (of a leaf)	upper surface
adventitious roots	roots arising from an organ other than the root
aflatoxins	group of secondary metabolites produced by *Aspergillus* spp. commonly growing on stored food and often highly toxic
alternate (of leaves)	inserted at different levels along the stem or branch, *i.e.*, not opposite
androecium	male component, *i.e.*, stamens (*q.v.*) of an angiosperm flower
annual	plant completing its life cycle within a year
apetalous	without petals
aril (of a seed)	an appendage covering or partly enclosing the seed and arising from the funicle (*q.v.*)
armed	equipped with spines
axil	the angle between the leaf and branch
axillary	arising from the axil (*q.v.*)
beaked	terminating gradually in a hard, long, straight point
berry	a juicy fruit with seeds immersed in pulp
bipinnate (of a leaf)	where the primary divisions of a leaf (leaflets) of a pinnate leaf (*q.v.*) are themselves pinnate
bony	hard and very close textured and only cut with difficulty
bract	a small leaf subtending a flower or flower stalk
bur, burr	a rough, prickly or spiny husk (*q.v.*), also commonly applied to the entire fruit
buttress	a plank-like outgrowth of the lower trunk and providing support
caducous	falling early
calcifuge	a plant that grows in calcium deficient soils
calyx	collective term for the sepals (*q.v.*)
carpel	a simple pistil formed by a fruit-leaf folded lengthwise and united by its edges (suture, *q.v.*), or one of several such united to form the ovary
cartilaginous	flexible but firm and tough
cathartic	purgative
catkin	a closely packed, bracteate, pendulous spike (*q.v.*), usually composed of small, inconspicuous unisexual flowers
chartaceous	papery
compound leaf	leaf divided to the midrib or petiole to form leaflets (*q.v.*)
coriaceous	leathery
corm	a short, swollen, perennating, underground stem
corolla	collective term for the petals (*q.v.*)
cotyledon	first leaf or leaves of the angiosperm embryo
cupule	cup-shaped structure partially or completely enclosing the fruit in the Fagaceae formed from the fused extensions of the pedicel (*q.v.*)

cyme	a type of inflorescence (*q.v.*) in which each axis ends in a flower
cypsela	a fruit similar to an achene (*q.v.*) but develops from an inferior ovary and consequently includes non-carpellary tissue. Typical of the Compositae, where the fruit is surrounded by hairs, pappus, (*q.v.*), derived from the calyx
deciduous	eventually falling; not evergreen
dehiscent	opening spontaneously when ripe
determinate	growth ending in a bud
dioecious	with unisexual flowers (*c.f.* monoecious)
disc	a circular enlargement of the receptacle (*q.v.*)
dorsal	lower surface, side facing away from the main axis
drupe	a fleshy, indehiscent fruit in which the seed or seeds are surrounded by a hardened, sclerochymatous endocarp (*q.v.*)
dry	not fleshy
ellipsoid	an elliptic solid
elliptic	oval shaped, broadest in the middle
endocarp	innermost layer of the pericarp (*q.v.*)
endosperm	the nutritive material stored within the seed
epicarp	see exocarp
etiology	the study of the casual agents of a disease
exocarp	the outer layer of the pericarp (*q.v.*)
exfoliate	peeling off
fan palm	palm with fan or wedge-shaped leaves
fastigiate	a tree in which the branches grow almost vertically
feather palm	palm with pinnate leaves
FOB	free on board
foliate	leaves divided into leaflets (*q.v.*)
follicle	a pod (*q.v.*) consisting of a single carpel (*q.v.*) usually opening along the inner suture (*q.v.*) to which the seeds are attached
funicle	the stalk attaching the ovule and later the seed to the ovary wall
gametophyte	the haploid generation in the life-cycle of a plant
geocarpic	where the fruit are pushed into the soil by the gynophore (*q.v.*) and mature
glabrescent	becoming glabrous (*q.v.*) or nearly so
glabrous	devoid of hairs
gourd	fruits of the Curcurbitaceae with a hard rind (*c.f.* pepo)
gynoecium	female component, *i.e.*, carpels (*q.v.*), of an angiosperm flower
gynophore	an extension of the receptacle (*q.v.*) which bears the ovary (*q.v.*)
hapaxanthic (palms)	a plant which flowers only once and then dies (*c.f.* pleonanthic)
hastula	a small flange of tissue at the junction of lamina (*q.v.*) and petiole (*q.v.*) of most palm leaves
haustorium	a nutrient absorbing organ, often produced by a plant parasite
hermaphrodite	male and female organs present in the same flower
herbaceous	soft, not hard or woody
hull	lay term for skin of kernel
husk	lay term rather loosely applied for the fleshy or fibrous outer cover of a fruit

hypanthium	a flat or cup-shaped receptacle (*q.v.*) on which the ovary is either immersed or on the same level as the calyx and corolla
imparipinnate (of a leaf)	leaf pinnate (*q.v.*) with an odd terminal leaflet (*c.f.* paripinnate)
indehiscent (of a fruit)	not opening when ripe
Indo-China	region of Southeast Asia which includes Myanmar, Thailand, Laos, Cambodia and Viet Nam and the Malay Peninsula
inflorescence	the arrangement of the flowers on a plant
infructescence	fruiting inflorescence
involucre	a number of bracts (*q.v.*) surrounding the base of a flower-head, sometimes persisting in fruit
kernel	the inner, usually edible part of a nut (*q.v.*) or stone (*q.v.*)
lamina	leaf blade
lanceolate	lance-shaped
leaf	leaf blade plus petiole (*q.v.*)
leaf sheath	basal part of a leaf surrounding the stem
leaflet	a leaf-like unit of a compound leaf (*q.v.*)
legume	the fruit-pod of the Leguminosae, consisting of a single carpel, usually opening along both sutures (*q.v.*) into two halves
locule	cavity of ovary or fruit
loculicidal	opening into the cells, when a ripe capsule splits along the back
Malaysia	Federation which includes Peninsular Malaysia, East Malaysia, Sabah and Sarawak
Malesia	bio-geographical region which includes Malaysia (*q.v.*), Indonesia, the Philippines, Singapore, Brunei and Papua New Guinea
mastic	resin
mericarp	one of the separate halves or parts of a fruit
mesocarp	the often fleshy or succulent middle layer of the pericarp (*q.v.*)
monoecious	where the male and female flowers are separate but on the same plant (*c.f.* dioecious)
mucilaginous	a substance that swells with water to form a slimy solution
muricate	with a surface covered by sharp points or prickles or hard, sharp projections
mycoplasma	small, parasitic microorganisms that lack rigid cell wall; they are believed to be responsible for certain yellow diseases of plants
nut	1-seeded, indehiscent (*q.v.*), fruit with a hard, dry pericarp (*q.v.*)
nutlet	a small nut (*q.v.*)
oblong	oval (*q.v.*) with parallel sides
obovate	ovate (*q.v.*) with the broadest part farthest from the petiole
oleaginous	oily
operculum	lid of a pyxidium (*q.v.*)
ovate	egg-shaped with the broadest part nearest to the petiole
ovoid	solid form of oval
oval	broadly elliptic
ovary	the swollen, basal part of a carpel (*q.v.*) containing the ovule (*q.v.*) or ovules
ovule	the immature seed before fertilization

panicle	inflorescence in which the axis is divided into branches bearing several flowers
pappus	rig of hairs or scales round the top of Compositae fruit
paripinnate	pinnate leaf (*q.v.*) without an odd terminal leaflet (*c.f.* imparipinnate)
pedicel	the stalk attaching a flower to the main axis of an inflorescence
peduncle	general name for a flower stalk bearing either a solitary flower or a cluster of flowers
peltate (of a leaf)	petiole attached to the undersurface instead of the margin
pepo	a type of berry (*q.v.*) with a hard exterior derived either from the epicarp (*q.v.*), or, in the Cucurbitaceae, from the receptacle (*q.v.*)
perennial	a plant that survives for several years
perianth	floral envelope consisting of sepals (*q.v.*) and petals (*q.v.*)
pericarp	fruit wall derived from the ovary; in fleshy fruits the pericarp is divided into an outer, toughened epicarp (*q.v.*), a fleshy mesocarp (*q.v.*), and an inner, variously thickened or membraneous endocarp (*q.v.*)
petal	an individual unit of the corolla (*q.v.*), interior to the calyx (*q.v.*), usually coloured
petiole	stalk attaching the leaf blade to the branch or stem
pinnate	a leaf divided along a common axis into leaflets (*q.v.*)
pinnatisect	a leaf almost divided to the axis into segments (*c.f.* pinnate)
piscicide	fish poison
pleonanthic (of palms)	method of flowering in which the stem does not die after flowering (*c.f.* hapaxanthic)
pod	a dry, indehiscent (*q.v.*) fruit
pome	a fleshy fruit where the succulent tissues are developed from the receptacle (*q.v.*)
pubescent	covered with short hairs
pyrene	a nutlet (*q.v.*) or kernel (*q.v.*), the stone of a drupe (*q.v.*) or similar fruit
pyxidium	seed capsule having a circular lid (operculum *q.v.*) which falls off to release the seeds
raceme	an inflorescence (*q.v.*) in which the flowers are borne on pedicels along an individual axis or peduncle (*q.v.*)
rachis	main axis of a compound leaf (*q.v.*) or inflorescence (q.v.)
receptacle	the extremity of a peduncle (*q.v.*) or pedicel (*q.v.*) on which the floral parts are borne
reniform	kidney-shaped
root tuber	a swollen root or branch of a root acting as a food reserve
samara	an indehiscent (*q.v.*), 1-seeded, winged fruit
samaroid	like a samara (*q.v.*)
sarcotesta (of palms)	outer seed coat developed as a fleshy layer surrounding the rest of the seed
schizocarp	a dry fruit derived from two or more 1-seeded carpels which divided into 1-seeded units at maturity
sclerenchymatous	composed of strengthening tissues
seed	the product of a fertilized ovule

sepal	an individual unit of the calyx (*q.v.*) exterior to the corolla (*q.v.*), usually green
septum (pl. septa)	dividing wall
septicidal	divided into compartments
serrate	with regular, saw-like, teeth
sessile	stalkless
shell	hard, dry pericarp (*q.v.*) of a nut (*q.v.*)
simple (of a leaf)	not divided into leaflets (*q.v.*)
solitary palm	stem not suckering
spike	inflorescence with sessile (*q.v.*) flowers along a simple, undivided rachis (q.v.)
stamen	male reproductive organ of a flowering plant
staminode	sterile or rudimentary stamen (*q.v.*)
stigma	receptive tip of the style (*q.v.*) or, where absent, carpel (*q.v.*) where the pollen is received at pollination
stipule	leaf-like or scale-like appendages , usually at the base of the petiole (*q.v.*)
stolon	a runner that roots
stoloniferous	with stolons (*q.v.*)
stone	woody endocarp (*q.v.*) of a drupe (*q.v.*)
strobili	pine cone
style	sterile portion of the carpel between the ovary (*q.v.*) and stigma (*q.v.*)
suture	line of union (and eventual opening) of a carpel (*q.v.*)
subcordate (of a leaf)	leaf base rounded and slightly notched
tendril	a coiling, modified plant organ used for climbing
terminal	at the end of
testa	outer seed coat
tomentose	densely covered with short, soft hairs
ton	long ton, equivalent to 1.016 tonnes
tonne	metric tonne (one thousand kilogrammes), equivalent to 0.984 tons
toothed (of a leaf)	variously and regularly indented (*c.f.* serrate)
trigonous	obtusely 3-angled
turgid	swollen
unarmed	without spines
valve (of fruit)	one of the segments produced by the splitting of a ripe capsule (*q.v.*)
ventral	upper surface, side facing the main axis
vermifuge	expels or destroys intestinal worms

INTRODUCTION 1

Edible nuts are used by mankind for food, edible oils, spices, condiments or beverages. They have been an important food source from prehistoric times and are among the most nutritionally concentrated of human foods, high in protein, oil, energy, minerals and vitamins. Nuts that are only rarely used as famine food have been excluded from this present study partly because of the paucity information available but mainly because they are not normally considered edible. Nuts used solely for spices or condiments have also been largely excluded since they are used sparingly, to flavour food and not as a food; traditionally they are considered separately from edible nuts. Nuts that are largely used as commercial sources of edible oil are not discussed in any great detail since they are already adequately dealt with in the literature, e.g., Hartley (1988) regarding the oil palms *Elaeis guienensis*. However, their local uses are briefly mentioned in Appendix A.

Melville (1947) has, perhaps not unexpectedly, noted a correlation in nutritive values between species within a genus or family. There are also similarities to be found between related species in the harvesting, storage and processing techniques, etc. The arrangement of edible nut species in Appendix A is, therefore, by families in the expectation that users can compare related species and possibly improve management techniques or deduce possible techniques where none are known.

Botanical terminology has been used where known but, in view of the uncritical use in the literature of layman terms, it has not always been possible to identify the true nature of the organs without further research and this may have led to the wrong deduction being made in this paper. As far as research time has permitted, the currently accepted botanical name is used within the text and these, together with their synonyms used in the consulted references, are given in Appendix C.

The term "forest", as used in the title of this report, embraces all the natural ecosystems where trees and shrubs form a significant component. As such, "forests" range from evergreen rainforest to desert, although in the latter habitat the trees and shrubs are confined primarily to oases and waterways (Wickens, 1991). In certain areas, trees and shrubs bearing edible nuts are preserved on farmlands and homesteads after land clearance and constitute the chief supplies available for household consumption or sale; as such they can be considered as relics of the natural ecosystems. There is also a rather grey area where forestry, horticulture and agricultural interests overlap. While nut plantations are included in this report, certain recognized nut crops, such as peanuts, sunflower seeds, pumpkin seeds and soya beans are definitely agricultural crops and are not considered in any great detail here.

WHAT ARE EDIBLE NUTS

The botanical use of the term "**nut**" refers to an indehiscent fruit that is usually shed as a 1-seeded unit. It is formed from more than one carpel but only one seed develops, the rest abort. The pericarp is usually lignified and is often partially or completely surrounded by a "cupule". True nuts include the hazelnuts, *Corylus* spp. (Corylaceae), and from the Fagaceae, beechnuts, *Fagus* spp. and acorns, *Quercus* spp. The term is also loosely applied to any woody fruit or seed, such as the walnut (drupe of *Juglans* spp., Juglandaceae), Brazil nut (seed of *Bertholletia excelsa*, Lecythidaceae) or peanut (indehiscent legume of *Arachis hypogea*, Leguminosae subfamily Papilionoideae). It is even incorrectly applied in the

vernacular names to non-fruiting bodies, such as the root tubers of the pignut or earthnut *Conopodium majus* (Umbelliferae) and *Cyperus esculentus* (Cyperaceae), although in the latter case the root tubers are eaten as a form of dessert nut. A further complication is that the seeds of several members of the Cucurbitaceae and the sunflower, *Helianthus annuus* (Compositae) are eaten as dessert nuts and are included in the literature on edible nuts yet they are always referred to both botanically and in the vernacular as seeds.

For the purpose of this work nuts are hard-shelled fruits, or the edible kernels of fleshy drupes or berries, or seeds that are traditionally referred to as nuts. The first two categories of nuts are the fruits of trees or shrubs, the third include some herbs. Since the value of some nuts as food is relative to what better alternatives are available, there are obvious grey areas regarding whether the nut is to be regarded as edible or not and an arbitrary decision has been made as to whether a species should or should not be included. Some 542 species of edible "nuts" have been listed in Appendix A. More detailed information is given in the text on the major, minor and potential nut species. However, researchers requiring even more information should bear in mind that the information given is a summary of information obtained from a selection of the published literature, the primary sources of which have not been consulted.

While a species may conform to the general description of "edible nut" it does not follow that an allied species also bears acceptable "edible nuts", as for example with the almond, *Prunus dulcis*, and plum, *P. domestica*; although children may very occasionally eat the plum kernels it has never been considered other than as a fruit crop.

It is possible that a number of species have been omitted because the information is not readily available or is too vague while others should be eliminated because the information obtained has been misleading.

Previous authors have also had problems in defining an edible "nut" and have provided their own apparently arbitrary limits. Menninger (1977) provides the widest definition where a nut is defined "as any hard-shelled fruit or seed of which the kernel is eaten by mankind". This definition is so broad that even grasses and a number of herb species have been included, the former are generally regarded as cereals while the latter would be more appropriately listed under edible seeds. However, all the authors consulted, with the exception of Verheij and Coronel (1991), have accepted the popular or everyday use of the term "nut", including its conservative use by Howes (1948) to include "any seed or fruit consisting of an edible, usually oleaginous kernel, surrounded by a hard or brittle shell". Interestingly, the major authors consulted, Howes (1948), Menninger (1977) and Rosengarten (1984), have, like the present author, all made their own interpretation as what to include or exclude as an edible nut, while Verheij and Coronel (1991) declare "it is not possible to define the edible fruits and nuts in such a way that clearly sets them apart from species in other commodity groups".

NUTRITIONAL VALUE

Most edible "nuts" contain concentrated food reserves for future generations of plants and provide valuable sources of energy, protein, oils, minerals and vitamins suitable for human consumption. Others have their food reserves in the form of starch instead of protein, including chestnuts - *Castanea* spp., acorns - *Quercus* spp., water chestnuts - *Trapa* spp., ye-eb - *Cordeauxia edulis*, Bambara groundnuts - *Vigna subterranea* and lotus seeds *Nelumbo*

spp. While *Pinus* spp. are protein rich, some members of the Gymnospermae such as *Ginkgo biloba* and *Araucaria* spp. also have starchy food reserves (Melville, 1947).

Nuts have a reputation for being indigestible, especially if eaten in large quantities or poorly masticated. They are generally a highly concentrated food but low in water and fibre content and consequently require thorough mastication if they are to be properly digested, and are preferably eaten with other foods. They have the additional value in that their fats are, in the main, highly unsaturated and are consequently beneficial in that they do not raise blood cholesterol. Peanuts (*Arachis hypogea*), sunflower seeds (*Helianthus annuus*), souari nuts (*Caryocar nuciferum*) and soynut (*Glycine max*) are specifically mentioned in this context (Howes, 1948; Rosengarten, 1984).

The nutritional value of a number of nuts are given in Appendix B. It is difficult to draw any firm conclusions from these analyses because the majority appear to be based on a single analysis which have been passed down through a number of publications. Ecotypic and seasonal variations, the effects of fertilizers, drought, etc., have not been investigated.

HARVESTING

The harvesting of nuts from arborescent species is often of fallen nuts and as such is generally a prolonged, laborious and wasteful process since fruits do not necessarily all ripen within a short period. Picking fallen fruits is time consuming, especially in rough terrain and, depending on the time lapse between consecutive harvestings, can lead to rapid deterioration as well as losses to predators. Plantations can improve efficiency by providing better accessibility and easier harvesting conditions and, provided they are large enough, lead to mechanized harvesting by the use of ground harvesters and/or tree shakers. Mechanization is being increasingly important in North America where labour costs are particularly high.

PROCESSING AND STORAGE

This discussion is limited to the major nuts, where appropriate techniques and equipment have been developed, about which more detailed information can be obtained from Woodroof (1979). By dealing with processing and storage in general terms it is hoped that readers will obtain ideas for dealing with similar problems in the less-known and little researched species.

Many dessert nuts loose their palatability or otherwise deteriorate if not properly dried or cured after collection or are badly stored, especially those with a high oil content. Among the major nuts walnuts and chestnuts are among the more perishable while pistachios and almonds are among the better keepers.

In-shell nuts are best stored at low temperatures. While rancidity is the main problem with shelled nuts, the kernels also have the ability to acquire off-flavours from the environment, such as tobacco and paint. Apart from rancidity, deterioration during long storage can be difficult to determine and aflatoxins can be present even when there are no obvious presence of moulds (Matz, 1984).

Dehusking

Modern packaging and marketing is increasingly demanding kernels ready for immediate use, both in the home and confectionery trade. Hand processing is being replaced more and more

by mechanization for providing a marketable product, especially where large-scale production is concerned.

Most tree nuts are enveloped in a fleshy or fibrous outer covering or husk which may or may not remain attached to the nut as it ripens and falls to the ground, as is the case for such important commercial nuts as the walnut, pecan, almond and macadamia. In some varieties of walnut and almond the ripe nut readily separates from the husk of their own accord; a few nuts, termed "sticktights" remain attached to their husks, the proportion depending on the cultivar. A poor or dry season may increase the number of sticktights.

The husk has to be removed either mechanically or by hand before nuts can be dried, shelled or otherwise processed. Walnuts especially must be dehusked as soon as they are collected, otherwise the colour and quality of the kernel will be progressively adversely affected the longer the husks remain (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Washing

Nuts gathered from the ground are frequently soiled or dirty, especially after rain, so that washing is necessary in order to make the product more attractive for the market. Again, hand washing in tubs or machine washing in cylindrical drums may be carried out. Any staining or discoloration is not affected by the washing and is removed at a later stage during bleaching (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Drying and dehydrating

Artificially produced heat and forced draughts are now increasingly replacing sun-drying for the drying or "curing" of nuts, especially by large-scale commercial producers. Outputs range from 1-7 tonnes for a drying time of 12-24 hours at, in the case of walnuts, not more than 43°C. Such mechanical dryers are not only independent of the weather but also give a more thorough and uniform drying of the nuts and, in the case of walnuts, result in less splitting. In America mechanical drying has been found to increase packing-house efficiency by stabilizing the delivery rate from the growers and to aid marketing by providing an earlier product. The investment costs did not exceed the high labour cost of sun-drying.

Sun-drying is still largely practised by small producers, particularly with almonds in the producing countries of Europe. It requires a high labour input to spread the nuts out on sheets or in trays, stirring frequently to ensure uniform drying, and also to provide protection at night or in the event of rain. Drying is completed when the kernels can be heard to rattle in the shells or can be broken rather than bent with the fingers. Drying may require only 2-3 days with continuous hot sun or take 2-3 weeks in inclement weather. Similarly, chestnuts in southern Europe were traditionally sun-dried or dried over a wood fire in a specially constructed kiln. A slow process, it may take several weeks and a heavy fuel input to achieve, although the smoke is reputed to have a beneficial effect in inhibiting subsequent fungal infestation but the process results in the loss of the fresh chestnut flavour and the chestnuts may even acquire a disagreeable one. The curing is complete when the shells may be easily separated from the kernels. Modern, mobile mechanical dryers now provide a faster and more uniform drying with a greater economy in fuel (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Bleaching

Some nuts intended for marketing in-shell may have their appearance enhanced by bleaching to remove stains due to sun scorch and disease; walnuts are frequently thus treated by immersion for 1-2 minutes in a bleaching solution.

Sulphur dioxide or burning sulphur may be used, particularly for almonds that have been blemished during harvesting or drying, but this is practised less so now than in the past. Good quality almonds that have been quickly sun dried are already of an attractive appearance and require no bleaching. Over bleaching can give the shells a sickly white appearance and is liable to soften them and flavour the kernels; too little causes irregular bleaching.

Pecans can be considerably improved by removing the outer rough layer and polishing, a process which, if required, makes the nuts more responsive to bleaching and drying. The outer layer may be removed by steel brushes or by the use of revolving drums containing coarse sand. Bleaching is effected by dipping the nuts for 4 minutes in, for example, sodium hypochlorite containing 2% active chlorine. Various dyes may be used to colour the polished and bleached nuts an attractive brown or reddish brown (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Grading

Mechanical graders, such as a perforated revolving cylinder, are commonly used to sort nuts into various sizes, the smaller nuts being the first to fall. Pecan nuts, due to their ovoid or oblong shape, require special graders consisting of variously spaced rollers.

Imperfect, faulty or broken nuts may be removed by hand as the nuts pass along a continuous belt. A suction machine may also be used to lift blank or imperfectly filled nuts over a trap while the heavier nuts pass on. The low specific gravity of Grade 1 macadamia kernels allows them to be removed by floatation in ordinary water. Grade 2 may be removed using 30 g of salt in 1 litre of water, with Grade 3 sinking to the bottom. The nuts are then thoroughly dried (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Storage

Most nuts can be satisfactorily stored for several months provided they are kept cool and dry. Many nuts are stored in the shell for longer periods but there is now a trend towards the cold storage of shelled nuts or kernels. Although requiring more space, the best results are obtained by storing in moisture proof containers after thorough dehydration. Cold storage in open receptacles can result in an uptake of odours such as ammonia, a loss of colour, flavour and texture and the possible development of rancidity. Cold storage in vacuumized containers or the use of inert gases appear to offer little advantage over cold storage for a similar period.

Commercial cold storage is general practice with the pecan. Better prices can be obtained by holding the nuts in store for some time after harvesting and the higher prices more than offset the cost of storage. It may also be profitable to hold a portion of a heavy crop in store in the expectation that the following crop will be smaller and the price higher.

Freshly gathered chestnuts have a high moisture content and consequently prone to fungal attack. Stored in small heaps or shallow layers in an airy store walled on three sides and periodically turned over, they will keep perfectly for up to 3 months or longer. If stored too

dry or in a single layer the kernels will shrivel and become hard. The onset of mould, as well as harmful grubs and insects, during storage may be prevented by immersing the fresh chestnuts in a solution of a fungicide for 48 hours. Gas treatment in autoclaves has been effectively used in France; chestnuts have also been successfully held in cold storage. Chestnuts placed in layers of sand and kept cool keep well and retain their germinability but may become less palatable.

Cob nuts are sometimes stored in sawdust, which helps to prevent shrivelling (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Cracking

The mechanical cracking of nuts is becoming increasingly important, nevertheless, large quantities of some kernels are still extracted laboriously by hand in some countries, such as the cashew in India and the almond in the Middle East. Mechanical cracking is faster but usually results in a higher percentage of broken kernels which, fortunately, usually finds a ready outlet in the confectionery trade.

Power-driven, self-feeding nut-cracking machines require grading for size before being fed to the cracking jaws or rollers with special shaking devices to separate the kernels from the broken shells. The kernels may still have to pass along a continuous belt for broken kernels and other debris to be removed by hand.

Individual pecan nuts are commonly picked up in cups on an endless chain passing through a hoppere of graded nuts. Each nut passes to a slot where a piston-like rod exerts pressure at the end of the nut and cracks it, the shells and kernels then being released to a receptacle below. Very dry pecans often shatter badly with this treatment; prior wetting can reduce this problem, the kernels being redried after shelling.

The varying differences in the thickness and texture of the macadamia shell has created problems in the development of a suitable machine for cracking the shell without damaging the brittle kernel as there is less than 0.4 mm clearance between the two. The current vice-like design employs the principle of the nut being held between two blunt movable wedges.

Special cracking machines are also used for pine nuts where the demand is almost entirely for kernels.

The tough leathery shell of the cashew is overcome by preliminary roasting, thus making the shell brittle and responsive to cracking, as well as lessening the danger of blistering from the caustic oils in the fruit. The roasting is usually done by hand, placing small quantities of kernels in an open iron pan over a small circular earthenware furnace. Care is required to avoid overcooking or charring of the kernels, while with undercooking, the shell remains tough. Attempts at using roasting ovens have been unsuccessful, resulting in discoloured kernels. Shelling is by hand; in southwestern India a wooden mallet and a flat stone is used to crack the shell, after which the kernel is sometimes removed with a wire prong. The kernels are then spread out on wire gauze trays in a hot-air room under controlled temperature in order to loosen the pink or reddish-brown skin before removal and also to remove any excess moisture.

The oyster nut cannot be cracked in the ordinary way due to its tough, leathery, fibrous shell. However, the shell is easy to cut and a slit is made around the edge of the disc-shaped nut with a knife.

A Chinese method of cracking hard-shelled nuts is to heat them in burning straw and then cool rapidly with cold water.

The shells, which were formerly regarded as a waste product for fuel, now have a number of industrial usages. Cleaned and ground to a fine powder, the shells of walnuts, coconuts, Brazil nuts and almonds have been used as an extender or filler in the manufacture of certain plastics and synthetic adhesives and is often considered superior to the softwood flours commonly used. The coarser grades of walnut shell powder have been utilized as cleaners and finishers in the fur, metal, tinplate and other industries; other uses are in linoleum, jointless flooring, and as a carrier for horticultural insecticides (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Cooking and salting

Some nuts are traditionally eaten cooked and salted. Peanuts and chestnuts are normally cooked before eating, while almonds are preferred roasted or toasted and salted, likewise the macadamia nut. Cooking definitely reduces the terebinthine or turpentine flavour in pine nuts.

The large, plump grades are used for roasted or toasted almonds; roasting or cooking in oil is said to produce the best flavour. A common method of salting is by immersion in a strong brine solution before allowing the almonds to drain and dry.

In Hawaii macadamia nuts are preferred cooked and salted, either by roasting in an oven or immersion in a vat of hot oil, the latter method is the preferred commercial method as it gives the nut an attractive gold-brown colour. Refined coconut oil is generally used and, because the hot oil tends to corrode many of the commoner metals, the vats are made of monel metal, stainless steel or glass. Excess oil is removed centrifugally and the nuts laid out to cool on wire mesh trays, being salted while they are still luke warm, using a 15% solution of gum arabic or a special oil to enable the salt grains to adhere more readily to the nut. As the cooked nuts tend to be hygroscopic, they are vacuum packed as soon as they are cool.

Cashew nuts are always marketed cooked as the roasting procedure to render the shell more easily removable automatically cooks the kernel. The risk of contact with the caustic sap in the fresh fruit is also removed (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

ECONOMICS AND MARKETING

Successful marketing may be defined as identifying what the consumer requires or can be educated to require and to supply that requirement at a profit. The marketing process, however, is customer orientated in as much as production is designed to meet the customer's needs. Like other food crops, nuts have a limited "marketing life". The production to marketing chain can be extremely complex, ranging through harvesting techniques, grading and sorting, packaging, transport, storage, processing, curing, distribution and selling. Furthermore, as markets develop, from rural markets to urban chain stores, the consumer become more and more demanding in their requirements and, as a consequence, increase pressures upon the various sectors in the marketing chain.

The local market in a rural community may initially represent the surplus in production to household requirements. Population growth and urbanization accompanied by a proportionate decrease in agrarian activities encourages increased production that has to be met either through cultivation or more intensive harvesting from the wild. The marketing process develops further through regional and national markets to the international. The further along the chain the more stringent are the consumer's requirements, with increasing emphasis on quality and constancy of supply. Local and regional markets are less valuable and may be expected to handle cheaper and lower quality nuts than would be acceptable by international markets. The majority of tropical tree nuts are not yet well represented on the international market. Of the ten major edible tree nuts it is noticeable that only the Brazil nut, macadamia and coconut are from the tropics, while only one out of six minor tree nuts and all 22 potential tree nuts are from the tropics or subtropics.

Nuts are largely tree crops and as such the production schedule will be long term, requiring careful selection of cultivars and, in some cases, root stocks. Initial investment may be high, with no return until the trees come into bearing. Labour requirements may be high for short periods in the year for pruning, harvesting and immediate post-harvest treatments and low for the rest of the year. High labour costs may be offset by increased mechanization, as in the North American nut plantations.

Quality is obviously of prime importance and good quality nuts can readily be spoilt, especially during harvesting and immediate post-harvest operations. The initial processing can result in broken or discoloured nuts unsuitable for the dessert nut trade. It is important, therefore, that producers should have ready access to other outlets, such as the food, oil and other industries.

Regularity and continuity of supply is important, especially for the international markets. Failure to comply will undoubtedly favour the importation of alternatives. A buoyant and profitable market can quickly change through oversupply or a sub-standard produce. Expansion in production must balance the market if prices are not to be depressed. However, nuts are a good candidate for marketing as "added value products" through processing, roasting, salting, etc., and have an excellent potential in the West for the health food market (Meadley, 1989; Honess, 1993).

The disposable world production of dessert nuts is shown in Table 1. These figures obviously do not show internal consumption. The general trend is towards increased production. In the league marketing tables almonds are the major product, pistachios have the fastest expansion rate while the trend for the Brazil nut (although not clearly shown from Table 1 but is discussed more fully in the section dealing with that nut) shows a steadily declining production due to deforestation and a chaotic marketing system.

The world disposable production of nuts primarily grown as a commercial source of edible oils is shown in Table 2. The proportion used directly for food is not known.

While the utilization of a few selected nuts by the developed world is reasonably well documented, there are no figures available for the remainder of the 520 edible nut-producing species listed. Their value within the rural community is largely based on anecdotal evidence.

Table 1: Disposable World Production of In-Shell Dessert and Table Nuts (tonnes)

	1979-81	1991	1992	1993
Almonds	1 000 457	1 232 222	1 281 355	1 194 497
Cashew nuts	446 004	707 583	726 418	479 804
Chestnuts	484 595	470 979	492 805	437 403
Filberts/Hazel nuts	477 662	520 428	721 622	565 157
Pistachios	109 379	329 804	313 256	345 305
Walnuts	788 097	938 998	931 697	1 006 547
Brazil[a]	53 333	32 000		
Miscellaneous[b]	3 648 000	4 675 000	4 924 000	4 579 000

Source: FAO, 1994

[a] Figures from LaFleur (1992)

[b] These include Brazil nuts, macadamia nuts, pili nuts and sapucaia nuts

Table 2: Disposable World Production of Oil Nuts and their Products ('000 tonnes)

	1979-81	1991	1992	1993
Coconuts				
in shell	35 062	42 668	43 768	43 385
copra	4 439	4 829	4 642	4 569
Groundnuts (in shell)	18 491	23 531	24 601	25 005
Palm kernels				
kernels	1 740	3 574	3 800	4 532
oil[a]	5 025	11 883	12 775	14 317
babassu oil	14	70	62	68
Sunflower seeds	14 413	22 947	21 979	20 489

Source: FAO, 1994

[a] Palm kernel oil excluding babassu oil

NUTS IN THE RURAL ECONOMY

The most obvious value of edible nuts is their contribution as a concentrated food to the diet and, in some cases, as a source of edible oils. The major and minor nuts discussed in the following sections also have an important commercial value as dessert nuts.

In many of the developing countries, especially in the tropics and subtropics, nuts are often available during the dry season or winter months when fresh vegetables are not always readily available. They can also have the additional advantage in that they are not bulky and can usually be readily stored. The arborescent nut producers may have other advantages too, as providers of fuel, timber, fibre, medicines, browse, etc., plus their role in conserving the soil against wind and water erosion, providing shade and shelter, etc., as well as being

aesthetically pleasing. The nut-producing herbs, i.e., groundnuts, etc., take their place in the agricultural rotation and, in the case of legumes, contribute to soil fertility.

The large-scale commercial production of nuts for the dessert and edible oil industries is well documented. However, the role of edible nuts in the rural economy is less clear. This is partly due to the confusion in the literature in defining what is an edible nut and as a consequence classing them with edible fruits, plus a paucity of information regarding their utilization. Like other economic plants, the value of edible nuts, whether they are used for food or edible oil, is relative to what other alternatives are available. This, in turn, creates a problem in ordering the potential for development. A well-written account of a single species by an enthusiastic author tends to mask the value of other species, including related taxa. The broader the field experience of an author the greater the likelihood of achieving an acceptable evaluation.

The work by Okafor and co-workers in the Nigerian forests on the utilization and improvement of indigenous woody food plants may be taken as an example of how to maximize this forest resource within the forest, homesteads and farmland (Okafor, 1977, 1980; Okafor and Lamb, 1994). Elite trees favoured by local inhabitants were selected and various vegetative propagation techniques investigated, including budding. Budded trees of *Irvingia gabonensis* and *Treculia africana* produced viable fruits in 3.5 and 4 years respectively. An additional benefit in the case of the latter species, a tree up to 35 m tall, was that the reduction in fruiting height from budding eliminated the serious danger from the globular fruits falling and injuring passers-by; the fruits can be up to 50 cm in diameter and weigh up to 15 kg! Perhaps rather surprisingly, the reduced risk resulted in an increase in popularity rating.

Taxonomic investigations into the range of variation within a species can also be rewarding. The recognition of two variants within *Irvingia gabonensis* with different flowering seasons, var. *gabonensis* fruiting in the rainy season from April to September, and var. *excelsa* in the dry season from December to March has encouraged rational selections to be made for extending seasonal availability.

Conservation and utilization of genetic resources

The requirements for the development, improvement and conservation of edible nut-producing species are similar to the requirements for other species. Information is required on distribution and reproductive biology, including flowering and fruiting patterns, pollination mechanisms and pollinators, seed dispersal, viability, predation, nature of the breeding system, breeding and propagation techniques, pests and diseases, etc. (Okafor, 1977).

There are two conflicting interests involved. Efficient production resulting in a low cost product is mainly obtainable from plantations where the emphasis is on selection of genetic uniformity for ease of management and productivity. Small-scale, usually peasant production, mainly makes use of wild resources or less rigorously selected cultivars and may even prefer an absence of uniformity in, for example, ripening in order to obtain a better spread in availability of mature fruit. Furthermore, peasant farming systems often protect useful trees during any land clearance operation while commercial farming systems tend to favour total land clearance with consequential loss of any genetic variability.

Wild resources often have the disadvantage in that the required species occurs sporadically in the surrounding vegetation. Whereas tree crops provide an excellent method of soil

conservation, small-scale production can often have the additional advantage of making efficient use of difficult terrain. However, the demand for reliable quantities of a cheap, high quality product is placing increasing pressure on the small-scale producer and favouring the development of large-scale plantations, especially of Old World temperate species introduced to North America. The often sporadic occurrence of a desirable edible nut-producing species in, for example, the rain forest, means that it can have a disproportionately low value as an economic species in any land clearance or reafforestation schemes. The Brazil nut population is an example of such a threatened species. Problems in maintaining an environment outside the rain forest that is suitable for its pollinator makes the establishment of *ex situ* conservation and commercial plantations difficult.

Although not strictly the result of selection, the canker-forming bark disease caused by the fungus *Cryphonectria parasitica* syn. *Endothia parasitica* which first appeared in the New York in the 1890s was probably introduced from Orient with some Asiatic chestnut planting stock. The American chestnut, *Castanea dentata*, was subsequently almost completely destroyed over its entire natural range in the Appalachian mountains (Rosengarten, 1984; Holliday, 1989). The moral of the above example is that there is always the possibility of a devastating fungal or virus infestation affecting plantation crops through poor crop sanitation coupled with uniform genetic susceptibility, and places increasing emphasis on the preservation of genetic diversity.

Plant conservation may be *in situ* or *ex situ*, the latter in gene or seed banks or *in vitro*. The simplest method is *in situ*, by maintaining breeding populations within their natural environment through the establishment of reserves. Several reserves will obviously be required for widely distributed species. Pressures on land use, especially if only a few conserved species are involved within a reserve can make such reserves politically undesirable. *Ex situ* conservation in gene banks, involving either botanical gardens or research establishments, depending on the land available, enables small numbers of a species to be grown under cultivation. They are expensive to maintain, do not offer safe long-term storage and there can be problems in preventing cross fertilization and maintaining genetic purity. Several fruits, including *Prunus* are normally conserved vegetatively in the form of clones, thereby conserving gene combinations that would be lost through sexual reproduction.

Seed banks are widely used for the long-term storage of orthodox seeds. However, many woody species that produce large seeds, e.g., *Castanea* spp., *Theobroma* spp., *Artocarpus* spp., *Nephelium lappaceum,* etc., are recalcitrant and any drying increases their rate of deterioration. Furthermore, most tropical recalcitrant species will suffer from chilling injury if the temperature of the seed bank falls below 10-15°C. Even under optimum conditions, longevity of recalcitrant seeds seldom exceed a few weeks or months. Unsuitable for storage in seed banks, they require *in vitro* conservation. The latter primarily involves the use of slow growth and cryopreservation in liquid nitrogen to store germplasm (Hawkes, 1991; Roberts, 1991; Withers, 1991; Tompsett, 1994).

MAJOR EDIBLE NUTS 2

There are twelve major edible nuts that are marketed commercially (Woodroof, 1979; Rosengarten, 1984). They are:

cashew nuts	*Anacardium occidentale,* Anacardiaceae
pistachios	*Pistacia vera,* Anacardiaceae
sunflower seeds	*Helianthus annuus,* Compositae
filberts	*Corylus avellana,* Corylaceae
chestnuts	*Castanea dentata,* Fagaceae
pecans	*Carya illinoinensis,* Juglandaceae
Persian walnuts	*Juglans regia,* Juglandaceae
Brazil nuts	*Bertholletia excelsa,* Lecythidaceae
peanuts or groundnuts	*Arachis hypogea,* Leguminosae
macadamia nuts	*Macadamia integrifolia,* Proteaceae
almonds	*Prunus dulcis,* Rosaceae
coconuts	*Cocos nucifera,* Palmae

Sunflower seeds and peanuts are here regarded as agricultural crops and are consequently not dealt with in detail. However, their marketing prospects are discussed because they do have an impact on the prospects of other nut crops. Coconut, although being an agricultural crop, is included here since it is a major component of agroforestry systems in many tropical countries.

CASHEW OR MONKEY NUT: *Anacardium occidentale*, Anacardiaceae

Distribution and ecology

Native of tropical America, probably originating in equatorial northeastern Brazil. Widely cultivated in the tropics with commercial production concentrated in India, Brazil and East Africa. High potential for development in West Africa, where plantations have been quickly developing recently. It occurs in warm and humid climates with 1 000-2 000 plus mm annual rainfall, from sea level to 1 000 m altitude (FAO, 1982; ITC, 1993).

Description

Evergreen shrub or tree to 15 m tall; leaves simple, oblong-ovate, 6-20 cm x 4-15 cm, leathery. Inflorescence polygamous, with *ca.* 60 hermaphrodite and *ca.* 10 male flowers. Pedicel and receptacle swollen and fleshy in fruit (cashew apple), thin-skinned, bright yellow, red or scarlet, eventually larger than fruit, 10-20 cm x 4-4 cm. Fruit obliquely kidney-shaped, 2-3 cm x 1.5-2.5 cm, compressed, greyish-brown; mesocarp oleaginous; seeds

kidney-shaped with thick cotyledons (Purseglove, 1987; Kokwaro, 1986).

Cultivation

Fast growing, drought-resistant and easy to grow under cultivation by direct seeding of germinated seeds - seedlings do not transplant readily. Well-drained friable soils at low altitudes recommended, frost-free with an annual rainfall of 1 000-3 000 mm, preferably with a pronounced dry season of 3-4 months. Cashews can also be grown satisfactorily in semi-arid areas but can show erratic production as a result of relative small variations in rainfall. Trees with a productive life span of 30-40 years, normally bearing in fruit in third or fourth year and, under favourable conditions, attaining maximum production in *ca.* 7 years. The effectiveness of insect pollination variable, for example, satisfactory in Tanzania, artificial pollination required in India. Fruits mature in 2-3 months (Menninger, 1977; FAO, 1982; Rosengarten, 1984; Purseglove, 1987; ITC, 1993).

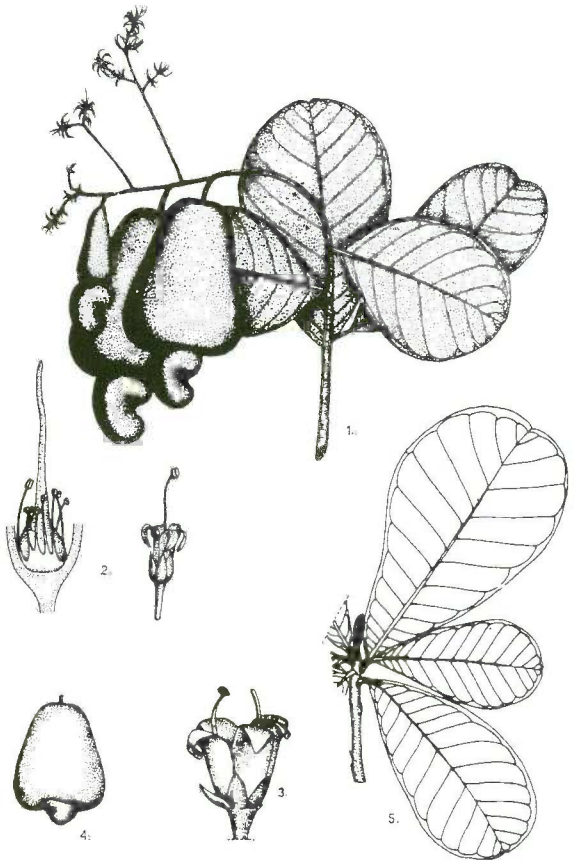


Figure 1
Anacardium occidentale. 1: fruiting branch. 2: bisexual flower. 3: male flower. 4: fruit. 5: leaves.

Harvesting

Fruits harvested when fully ripe. In Tanzania the nuts are collected after falling to the ground. In dry weather they can be left on the ground until the apple dries but should be collected daily in wet weather. The nuts are then removed from the apples and dried (Rosengarten, 1987).

Post-harvest treatments

After drying and roasting the kernels are separated from the shells and graded. Care must be taken when shelling to avoid the caustic juice that squirts out on roasting. Shelling is usually done manually, using cheap labour in India, elsewhere mechanical processing has been introduced. Stored in vacuum packed, hermetically sealed tins where cashews remain stable at room temperatures; under refrigeration a shelf life of one year (Menninger, 1977; Matz, 1984; Rosengarten, 1984; ITC, 1993).

Production and consumption/utilization

Approximately 60% of cashew kernels are marketed as salted nuts; they are also used in confectionery and bakery products. Un-shelled, un-roasted cashew nuts should not be eaten (Rosengarten, 1984).

Nutritional value

Cashew nuts contain approximately 12.8% protein, 46.7% digestible fat or oil and 18% carbohydrates (Melville, 1946); vitamin content high (Menninger, 1977).

By-products and other uses

Seeds yield an edible oil but, due to the high value of the kernels, this is not usually extracted. The shells or pericarp yield cashew nut shell liquid (CNSL), which contains toxic cardol and anacardic acid and acts as a vesicant. CNSL has high polymerizing and friction-reducing properties and is used as a waterproofing agent and preservative. Distilled and polymerized, the oil is also used in insulating varnishes and in the manufacture of typewriter rolls, oil- and acid-proof cements and tiles, friction-modifying material for brake linings, as a component of space-rocket lubricants, inks, etc. It is also used in tropical medicine for treating scurvy, leprous sores, warts, ringworms, etc. (Menninger, 1977; Rosengarten, 1984; Purseglove, 1987).

The cashew apple (swollen pedicel) is juicy, astringent and edible; the juice may be drunk fresh or fermented for wine; the pulp may be made into preserves, jellies, syrups, etc., or, in Brazil, fermented into wine resembling Madeira. With the emphasis on nut production about 95% of the world cashew apple crop is allowed to rot, about 1.25 million tonnes in India are wasted each year. The sap from the bark provides an indelible ink. Timber is used for construction and general carpentry but subject to termite attack; also used for firewood and charcoal. Grown as a shade tree, hedges and for dune stabilization. Flowers attractive to honey bees (FAO, 1982; Rosengarten, 1984; Purseglove, 1987; Anthony *et al.*, 1993).

Marketing

World production has risen from 446 000 tonnes in 1979-81 to 726 000 tonnes in 1992, falling dramatically to 479 000 tonnes in 1993, largely due to an unexplained fall in production in India from 35 000 tonnes to 15 000 tonnes (FAO, 1994).

India is the largest exporter with *ca.* 50% of the market (also with a large internal consumption), Brazil is second with *ca.* 25% of the world market, followed by Indonesia, Mozambique and Viet Nam, the two latter plus Tanzania mainly export raw, unprocessed seed to India for processing. The USA is by far the largest importer (about 59 000 tonnes in 1992) with the UK the largest market in Europe for raw cashew. Most of the international trade is in raw nuts, with less than 25% of the trade in processed nuts, which are salted and/or roasted (Purseglove, 1987; ITC, 1993).

Discussion

Cashew is regarded as a good crop for the Andean countries for which North America should be the main target market. Despite *ca.* 20% decline in import prices during the period 1987–91 demand has increased and has been met by increased imports (ITC, 1993).

The appalling waste of cashew apple each year is intolerable, however, there is almost certainly limit to the quantity of cashew drinks and jams that can be consumed. The possibility of fermenting the cashew apple for the production of an industrial alcohol should be investigated.

PISTACHIO: *Pistacia vera*, Anacardiaceae

Distribution and ecology

Native of Iran, Afghanistan and central Asia from Turkmenia to Pamir-Alai and Tien Shan. Now cultivated and perhaps naturalized in Spain, France, Italy, Greece, Cyprus, Syria, Lebanon, Israel, Turkey and Iran. Grows in subtropical, warm and Mediterranean climates with a hot dry season with a daily mean temperature of 30°C for 3 months (Townsend and Guest, 1980; Macrae *et al.*, 1993).

Description

Winter deciduous, dioecious tree to 10 m tall; leaves pinnate, leathery, leaflets 3-7. Flowers in panicles, appearing before the leaves. Fruit a narrowly ovoid to oblong or subglobose, 1-seeded, drupe, 1-2 cm x 0.6-1.2 cm; mesocarp fleshy, endocarp bony, dehiscent or semi-dehiscent; kernel light green, agreeable flavour (Menninger, 1977; Townsend and Guest, 1980; Matz, 1984; Macrae *et al.*, 1993).

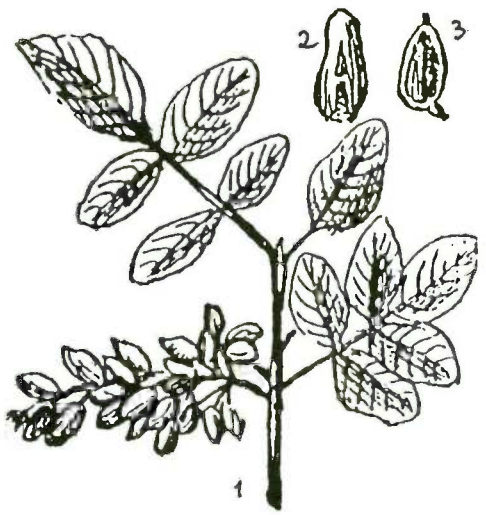


Figure 2
Pistacia vera. Branch with leaves and fruits.

Cultivation

Pistachio requires well-drained soils, is tolerant of drought and poor soils, it prefers cool winters with 1 000 hours below 7.5°C enough to break bud dormancy (temperatures can fall as low as -10°C). A frost-free period of 200 days is necessary to ensure that the inflorescence develops undamaged and long hot summers (to 45°C or more) to ensure ripening of the fruit. Cold and wind resistant but intolerant of excessive dampness and high humidity (Rosengarten, 1984; Macrae *et al.*, 1993).

Introduced from Iran to California in 1930, California is now the second largest producer worldwide. Commercial crop after 7-10 years with peak production at *ca.* 20 years; trees with a life span of *ca.* 700 years. Yields alternating with a heavy crop followed by a lighter crop in the next year (Rosengarten, 1984; Paramount Farms Pistachios, 1991).

Harvesting

The correct stage of maturity is critical when harvesting. The outer skin or hull turns from translucent to opaque rosy when ripe, the husk splitting naturally to expose the kernel when ready to harvest. The mature nuts hang on the tree and may be left until nearly all are ripe. However, if the harvest is unduly delayed the husk may dry onto the nut and cause staining. Primitive methods of harvesting involves either picking by hand or knocking the nuts from the tree with long poles onto sacking spread on the ground. The enveloping husk is manually removed by squeezing and empty shells are removed by flotation with the full nuts sinking to the bottom of the tank. The nuts are then sun-dried.

In USA a machine is used to shake the pistachios from their grape-like clusters while another, equipped with a catching frame encircling the tree, collects the falling nuts before they touch the ground (Menninger, 1977; Paramount Farms Pistachios, 1991; Macrae *et al.*, 1993).

Post-harvest treatments

To prevent the tannic acid in the rosy hull from staining the nuts, the pistachios are either hand or mechanically peeled within hours of harvesting, after which they are washed and rapidly dried before storing. Humid or showery weather, especially favours staining as well as aflatoxin.

Any blank shells can be removed by flotation. Freshly harvested nuts can contain up to 45% moisture, which small producers may reduce by sundrying and any stained nuts removed by hand. In large commercial plantations the pistachios are artificially dried in silos at 65-72°C, which can reduce the moisture content to 5% in 10 hours. Mechanical pin prickers are used to separate naturally split pistachios from the closed shell product. The in-shell pistachios are then passed through an electronic colour sorter to remove any stained nuts. They are then graded for size and quality where they are shelled and stored (Ryall *et al.*, 1974; Rosengarten, 1984; Paramount Farms Pistachios, 1991; Macrae *et al.*, 1993).

Production and consumption/utilization

Marketed locally in Middle East either in-shell or as roasted and salted kernels. Because of the antiquated harvesting techniques in the Middle East which yielded stained shells, the early imports to the North American market were dyed red in order to cover the blemishes and make them more appealing. Roasted nuts are hygroscopic and require moisture resistant packaging, which gives a shelf life in excess of 24 months (Menninger, 1977; Paramount Farms Pistachios, 1991; Macrae *et al.*, 1993).

Nutritional value

High in carbohydrates, especially sucrose (16%), oil consisting largely of unsaturated fats (55%) and essential amino acids (25%) (Macrae *et al.*, 1993). See also Table 6 for comparison with macadamia nuts.

By-products and other uses

Wood much prized in Iran and Afghanistan for agricultural implements, spoons, etc. Resin yielded from tapped stems and larger branches similar to mastic from *P. lentiscus* and used in local medicine, high quality paints and nitro-lacquers. Galls and fruit pericarp employed in India to dye silk, the fruit husks used as a mordant and tan. Fruit yields *ca.* 60% of a greenish fatty oil, sweet flavoured and aromatic, which is sometimes extracted for medicinal use, however, because of the high price obtainable for the nuts the oil is not extracted commercially (Townsend and Guest, 1980; Rosengarten, 1984).

Marketing

World production has soared from 109 000 tonnes in 1979-81 to 345 000 tonnes in 1993 and, in North America particularly, production has increased during those years from 8 800 tonnes to 69 000 tonnes (FAO, 1994).

About 1 500 tonnes of pistachios are consumed annually in USA and is expected to reach 23 000 tonnes in the next decade. Pistachios are exported from California to Japan, Hong Kong, China, Singapore, Germany and UK. Other major exporting countries are Iran and Turkey, and to a lesser extent, Syria, Afghanistan, Italy, India, Greece, Pakistan and Tunisia. Premium nuts made up 25% of the UK snack market in 1990 and is expected to reach 30% by 1995 (Rosengarten, 1984; Paramount Farms Pistachios, 1991).

Discussion

There are 11 species of *Pistacia* but only *P. vera* has a dehiscent shell. Pistachios, like the macadamia nut, are expensive. Although future expansion may reduce prices, greater emphasis is still needed on market development and promotion in order to compete with other nut products. Unlike lesser-known nuts, pistachios should develop beyond present regional boundaries (Macrae *et al.*, 1993). Prospects for an expansion in production would appear to be good.

SUNFLOWER SEEDS: *Helianthus annuus*, Compositae

Discussion

Sunflower seed is currently catering for a small and specialized market, especially in the health-food, confectionery and snack trade in USA (*ca.* 3 500 tonnes in 1977). It is relatively little known elsewhere but, with its high nutritional rating and low price compared to other nuts, there are good prospects for production to increase, especially since it has been recommended as a major ingredient in concentrated food for human consumption in the developing countries (Rosengarten, 1984).

FILBERT, COB OR HAZEL: *Corylus* species, Corylaceae

Historically "filbert" refers to a nut where the enveloping husk is longer than the nut, "cob" where the husk is as long as the nut and "hazel" where the husk is much shorter than the nut (Menninger, 1977).

Distribution and ecology

European hazel: *Corylus avellana*, throughout Europe and eastward through West Asia to Syria and Iran; cultivated in North America for its nuts.
Turkish filbert: *Corylus maxima*, Balkan peninsula; cultivated elsewhere for its nuts.

Description

Deciduous trees or shrubs; leaves alternate, simple, stipules soon falling. Inflorescence monoecious, male flowers in pendent catkins, female flowers in small, bud-like inflorescences. Fruit a large nut surrounded by more or less tubular involucre (Tutin *et al.*, 1964).

Cultivation

The European hazel is chiefly cultivated, the Turkish filbert to a lesser extent. Hybridization between the two species and others, both naturally and by breeders, has made identification

difficult. Commercial production limited to regions with mild winters, rather warm spring, late frosts rare and summers cool. Approximately 70% of world production is from Turkey along the southern coast of the Black Sea. The coastal regions of Italy and the Mediterranean coast of Spain supply a further 20% and 7% respectively. The remaining 3% is from the coastal valleys of Oregon and Washington in USA.

Turkish production is based on rather haphazard clumps of four or five multi-stemmed bushes arranged in 1.5 m circles on the rocky hillsides. Stems grow to 3-4.5 m and are removed after 30 years to allow younger stems to come into production. Livestock are frequently allowed to graze among the bushes to control the weeds.

Bushes are more regularly spaced and planted either along the contour or in rectangles in Italy although, like Turkey, the multi-stemmed clump habit is usually maintained. Yields are higher due to the warmer climate, better use of fertilizers and more fertile soils.

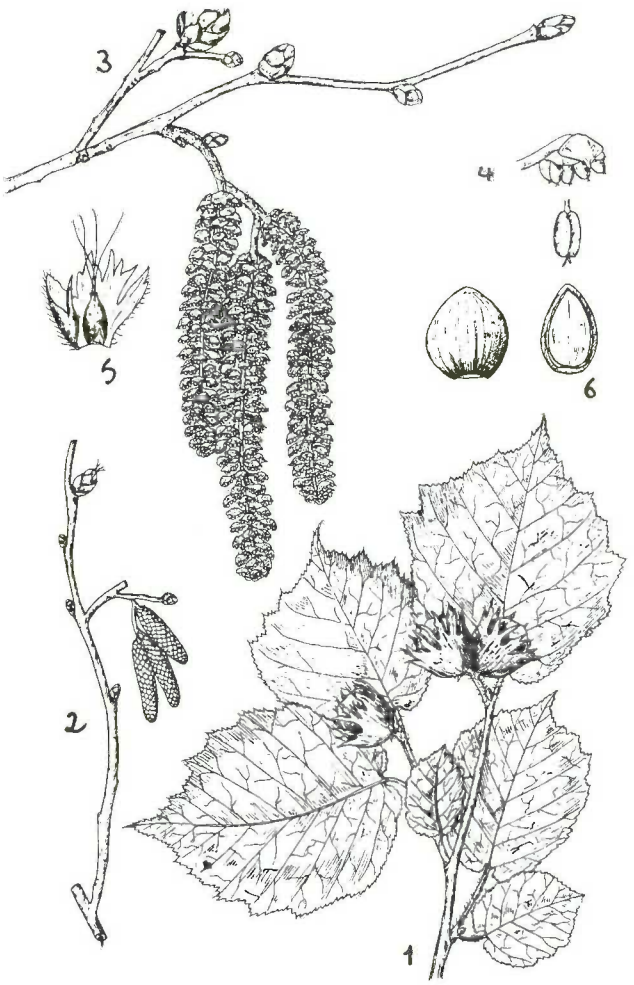


Figure 3
Corylus avellana. 1: branch with fruits. 2: Branch with catkins. 3: Shoot with male catkins developed. 4: Elementary male inflorescence and anther. 5: Female flower with bract. 6: Fruit and section of the fruit.

In Tarragona, Spain, single bushes are planted out in regular rows, although elsewhere clump planting is still practised. Irrigation is standard practice in Tarragona as well as in other areas where the soils are poor and rocky.

In USA the filberts are planted in regular rows and trained to form a single-stemmed tree in order to permit mechanical cultivation. To facilitate wind pollination every sixth tree in every third row is a pollinator. Average yield of dry in-shell nuts from good orchards is 2 250 kg/ha (Rosengarten, 1984).

Harvesting

Nuts tend to drop uniformly when ripe, hence easy harvesting from the ground, although frequent pick-up still necessary to avoid fungal infections. In Turkey the nuts are picked by hand before the crop drops while in Italy the bushes are beaten and the fallen nuts picked from the ground. In USA the nuts are also allowed to fall naturally and then swept into windrows and picked up by a mechanical harvester which also provides a preliminary cleaning (Ryall and Pentzer, 1974; Rosengarten, 1984).

Post-harvest treatments

Drying is required to reduce moisture content of in-shell nuts to 7-8% and 3.5-4.5% for shelled nuts.

In Turkey the filberts are mainly sun-dried, drying with the use of artificial heat is less common. The husks are usually removed by husking machines, less commonly by hand-beating with sticks. The nuts are then cracked between revolving millstones and blowers used to remove the shells. The kernels are finally screened, graded according to size, sorted and bagged for export.

The harvested nuts in USA are washed, further cleaned and then dried to 8-10% moisture content for marketing or processing.

Production and consumption/utilization

Nuts are sold to consumers either in-shell or shelled as kernels for salted kernels or use in the food trade, especially in confectionery for nut chocolate; kernels may be ground to a flour and baked as filbert bread, which is reputed to be delicious (Menninger, 1977; Rosengarten, 1984).

Nutritional value

On a moisture-free basis hazel nuts contain approximately 16.3% protein, 61.2% fat and 11.5% carbohydrates (Melville, 1947).

By-products and other uses

Broken but edible nuts are utilized for the extraction of edible filbert oil, rancid and inferior nuts are used for industrial filbert oil. The combustible trash from bushes, husks and shells are used for fuel (Rosengarten, 1984).

Wood formerly a principal source of charcoal for gunpowder. Coppice growth formerly used for hurdles, wattle and daub, legume poles, firewood (Mabberley, 1987).

Marketing

Up to 65% of Turkish filberts are sold through the government financed FKB (Fiskobirlik) cooperative, which stabilizes the market and prices paid to the farmers. The government also has a strict system of inspection and certification before export. The plantations in Oregon and Washington yield larger nuts than found in the Mediterranean countries and are becoming increasingly popular (Menninger, 1977; Rosengarten, 1984).

Discussion

As USA imports *ca.* 45% of the filberts it consumes annually, there is a promising future for expansion in Oregon and Washington, especially since they are able to produce the desired larger nut (Rosengarten, 1984). The European nut producing countries will have to increase quality and productivity if they are to compete with America. The fact that the filbert was introduced to America suggests the larger nut may be due to management rather than breeding.

CHESTNUT: *Castanea* species, Fagaceae

Ecology and distribution

American chestnut: *Castanea dentata*, native to USA, east of the Mississippi River.
European chestnut: *Castanea sativa*, native to southern Europe from Italy to Iran and extending northwards to Hungary, also in North Africa; extensively planted and naturalized elsewhere in Europe. Usually a calcifuge, in woods on well-drained soils.
Chinese chestnut: *Castanea mollissima*, from northern China, introduced into USA.
Japanese chestnut: *Castanea crenata*, native to Japan; grown for timber in southern Europe (Rosengarten, 1984).

Description

Deciduous trees or shrubs; leaves simple. Catkins erect, flowers monoecious with male in upper and female in lower portion of the same catkin. Fruit 1-3 nuts, brown, coriaceous, in a swollen, spiny cupule which dehisces irregularly by 2-3 valves (Tutin *et al.*, 1964).

Cultivation

Populations of American chestnut were devastated by the mid-20th century by chestnut blight, *Cryphonectria parasitica*, syn. *Endothia parasitica*; Chinese chestnut and Japanese chestnut are relatively immune. Devastation was such that American chestnuts are no longer commercially viable. The European chestnut is also susceptible and has been attacked by blight since 1938 and production is consequently decreasing. Attempts are being made to develop benign strains of the fungus to inoculate trees against chestnut blight as well as hybridizing American chestnut with blight resistant introductions. Japanese chestnut is less hardy and more susceptible to blight than the Chinese chestnut (Payne et and Pentzer, 1983; Rosengarten, 1984).

Figure 4
Castanea sativa. 1: shoot with leaves and male and female catkins. 2: male flower. 3: anther. 4: section of female catkins. 5: female flower. 6: mature fruit. 7: open cupule.

The average yields of the European chestnut grown in California are 2 220 kg/ha. However, recent plantations with high-yielding, large nut, grafted cultivars are expected to yield 3 360-

4 480 kg/ha. The Chinese chestnut, which are adaptable to a range of edaphic and climatic conditions apart from frost pockets, bear in 5 to 6 years and are expected to yield 3 000 kg/ha, with yields of experimental plantings as high as 4 400 kg. At least two cultivars should be grown to ensure cross-pollination otherwise the kernels will not develop (Menninger, 1977; Payne *et al.*, 1983).

Harvesting

Traditionally mature nuts are allowed to fall from the tree and may remain on the ground for several days or longer before gathering by hand. To reduce hand harvesting costs, attempts are being made to develop strains where the burrs drop to the ground before the nuts fall out. Since at dehiscence the undamaged nut contains an array of weakly parasitic organisms which can cause serious damage under unfavourable storage conditions, daily gathering is strongly recommended. Tree shakers and catchers, which can be used after 4-9% of the ripe nuts have fallen naturally, are being developed, as well as the necessary means of removing the burr (Ryall and Pentzer, 1974; Menninger, 1977; Payne *et al.*, 1993).

Post-harvest treatments

Commercially nuts may be held in refrigerated storage at 0°C to -1°C for several months in ventilated polyethylene liners. Weevil damage may occur during storage and later; unfortunately it is not possible to remove infested nuts by flotation before storage. The risk of incipient fungal infection is increased by the absence of visible moulds on many infected kernels although no mycotoxins have yet been observed on the marketed product. Unless properly handled, fresh nuts quickly dry out and harden and cannot be roasted or boiled satisfactorily unless regenerated by soaking (Ryall and Pentzer, 1974; Payne *et al.*, 1983).

Production and consumption/utilization

Chestnuts are starchy and a brief curing period (3-4 days) is required to permit some starch to convert to sugar, especially after refrigeration. Eating quality is best at harvest time. In-shell nuts are roasted and sold as "hot chestnuts"; shelled nuts can be ground to a flour and eaten as chestnut bread or porridge, roasted or boiled they can be eaten as a vegetable or used for stuffing poultry. In France chestnuts are preserved in syrup as marrons glacés and other sweetmeats (Ryall and Pentzer, 1974; Rosengarten, 1984).

Nutritional value

The nutrient value of chestnuts varies according to species. Respectively, raw American, European and Chinese chestnuts contain approximately 43.7%, 54.9% and 44% water; 4.8%, 2% and 4.2% protein; 1.3%, 1.6% and 1.1% fat; and 48.6%, 40.3% and 49.1% carbohydrates (McCarthy and Meredith, 1988). High in carbohydrates they are readily digestible when roasted or boiled. They also have the lowest fat content of all the major edible nuts as well as being very low in calories with *ca.* 1 700 calories per kg (Rosengarten, 1984).

By-products and other uses

Timber is durable and rot-resistant, used for fencing, furniture, ship masts, telegraph poles, mine props, railway sleepers. Bark and wood extracts used for tanning leather (Rosengarten, 1984).

Marketing

European chestnuts, which are larger but less sweet than the American chestnut, are marketed in-shell for roasting. Chinese chestnuts are smaller and less sweet than the American chestnut but sweeter than the European chestnut. Japanese chestnuts are a variable product with some trees producing huge nuts up to 5 cm in diameter and weighing 30 g or more while others bear smaller nuts; their nuts are also less sweet than those from the Chinese chestnut. Despite the strong demand for chestnuts and chestnut products, the problems outlined above regarding harvesting and storage and the difficulties in obtaining a good, clean nut make chestnut production a difficult venture (Payne *et al.*, 1983; Rosengarten, 1984).

PECAN: *Carya illinoinensis*, Juglandaceae

Distribution and ecology

Native of the rich bottom lands of the Mississippi Valley from Indiana and Illinois west to Kansas and Texas and at higher altitudes south into central Mexico, with local outliers to the north and east. Cultivated in USA, Mexico, Brazil, Australia, South Africa and Israel (Menninger, 1977; Townsend and Guest, 1980; Rosengarten, 1984; Prescott-Allen and Prescott-Allen, 1986).

Description

Large deciduous tree to 50 m or more tall with ascending and outwardly arching branches. Flowers monoecious with slender male catkins and small erect clusters of female flowers. Fruit borne in clusters of 4-12, a globose to oblong drupe, angled and narrowly 4-winged at the sutures, 2.5-7 cm x 1.25-2.5 cm, exocarp more or less separating by 4-valves; nut ovoid to ellipsoid, cylindrical or faintly 4-angled; seed solitary, deeply divided longitudinally, somewhat grooved and convoluted, not closely adherent to the shell (Menninger, 1977; Townsend and Guest, 1980; Rosengarten, 1984).

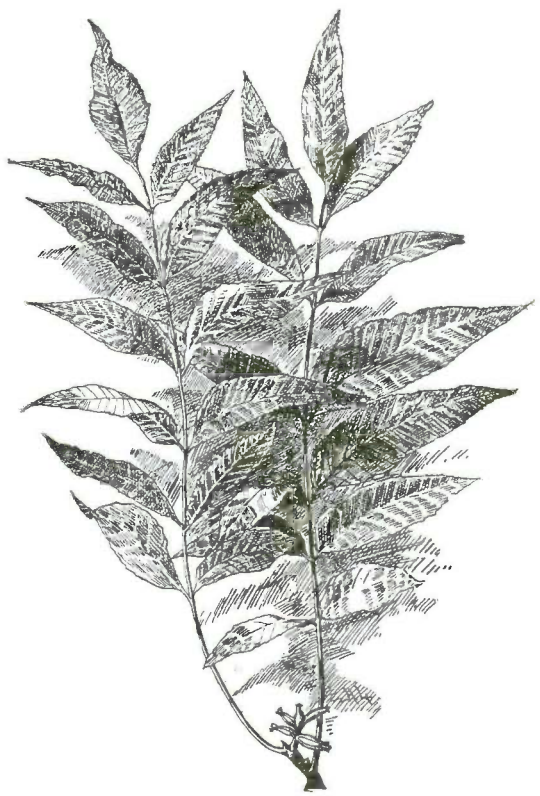


Figure 5
Carya illinoinensis. Leaves and flowers.

Cultivation

Orchards largely planted out with grafted and budded trees in the southeast USA, and with seedling trees in the southwest, although there is now a trend towards selected cultivars. Over 300 cultivars have been recognized. Varietal differences range from nuts less than 0.6 cm in diameter to more than 2.5 cm and weighing from over 90 to 18 nuts per kg. Production begins at 6-10 years and can continue profitably for up to 200 years - some native trees are known to be over 1 000 years old. Yields from 9-27 kg per tree at 8-10 years rising to

45-68 kg at 16 years or more with exceptional individuals attaining 360 kg under unusually favourable conditions (Ryall and Pentzer, 1974; Rosengarten, 1984).

Trees prefer a deep, well-drained soil, adequate rainfall or supplementary irrigation and a frost-free growing season of 140-210 days. A cool period is also essential in order to break dormancy; the climatic requirements vary with the variety (Rosengarten, 1987).

Harvesting

Fallen nuts formerly harvested by hand. Hand harvesting now largely replaced by mechanization, including tree or limb shakers, shake and catch harvesters, windrowers, sweepers, vacuum harvesters, conveyers and trash separators (Ryall and Pentzer, 1974; Rosengarten, 1984).

Post-harvest treatments

Pecans harvested mechanically have a higher moisture content than nuts that have fallen naturally. Artificial drying is essential in order to reduce moisture to 4.5% as soon as possible in order to prevent mould and discoloration. Matz (1984) recommends dry storage for 3 weeks at room temperature to cure and reduce moisture in entire nuts to 8.5-9% and to 4.5% for kernels. During curing the free fatty acids and peroxide value of lipids increase and seed coat tannin oxidize to pale or medium brown, the general effect of which is to give the pecan its characteristic appearance, aroma, flavour and texture. Pecans are then stored until required for shelling at temperatures below 2°C and less than 70% relative humidity in order to prevent the development of rancidity and/or insect infestation. Long-term storage should be at *ca.* -8°C in order to maximize freshness and shelf life. Any traces of ammonia during refrigeration, not detectable by odour, can rapidly and permanently blacken the seed coat but not affect the flavour. Storage facilities not using ammonia as a refrigerant are essential. Nuts are shelled using a rotary cracker which delivers a shock wave to the pecan and explodes the shell without damaging the kernel. Shell fragments are removed using a double flotation system in addition to air separation systems and infrared colour sorting equipment (Ryall and Pentzer, 1974; Rosengarten, 1984; Young Pecan Company, undated).

Production and consumption/utilization

Approximately 85-90% of the crop is shelled prior to marketing, the balance being sold in-shell. Shelled pecans are sold to bakeries (36%) and confectioners (20%), the remainder to retailers, grocery-wholesalers and dairies for ice cream production, etc. Trade in in-shell is declining, sales being mainly to Europe (Ryall and Pentzer, 1974; Rosengarten, 1984; Prescott-Allen and Prescott-Allen, 1986).

Nutritional value

Nutritional analyses of pecans are given in Table 3.

By-products and other uses

Pecan shells are used for gravelling paths, as a fuel and as a garden mulch, stock and poultry litter; ground to a flour for degreasing aero engines, as an ingredient of carpet cleaners and as a filler in feeds, insecticides and fertilizers, soft abrasives in hand soap, non-skid paints and metal polishes, as fillers in plastic wood, adhesives and dynamite, also for veneer and

polyesters. An excellent hardwood, the wood and veneer is in high demand for decorative panelling, fine furniture and flooring. The tree is also grown as an ornamental and for shade (Menninger, 1977; Rosengarten, 1984).

Table 3: Nutritional Analyses per 100 g Sample of Raw Pecans and Pecans Roasted in Cotton Seed Oil with Butter and Salt

	Raw	Roasted
Calories	710.0	740.0
Calories from fat (kJ)	630.0	673.0
Protein (g)	10.0	9.3
Total fat (g)	70.0	74.7
Saturated fat (g)	6.7	9.3
Cholesterol (mg)	0.0	0.0
Carbohydrates (g)	13.3	13.7
Sugars (g)	3.3	3.0
Dietary fibre (g)	6.7	5.7
Ca (mg)	73.0	73.0
P (mg)	603.0	603.0
Fe (mg)	2.4	2.4
K (mg)	603.0	603.0
Na (mg)	0.0	128.0
Mg (mg)	142.0	142.0
Vitamin A (IU)	130.0	120.0
Vitamin C (mg)	2.0	0.0
Thiamin (mg)	0.9	0.9
Riboflavin (mg)	0.1	0.1
Niacin (mg)	0.9	0.9

Source: Young Pecan Company, undated.

Marketing

Undoubtedly North America's most important native nut tree with an annual average production of over 90 million kg, of which 18% is still obtained from wild sources (Prescott-Allen and Prescott-Allen, 1986; Rosengarten, 1987).

Discussion

The pecan is relatively little known outside America and there is certainly a possibility for developing a wider market.

ENGLISH, PERSIAN, EUROPEAN, ROYAL, ITALIAN, MADEIRA, FRENCH, CHILE, MANCHURIAN, CAUCASIAN OR CIRCASSIAN WALNUT: *Juglans regia,* Juglandaceae

Distribution and ecology

Balkan peninsula, Turkey to the Himalayas at altitudes up to 3 000 m; widely cultivated and often naturalized (Menninger, 1977).

Description

Monoecious, deciduous, aromatic tree to 30 m tall; leaves alternate, pinnate, leaflets 7-9. Male catkins on twigs of previous year's growth, female flowers few, on twigs of current year's growth. Fruit a large, subglobose, indehiscent drupe 4-5 cm in diameter; stone ovoid, acute, wrinkled, easily splitting (Tutin *et al.*, 1964; Townsend and Guest, 1980).

Cultivation

Grown in orchards in California and southern Europe, propagated by budding and grafting of cultivars on rootstock of various species of *Juglans* (Menninger, 1977).

Harvesting

Walnuts mature when hull easily separable from the shell; the hull normally opening while fruit still attached to the tree. Harvesting by hand or by machine. Older plantings tend to be of large trees and harvesting is by mechanical shaking of the branches using slings attached to a cable and tractor-driven eccentric. Approximately 80% of the nuts can thus be removed from the tree; with care, tree shakers may also be used. For smaller trees the shake and catch method may be used. Nuts may be caught in sheets or mechanically windrowed and collected by a machine with which the leaves and trash are separated, the harvested crop consisting of a mixture of hulled and unhulled walnuts. Prior land preparation to remove weeds and obstacles will speed up the harvest operations. Average yield for California range from about 2.2 tonnes per ha to 6.7 tonnes; in Italy the average yield from specialist orchards is also about 2.2 tonnes per ha while yields from other producing countries are undoubtedly lower (Ryall and Pentzer, 1974; Rosengarten, 1984).

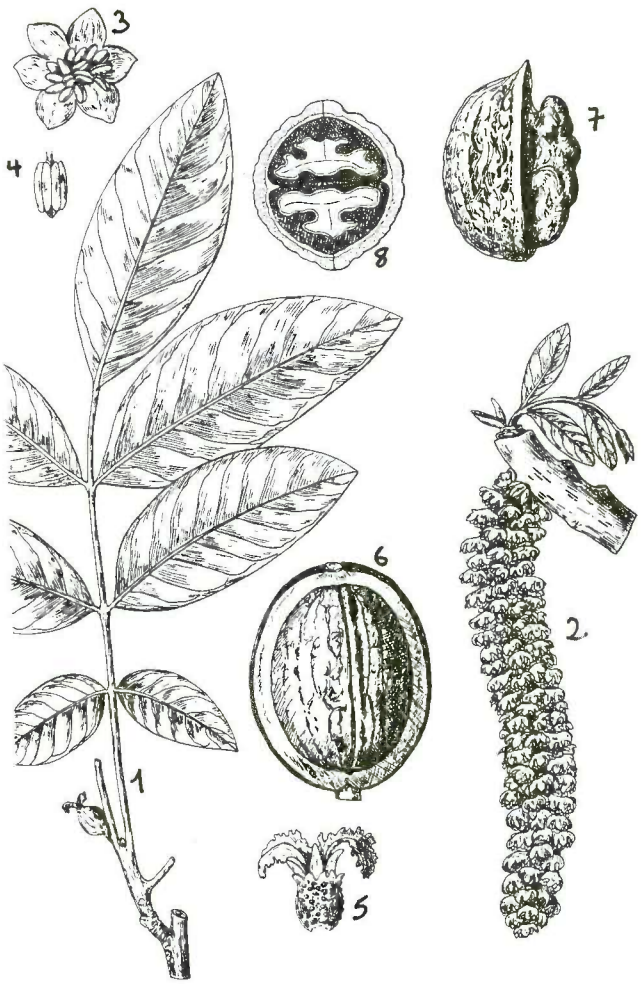


Figure 6
Juglans regia. 1: branchlet with leaves with female flower. 2: male catkin. 3: male flower. 4: stamen. 5: female flower. 6: fruit showing endocarp. 7: seed covered by one valve of endocarp. 8: section of fruit.

Post-harvest treatments

Walnuts contain as high as 35% moisture when harvested. They should be hulled, washed and dried as quickly as possible to 8% moisture or less and graded. Shelled walnuts quickly darken and develop rancidity under unfavourable conditions; maximum stability is achieved at *ca.* 3% moisture. Contamination by ammonia during storage can cause severe damage (Ryall and Pentzer, 1974; Matz, 1984; Rosengarten, 1984).

Production and consumption/utilization

Immature walnuts are pickled and the ripe walnuts eaten as a dessert nut; they are also widely used in baking and confectionery. In the Himalayan region walnuts are an important item in the diet. The kernels yield *ca.* 50% of a clear sweet oil, the first pressing, known as virgin oil, is largely used for culinary purposes. Expression is carried out 2 to 3 months after harvesting, earlier the kernel contains a sort of emulsive milk, if expressed later the oil is less sweet and possibly rancid. Pounded walnuts and walnut oil is the basis of the delicious Circassian dish "charkasîya" (Menninger, 1977; Townsend and Guest, 1980; Rosengarten, 1984).

Nutritional value

On a dry weight basis walnuts contain approximately 17% protein, 65% fat and 16.5% carbohydrates. Although the vitamin C content of mature walnut kernels is low, that of immature green fruit is exceptionally high, as for walnuts used for pickling. However, the vitamin is destroyed where the method of pickling turns the nuts black. They should remain green, or white if the centres only are used (Melville, 1947).

By-products

The second pressing of seed oil, known as fire drawn, is used as a salad oil or as a drying oil for use in paints, printing ink, manufacture of soap. Residual cake used for feeding livestock. The husk is the source of a dark brown dye used for darken hair. The sap is the source of sugar in the Caucasus. Large shells are made into trinket boxes. Shells are also used as a filler for external plywood glue, plastics, hard rubber products, asphalt roofing material, fire bricks, tiles, and stuffing in toys. Shells reduced to dust are used as insecticides and as an abrasive for cleaning jet aircraft engines. The timber is highly valued for cabinet work and gunstocks. Various parts are used medicinally as an alternative laxative and detergent (Menninger, 1977; Townsend and Guest, 1980; Rosengarten, 1984).

Marketing

The USA is the largest producer with approximately 90% of the exports as in-shell. However increasing competition may be expected from India and China as their walnut industries expand. Walnut oil for salads and cooking is produced by France while pickled walnuts are exported from the United Kingdom (Rosengarten, 1984).

Discussion

A popular dessert nut whose production has increased significantly since 1979-81 to 1993 from 79 000 tonnes to 1 million tonnes. The gourmet trade in salad oil and pickled walnuts

currently monopolized by France and the United Kingdom could be developed in other producing countries.

BRAZIL NUT: *Bertholletia excelsa*, Lecythidaceae

Distribution and ecology

Probably originated in southeastern Amazonia. Present in natural stands (*castanhais*) of 50-100 trees at densities of 5-20 trees per ha, each stand separated from one another by up to 1 kilometre as emergent trees in rainforest on non-flooded ground in the Guianas, Amazonian Brazil, southeastern Colombia, southern Venezuela, eastern Peru and northern Bolivia. Climatic limits for its natural distribution are a mean annual rainfall of 1 400-2 800 mm, a mean annual temperature of 24-27°C and a mean annual relative humidity of 79-86%. In eastern Amazonia, in the lower limits of its climatic range there can be 2-7 months where the monthly rainfall is less than 100 mm.

Cultivated in South America outside its natural range. Nuts from trees growing on barium-rich soils can accumulate up to 0.29% barium and should be avoided due to danger of barium toxicity (Prance and Mori, 1979; Mori and Prance, 1990; Clay and Clement, 1993). It has been introduced to Malaysia, Sri Lanka, Java, Hawaii and the Caribbean (FAO, 1982; Rosengarten, 1984).

Description

Large, deciduous tree to 50 m tall; leaves simple, leathery. Fruit (pyxidium) a globose, circumscissile, woody capsule 10-12.5(-16) cm x 10-12.5(-14) cm, lined with hard fibres; seeds acutely trigonoid, 10-25, *ca.* 3.5-5 cm x 2 cm, packed in 2 concentric rings around a core; seed coat woody (Menninger, 1977; Prance and Mori, 1979; Mori and Prance, 1990).

Cultivation

There exist problems with pollination because the natural bee pollinators require natural forest for their survival. Strip plantations within the

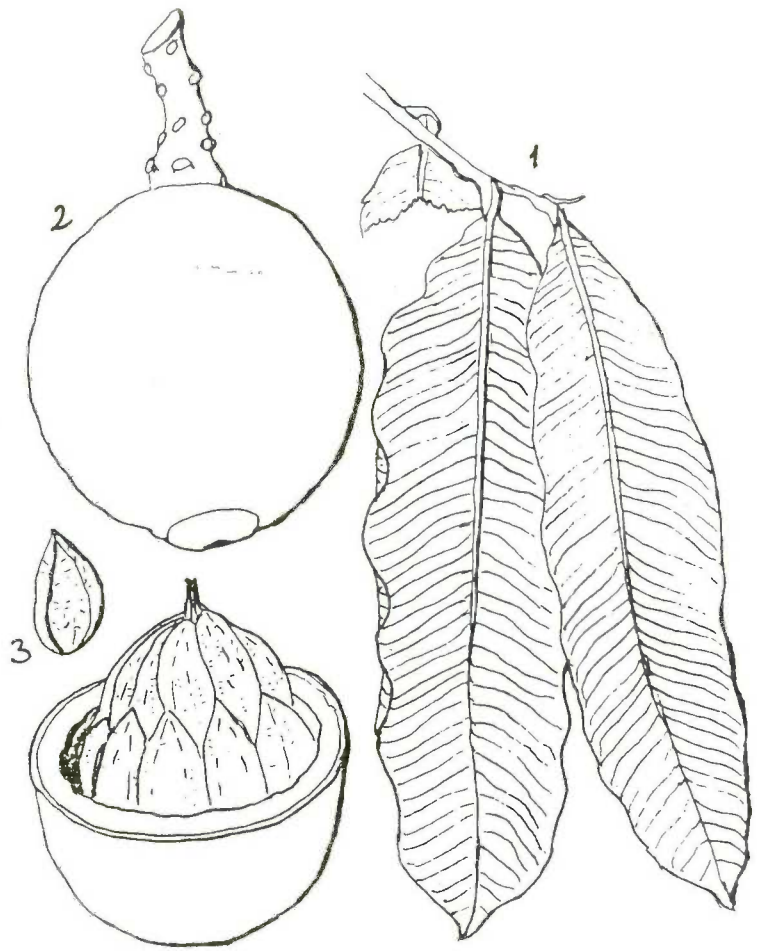


Figure 7
Bertholletia excelsa. 1: leaves. 2: fruit. 3: open fruit showing seeds.

rainforest may be the solution (Mori and Prance, 1990). Nuts mainly harvested from the forest where they are managed under a traditional system of swidden agroforestry. Nuts may take 1-3 years to germinate, 1-6 months if shelled. Seedlings are transplanted into new swiddens and then managed during the succeeding swidden fallow, thereby creating the "castanhais". The seedlings quickly develop a vigorous taproot and need to be planted out when 40-60 cm tall. Attempts are now being made by the Agricultural Research Centre of the Humid Tropics (CPATU-EMBRAPA) in Brazil to identify elite trees, create a clonal germplasm collection and provide grafted clones for commercial plantations (Clay and Clement, 1993; Clement and Villachica, 1994).

Forest trees are 12-16 years old before fruiting, with maximum production from 25-30 years; cultivated compact, grafted trees may start production after 8 years. The trees grow best on deep, well-drained, alluvial soils on high ground not subject to flooding (Prance and Mori, 1979; Rosengarten, 1984; ITC, 1993).

Harvesting

High yielding mature trees may produce 200-400 fruits yielding 100-120 kg unshelled seeds (commercial nuts), however production variable with a good yield often followed by a poor yield in the following year. Within the area of distribution mature fruits fall between November and August. The seeds (Brazil nuts) are retained within the capsule because they are larger than the opening. Nuts are harvested regularly to avoid damage by agoutis, insects and fungi. Harvesting is a hazardous operation and usually starts after most of the fruits have fallen because of the danger of being hit by the 0.5-0.75 kg fruit falling from a height of up to 50 m (Menninger, 1977; Prance and Mori, 1979; Clay and Clement, 1993).

In Brazil the gatherers are paid in advance in cash or kind and are contracted to deliver the nuts to the shipper's agent (the trading agent is known as the shipper). In Bolivia the major shippers own large estates and largely make use of bonded labour, exchanging Brazil nuts and rubber for over-priced goods from the estate shops. The nuts are then brought by truck or barge to Belém for onward shipment (Holt, 1991).

Post-harvest treatments

After sufficient fruits have been harvested they are split open, washed and dried before on-site storage under rather primitive conditions; the nuts then have a moisture content of *ca.* 35%. By the time the nuts have reached the collecting point moisture content would have fallen to *ca.* 27%. The nuts are then cleaned and dried to *ca.* 16% moisture content or 12% if they are to be sold in-shell. In Brazil giant rotary driers are used while in Bolivia and Peru nuts are dried on slatted floors in the warehouses.

In Brazil and Bolivia the "autoclave" process is used for removing the shell, using a brief burst of stem to expand the shell and loosen the inner skin (testa), thereby producing a whiter kernel. The process produces a dry nut with little attached testa. Those from Brazil have a 4.5-5% moisture content, those from Bolivia have slightly more skin and 5-5.5% moisture. In Peru the nuts are first soaked for 24 hours to expand the shell; here the testa remains fixed to the kernel, giving a darker kernel. The individual nuts are then manually cracked in small vices and roughly graded.

Grading is by machine in Brazil and by hand in Bolivia and Peru. The nuts are then oven dried, or, in Peru, sun-dried, resulting in a skin-covered nut with 6.5-8% moisture, often

with pieces of shell still attached. The high moisture makes mould and aflatoxin more common (Holt, 1991). Properly dried and aerated intact seeds can be stored for 1-1.5 years, with seed coat removed they can be kept for 2-3 years (Prance and Mori, 1979).

Attempts at freeze cracking has been tried in a few factories in Bolivia where the frozen nut is centrifugally thrown against a steel screen. Unfortunately the process is difficult to control in order to prevent broken kernels or excessive fragmenting of the shell, resulting in an almost unmarketable product (Holt, 1991).

After drying in-shell nuts are graded as follows: Extra Large, 40-45 nuts per pound; Large 46-50; Weak Large 51-56; Medium "Tocs", 57-62; and Small, 63-110 nuts per pound (ITC, 1993).

Production and consumption/utilization

Deforestation in the Amazonian rainforest has brought about a reduction in the harvest of Brazil nuts from about 104 000 tonnes in 1970 to only about 50 000 tonnes in 1980 (Mori and Prance, 1990). In-shell Brazil nuts are traditionally for the Christmas market in UK, Germany and USA as "mixed nut in-shell pack". Kernels are used in USA for roasting and salting for inclusion in mixed salted kernel packs. Approximately 60% of the UK market is in kernels for coating with chocolate (enrobing), the remaining 40% are marketed as raw packed kernels. The kernels are used for repacking in Continental Europe (Holt, 1991).

Nutritional value

Brazil nuts are highly nutritious, containing approximately 14% protein, 67% digestible fat or oil and 11% carbohydrates in addition to calcium, phosphorus, potassium, vitamin B and the rare vitamin excelsine (ITC, 1993). The oil is rich in unsaturated fatty acids (Table 4); the nut is also rich in the sulphur amino acids methionine and cysteine, which are deficient in seeds of *Phaseolus vulgaris* (common bean), a major source of protein in developing countries (Clay and Clement, 1993).

Table 4: Percentage Fatty Acid Composition of Pressure Extracted Brazil Nuts Kernel Fat

C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	%IS
0.05	13.85	0.45	10.25	30.50	44.90	-	75.85
0.48	13.74	-	5.45	42.79	26.54	-	69.33

C14:0 = myristic; C18:1 = oleic;
C16:0 = palmitic acid; C18:2 = linoleic;
C16:1 = palmitoleic; C18:3 = linolenic;
C18:0 = stearic; %IS = insaturation = C16:1 + C18:1 + C18:2 + C18:3

Source: Adams, 1975 cited by Clay and Clement, 1993.

By-products and other uses

Seed oil is bright yellow, nearly odourless and with a pleasant nutty flavour. The first extraction yields an excellent cooking oil, the second extraction is suitable for soap-making

and as an illuminant. The seed cake may be used for feeding livestock (Prance and Mori, 1979).

The capsule (pyxidium) may be used for fuel, and is a preferred source of smoke for coagulating rubber latex. Variously used for local craft work for ashtrays, trinket cases, candle holders and ornaments; also used by the native tribes for containers or mortars. Timber is excellent but little used because of the high value of the nuts as well as felling being prohibited by law in Brazil (Mori and Prance, 1990; Clay and Clement, 1993).

Marketing

The world supply of Brazil nuts has varied from as high as 60 000 tons to *ca.* 30 000 tons and over the past 22 years has decreased at the modest rate of *ca.* 820 tons a year (Table 5). This decrease can be attributed to the destruction of the rainforest (LaFleur, 1992).

Table 5: World Production of Brazil Nuts by Country, 1970-1991

Year	Brazil	Bolivia	Peru	Total	Approximate price FOB
	('000 tons)				£/ton or US$/lb
1970	50			50	£378/ton
1971	30			30	£487/ton
1972	65			65	£466/ton
1973	65			65	US$ 0.63/lb
1974	33			33	US$ 0.77/lb
1975	50			50	US$ 0.59/lb
1976	32			32	US$ 0.76/lb
1977	38			38	US$ 1.28/lb
1978	32	8	2	42	US$ 1.33/lb
1979	50	7	3	60	US$ 1.04/lb
1980	60			60	US$ 0.98/lb
1981	40			40	US$ 1.07/lb
1982	28			28	US$ 1.63/lb
1983	35			35	US$ 1.41/lb
1984	35	10	6	51	US$ 0.81/lb
1985	40	6	4	50	US$ 0.82/lb
1986	35	8	5	48	US$ 0.90/lb
1987	33	10	7	50	US$ 1.09/lb
1988	29	7	5	41	US$ 1.18/lb
1989	25	9	6.5	40.5	US$ 1.70/lb
1990	42	9	3	54	US$ 1.48/lb
1991	24	5.5	2.5	32	US$ 1.36/lb
Average	36.3	8.0	4.4	45.2	US$ 1.20/lb

Source: LaFleur, 1992.

It was formerly second only to rubber as an export crop from Amazonian Brazil and still is a major crop in the overall economy of the region. Nuts are mainly exported to USA, United Kingdom and Germany (Prance and Mori, 1979).

Export is mainly concentrated in northwestern Amazonia, Acre State and the Pando/Beni regions of Bolivia. The in-shell nuts are from the generally larger and round nuts from central and lower Amazonia and Pará and the kernels from Acre and Pando/Beni regions. However, over the past decade the demand for in-shell has been decreasing worldwide as traditions have changed and the Food Authorities have become more demanding; the demand for kernels, however, has remained relatively constant. Over 80% of the commercial supply is from Acre where the differences between the Cruzeiro "official" and the Cruzeiro "parallelo" generally favours a contraband traffic between Bolivia, Peru and Brazil (Holt, 1991).

The three influencing factors between production and final usage are the out-turn quality at the shipper's factory, the quality received by the importer at the port of destination and the quality delivered to the consumer, resulting in a rather precarious market. The situation is further complicated by three of the major processing/exporting facilities in Brazil being owned by members of the same family and controlling over 50% of the market.

The importer buys a Fair Average Quality (FAQ) of the crop, which is determined by Combined Edible Nut Trade Association (CENTA) or by the Association of Food Industries, New York (AFI) from time to time during the year. This theoretically allows the market to trade different qualities as determined by the state of the crop at the point or origin. Sale by the importer to the final customer will invariably include guarantees and conditions not covered by the original purchase. Manufacturers have to conform to increasingly tighter legal specifications, particularly with regard to aflatoxin and coli bacteria, especially in Europe where raw or enrobed nuts are eaten. Since much of USA import is rendered sterile by roasting or blanching and detoxification processes, their import regulations tend to be less strict (Holt, 1991; LaFleur, 1992).

Blanched grades have been shown to be 99% less contaminated than naturals (shelled but not processed) and are marketed as blanched whole, sliced, diced, slivered, balls, ovals, broken and paste; natural grades are marketed as natural wholes, sliced and powder.

Discussion

The feudal contract system by which the disenfranchised gatherers are bonded to harvest the nuts means that any benefits of high prices are not passed onto the gatherers. The destruction of the rainforest has resulted in a steady decrease in both production and share of the edible nut trade, promising a bleak future for the Brazil nut trade (LaFleur, 1992).

However, long-term prospects are considered reasonably promising. Producers from the Andean region can expect little or no competition from other parts of the world. However, their main concern should not be production and exports but quality control (ITC, 1993).

Brazil nut trees can continue be managed under the present "castanhais" system, thereby helping to conserve the tropical forest and Amerindian cultures. A second possibility is one of agroforestry/forest management to restore degraded forest sites with the Brazil nut as a multipurpose species, yielding nuts after 15-20 years and timber after 50-100 years, which could lead to the provision of long-term capitalization for the Amazonian farmer. The third option is that of investment in a monoculture plantation crop but with the inherent risks of

pests and diseases. Clay and Clement (1993) prefer the second option. However, there is also a case for the Amerindians to be allowed to continue their traditional way of life in their own territories and the second option to be used in degraded areas.

PEANUT OR GROUNDNUT: *Arachis hypogaea*, Leguminosae subfamily Papilionoideae

See Smartt (1994) for agronomic details, etc.

Discussion

Peanuts are the second largest source, after soya beans, of vegetable oil; the crops from all the major producing countries with the exception of USA is predominantly for oil extraction (Purseglove, 1987).

As a dessert nut, peanuts were first introduced in USA as roasted, in-shell in 1870; packaged, salted and roasted, shelled peanuts were introduced around 1906 (Matz, 1984).

It is a valuable, high protein, legume crop widely grown throughout the tropics, especially in the lower rainfall areas. Where other sources of food protein are not readily available the emphasis should be on peanuts for local consumption rather than commercial oil extraction.

MACADAMIA OR QUEENSLAND NUT: *Macadamia integrifolia*, Proteaceae

Distribution and ecology

Native of Queensland and northern New South Wales of Australia; occurs along fringes of subtropical lowland rainforests. Introduced to Hawaii in 1880s for growing as windbreaks. The commercial potential as a dessert nut was developed by the University of Hawaii in the 1930s although a plantation had been established in Australia as early as 1888; recent plantations in California, Florida, Jamaica, Mexico, Guatemala, El Salvador, Costa Rica, Colombia, Venezuela, Brazil, Peru, Ethiopia, Kenya, Tanzania, Malawi, Zimbabwe, South Africa, Thailand, China, Indonesia, Tahiti, Samoa, Fiji, New Caledonia, New Zealand and Israel. Optimum temperature is 25°C; mature trees are frost tolerant for short periods down to -6°C, longer periods or lower temperatures are fatal. The developing inflorescence is susceptible to frost while the critical temperature above which flowering is suppressed is 20°C (Rosengarten, 1984; ITC, 1993; Macrae *et al.*, 1993).

Description

A spreading, evergreen tree up to 10 m tall; leaves in whorls of 3, simple, entire 10-28 cm long, new leaves pale green (in whorls of 4 and margins serrate with *ca.* 40 per margin, new leaves pink to red in the closely related *M. tetraphylla*). Inflorescence 10-15 cm long with up to 200 creamy white flowers (racemes up to 30 cm long and bearing more than 500 reddish pink flowers in *M. tetraphylla*). Follicles 1-sutured, only 1 out of 2 ovules develops (rarely both, then whole kernel difficult to extract). Fruit borne in hanging clusters of 12 or more, globose, 2-3 cm in diameter, exocarp fleshy, dehiscing on the tree; endocarp very hard, kernels globose (Menninger, 1977; Rosengarten, 1984; Macrae *et al.*, 1993).

Cultivation

Macadamia prefers well-drained soils, sheltered from strong winds and a mild, frost-free, subtropical climate with a well distributed annual rainfall of at least 1 200 mm. Plantations from seed start profitable bearing after 7 years, with productivity peaking after 15 years; the economic life of the tree being 50 years. At full production the yield is from 23 to 70 kg in-shell nuts per tree. Desirable clones may be developed by grafting. The species is cross pollinated, therefore desirable that at least two cultivars are grown in orchards, preferably in alternate rows. The presence of bees should be encouraged (Rosengarten, 1984; Macrae *et al.*, 1993).

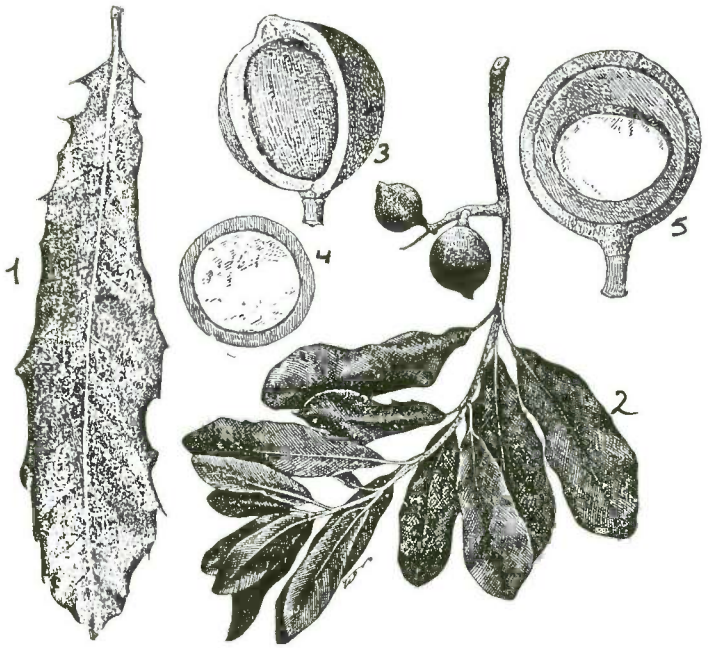


Figure 8
Macadamia integrifolia. 1: leaf. 2: branchlet. 3: nut showing dehiscence of husk. 4: cross-section. 5: longitudinal section.

Harvesting

Mature trees bear continuously and ripe fruits are difficult to distinguish from immature ones on the tree as the mature fruits usually abscise when the fibrous husk is still green. As the husk dries it splits along the suture to release the nut with its thick, rough, strong, light tan shell enclosing the kernel. Consequently the ripe nuts are usually harvested from the ground. A blower is used to move leaves and nuts away from the base of the tree where they can be swept into windrows and picked up by a mechanized harvester, although some hand labour is always necessary. Harvesting should be carried out every 6-8 weeks to avoid any deterioration (Menninger, 1977; Rosengarten, 1984; Macrae *et al.*, 1993).

Post-harvest treatments

Freshly harvested nuts contain up to 30% moisture in the husk and 10-25% in the rest and it has to be removed within 24 hours if possible to prevent mould. The husk is removed by husking machines and initially dried to 10% moisture before delivery to the processor. The in-shell nuts are then reduced in stages to about 1.5% water content in drying ovens for long-term storage, efficient cracking and more complete removal of whole kernels. The dried nuts are then shelled in stainless steel drums and the kernels separated by a combination of sieving and air blasting before grading by air or water flotation. The final product is either lightly roasted and salted or packaged raw in vacuum-filled, foil laminate bags (Ryall and Pentzer, 1974; Rosengarten, 1984; Macrae *et al.*, 1993).

Production and consumption/utilization

The optimum requirements for eating and processing are kernels containing at least 72% oil, i.e., specific gravity (SG) <1.0); second grade kernels with SG 1.0-1.025 can be used for

low grade production, while third grade kernels with SG >1.025 are commercially unacceptable. The bulk of the macadamia nuts are traditionally roasted in coconut oil and salted although dry roasting is increasing in popularity; also used in confectionery - chocolate coated kernels and nut chocolate, ice cream and baking (Rosengarten, 1984; ITC, 1993; Macrae *et al.*, 1993).

Nutritional value

Kernels contain more than 75% of oil, the rest being protein and little sugar but no starch (Menninger, 1977). The nutritional value of roasted and salted nuts compared with shelled pistachio nuts are shown in Table 6.

Table 6: Nutritional Value per 100 g of Roasted in Oil and Salted Macadamia Nuts and Dried and Shelled Pistachio Nuts

	Macadamia	Pistachio
Water (%)	2	4
Food energy (kJ)	3 064	2 465
Protein (g)	7.1	21.4
Fat (g)	78.6	50
Fatty acids, saturated (g)	11.4	6.1
Fatty acids, monounsaturated	61.1	33.2
Fatty acids, polyunsaturated	0.14	7.5
Cholesterol (mg)	0	0
Carbohydrates (g)	14.3	25
Ca (mg)	46.4	135.7
P (mg)	203.6	510.7
Fe (mg)	1.8	6.8
K (mg)	332.1	1 107.1
Na (mg)	264.3	-
Mg (mg)	0.12	-
Zn (mg)	1.4	-
Mn (mg)	0.38	-
Cu (mg)	0.33	-
Vitamin A, iu	trace	250
Vitamin A, RE (mg)	trace	25
Thiamin (mg)	0.21	0.82
Riboflavin (mg)	0.11	0.18
Nicotinic acid (mg)	2.14	1.07
Ascorbic acid (mg)	0	trace

Source: Macrae *et al.*, 1993.

By-products and other uses

Macadamia shell may be used as fuel, generating sufficient energy to dry wet, in-shell nuts. Kernel oil suitable for human consumption (Menninger, 1977; Rosengarten, 1984).

Macadamia tree. (Photo: G. Blaak)

Macadamia in flower. (Photo: G. Blaak)

Marketing

World production for 1991/1992 was approximately 11 000 tonnes of kernels per year of which 50% were consumed in USA. The major exporter is Hawaii, producing about 5 700 tonnes in 1991, with over 50% of the world production and a projected kernel production of about 13 600 tonnes by the year 2000. Australia, the second largest producer in the world has an annual production of *ca.* 3 000 tonnes, or near 30% of the world production (ITC, 1993). Considered a gourmet delicacy, it is, with pine nuts and pistachios, one of the world's most expensive nuts (Rosengarten, 1984).

Discussion

World production is increasing at an alarming rate and is expected to double by the beginning of the next century. There is still only a small demand for this expensive nut and it is a crop that requires considerable initial investment (ITC, 1993). Nevertheless, the market for macadamia could be expanded considerably into Europe and Asia, where it is still relatively little known. The increase in production can be expected to result in a price reduction.

With our present knowledge there are only limited areas in the world where the trees can be grown successfully. To date there have been no successful plantations within *ca.* 15°N and S of the equator and, unlike coffee, a suitable altitude cannot be substituted for latitude when seeking a favourable environment (Rosengarten, 1984). Obviously there is a need for further exploration for and selection of potential genotypes and a better understanding of the environmental and management factors involved in establishing productive macadamia plantations.

ALMOND: *Prunus dulcis*, Rosaceae

Distribution and ecology

Naturally occurs in the oak forests of Northern Syria, Turkey, Caucasus, Iran and Iraq. Introduced and widely naturalized in North Africa, Cyprus, Crete, southern Europe, Afghanistan, Kashmir, California, etc. (Townsend and Guest, 1966).

Description

Spreading tree up to 10 m tall; leaves deciduous, simple. Fruit ovoid-ellipsoid, 3-4 cm x 2–2.5 cm (larger in cultivated varieties), splitting at maturity, stone 2.5-3 cm x 1.5-2 cm, pitted, seed ovoid, compressed, *ca.* 1.5-2 cm x 1-1.5 cm (Townsend and Guest, 1966). Two races recognized, sweet almonds grown for their edible nuts and the bitter almonds for oil of bitter almond. Hard and soft shelled forms are recognized in the former (Ryall and Pentzer, 1974; Matz, 1984; Rosengarten, 1984); the latter will not be considered further here.

Cultivation

Most almond cultivars are soft shelled; they are also self-incompatible, consequently plantations require the interplanting of two rows of self-incompatible with a row of cross-compatible cultivars; the keeping of honey bees for pollination is considered an essential part of almond production. Trees in California begin to bear after 3-4 years and reach full productivity in *ca.* 7-8 years. Irrigation is favoured in California (Rosengarten, 1984).

Harvesting

Almonds ready for harvesting when the hulls start to split open. Formerly harvested by beating the tree and collecting the falling almonds on canvas sheets. Now harvested using mechanical shakers which can deal with 120 trees per hour; the fallen nuts are then swept into windrows and picked up mechanically for transport to the factory. The use of shake and catch machines lessens the danger of fruits of the more open cultivars coming into contact with the soil, thereby lessening the risk of mould and aflatoxin infestation (Ryall and Pentzer, 1974; Rosengarten, 1984; Paramount Farms Almonds, 1991).

Figure 9
Prunus dulcis. 1: branch with flowers. 2: longitudinal section of flower. 3: Branch with fruits. 4: fruits without pericarp.

Post-harvest treatments

At the factory the brown, outer, leathery coat (hull) is removed by blanching, which involves placing the almonds in contact with water at 82°C for 3 minutes and either skinning by hand or by a special machine. The almonds are then dried to less than 8% moisture content and stored. Air tight containers must be used to prevent moisture pick-up. Although relatively resistant to rancidity the almonds will deteriorate in time. On delivery to the packing company, the almonds are shelled and graded. The grading process uses ultraviolet scanners for high-tech colour sorting to separate damaged and foreign matter before mechanical grading (Matz, 1984; Paramount Farms Almonds, 1991).

Production and consumption/ utilization

Approximately 98% of the crop is sold shelled either as natural and retaining the brown skin or blanched, with the skins removed. Almonds can be eaten as a dessert nut either dry roasted or roasted in almond oil and then salted and seasoned. They are also used for baking, confectionery, cereal, dairy or snack formulations; processing may produce blanched whole, slivered, meal, diced, split, sliced or flaked almonds; almond butter is a recent development (Rosengarten, 1984; Paramount Farms Almonds, 1991).

Nutritional value

Almonds contain approximately 22% protein, 57.7% digestible fat or oil and 15% carbohydrates (Melville, 1947).

By-products and other uses

The gum exudate may be used as a substitute for gum tragacanth and was formerly exported from Iran via Bombay to Europe. Almond yields both an essential oil and fixed fatty acid for use in perfumery but frequently adulterated with other oils. The essential oil from the bitter variety is highly toxic due to presence of HCN but with careful preparation yields an agreeable essence for use in perfumery and confectionery. Both bitter and sweet varieties may be grown as ornamentals (Townsend and Guest, 1966).

The hulls of sweet almonds can be fed to livestock. The shells can be used for roughage in cattle feed or converted into charcoal briquettes (Rosengarten, 1984).

Marketing

Regarded as the most important and versatile of all edible tree nuts. Almond producing countries in current order of importance are USA (California), Spain, Italy, Iran, Greece, Morocco, Turkey, Tunisia, Pakistan, Libya, Syria, Portugal, China and Lebanon (FAO, 1994).

World production rose steadily from 1 million tonnes in 1979-81 to 1.3 million tonnes in 1992 and fell to 1.2 million tonnes in 1993. This trend is reflected in North America by 273, 412 and 356 000 tonnes for 1979-81, 1992 and 1993 respectively. Production in Europe, the largest of the continental scale producers has decreased steadily from 482 000 tonnes in 1979-81 to 436 000 tonnes in 1993. Spain, the major producer in Europe increased production slightly from 243 000 tonnes in 1979-81 to 251 000 tonnes in 1993, while in Italy production has declined markedly, from 174 000 tonnes in 1979-81 to 99 900 tonnes in 1993 (FAO, 1994).

Discussion

The world's major edible nut, there is an obvious need for improving Old World production if it is to compete with the highly mechanized production in USA.

COCONUT: *Cocos nucifera*, Palmae

Distribution and ecology

Origin unknown, possibly western Pacific; cultivated throughout the lowland tropics. Salt tolerant, the coconut requires an equable climate, good drainage, adequate soil aeration and constant supply of ground water (Purseglove, 1987; Dransfield, 1986).

Description

Solitary, unarmed, monoecious tree palm ranging from "dwarfs" with trunks up to 2 m at first flowering to tall forms with trunks to 30 m or more. Leaves pinnate, 4-5 m long. Inflorescence up to 1.5 m long, bisexual; male flowers distal. Fruit massive, obovoid,

obscurely trigonous, up to 25 cm long and 25 cm or more in diameter, with basal persistent calyx and corolla; usually with only 1 of the 3 carpels developing; mesocarp massive, fibrous; endocarp to 5 mm thick, extremely hard and woody, with 3 basal "eyes", usually only 1 functional; seed filling the large endocarp cavity, 10-15 cm in diameter; endosperm to 2 cm thick, lining the endocarp (Dransfield, 1986).

Figure 10
Cocos nucifera.

Cultivation

A number of rather heterogeneous cultivars are recognized including one where the endosperm hypertrophies to fill the entire cavity with a thick, edible curd. Tall palms tend to be slow maturing, flowering 6-10 years after planting and with a life-span of 80-100 years. Dwarf palms begin bearing in their third year and have a productive life of 30-35(-40) years.

A satisfactory method of vegetative propagation has yet to be found, although some success has been reported with tissue culture. Propagation is, therefore, from seed. The seed has no dormancy and growth may even begin while the fruit is still attached to the tree. Germination is slow and may take *ca.* 4 months. Transplanting into the field is from 6-9 months and should be accompanied by stringent selection for early germination, vigour and rapid growth. The normal spacing for tall palms is for 120-175 palms per ha with square planting and 140-200 palms per ha with triangular planting. Palms require careful attention during their initial 4-6 years to ensure good development; catch crops may be grown until the palms come into bearing. Manuring is highly beneficial.

An inflorescence is produced every month and the fruit takes a year to mature (Rosengarten, 1984; Purseglove, 1987).

Harvesting

Depending on the cultivar, the average weight of fruit from tall palms ranges from 1.2-2 kg with nuts from 0.7-1.2 kg containing 0.35-0.6 kg endosperm and yielding 0.2-0.29 kg of copra. Dwarf palms bear fruits weighing 1.1 kg with nuts weighing 0.6 kg and yielding 0.2 kg of copra.

Harvesting usually begins when tall palms are 6-8 years old and continues throughout the year. Fully ripe fruits are required for copra production and manufacture of desiccated coconut. The fruits may be harvested by skilled climbers or, in Malaysia, Thailand and Sumatra, by trained pig-tailed monkeys; coconuts may also be cut down using a knife fixed to a long pole or the fallen fruit picked up from the ground (Rosengarten, 1984; Purseglove, 1987).

Post-harvest treatments

The endosperm is the source of an edible/industrial oil which is either extracted by the producing countries or dried and exported as copra for extraction elsewhere; copra contains 60-68% oil of which *ca.* 64% is extractable. The copra is extracted by first removing the husk by impaling and twisting the fruit on an erect steel bayonet and then splitting the nut with a cutlass and gouging out the endosperm. The copra is dried either in the sun or in kilns immediately after breaking the nut in order to avoid any deterioration (Howes, 1948; Purseglove, 1987).

Production and consumption/utilization

For domestic consumption in the countries of origin the endosperm is grated and macerated, the emulsion is boiled and the resulting scum skimmed off and the oil poured off. Hydraulic presses are used industrially to extract the oil; additional oil is sometimes recovered from the cake residue using hydrocarbon solvents.

The endocarp of green, unripe fruits contain *ca.* 500 ml of a sweet and refreshing liquid. The fresh endosperm is variously eaten in the East and Pacific. Coconut milk, which is widely used in curries and other cooking, is obtained by squeezing freshly grated endosperm through a sieve.

The dried endosperm (copra) is an important commercial source of oil for margarine and soap production. The low content of unsaturated acids present makes coconut oil resistant to oxidative rancidity, thereby adding to the keeping quality in baked foods and fillings. With a higher melting fraction, coconut stearin is valued as a confectionery fat and as a substitute for cocoa butter.

The shredded and dried fresh endosperm is used in confectionery and bakery products as desiccated coconut and contains 68-72% oil and less than 2% water.

The haustorial organ or coconut apple within a germinating coconut is eaten in some countries (Howes, 1948; Hedrick, 1972; Menninger, 1977; Johnson, 1983; Rosengarten, 1984; Purseglove, 1987; Mabberley, 1987).

Nutritive value

The endosperm contains 36.3% water, 4.5% protein, 41.6% fat, 13.0% carbohydrates, 3.6% fibre and 1.0% minerals, while copra contains 6.8% water, 7.6% protein, 63.7% fat, 16.1% carbohydrates 3.8% fibre and 2.0% minerals (Purseglove, 1987).

By-products and other uses

The fibrous mesocarp (husk) yields fibre coir for doormats, matting, cordage, while the residual coir-dust is used as a peat substitute in horticulture. The coconut liquid from unripe fruit, which contains plant growth substances, is used in plant physiology experiments; it has also been used in the Pacific theatre during World War II as a substitute for a glucose drip in surgery. In addition to the commercial importance of coconut oil for margarine it is also used in the soap and cosmetic industries and in the manufacture of detergents and resins, it is also used for cooking and as an illuminant, and the coconut stearin used for candles. The copra residue after extraction of oil is used in cattle and poultry foods; the stony endocarp

(shell) may be used for fuel, also used for containers and craft work, buttons, combs, bangles, musical instruments, etc. The finely ground shells are used in the plastics industry as fillers, also in the manufacture of gas absorbent charcoal for use in gas masks, etc.; the distilled shells yield wood tar and, although not currently economic, furfural ($C_5H_4O_2$), which may be used as a solvent for cellulose nitrate and in the manufacture of dyes and plastics.

The apical buds from old trees are used for tinned palm hearts. The trunk is tapped for the sugary sap known as toddy which, when fresh, may be used as a bread yeast. Evaporated, toddy yields jaggery (palm sugar). Toddy may be fermented to produce coconut vinegar. The distillation of fermented toddy yields a strong alcoholic liquor (arrack) containing 30-40% alcohol. The leaves are used for basketry, thatch, etc., and the midribs for brooms, baskets, fish-traps, fences, etc. The trunk is used for building; the closely grained outer wood (porcupine wood) is used for furniture, carving and veneers. The roots are used for tooth sticks. Almost all parts are used in local medicines and various ceremonial customs. Dwarf cultivars serve as the mother palm in creating productive hybrids, they may also be grown as ornamentals (Howes, 1948; Hedrick, 1972; Menninger, 1977; Johnson, 1983; Rosengarten, 1984; Purseglove, 1987; Mabberley, 1987).

Marketing

Coconut has been the major source of vegetable oil in the twentieth century, now surpassed by the soya bean and oil palm. World production of coconuts is currently 43.4 million tonnes (and of copra 4.6 million tonnes), of which Indonesia is the largest producer with 14.2 million tonnes, followed by the Philippines with 9.3 million tonnes; the Philippines is also the largest producer of copra with 1.8 million tonnes followed by Indonesia with 1.1 million tonnes. Mozambique is the largest producer in Africa with 0.4 and 0.07 million tonnes of coconuts and copra respectively with Mexico the largest producer in America with 1.0 and 0.2 million tonnes of coconuts and copra respectively (Purseglove, 1987; FAO, 1994).

Discussion

Due to its multiplicity of uses the coconut is known as the "tree of life", the tree of heaven's and mankind's greatest provider in the tropics. New World production from tall palms has been seriously threatened by palm lethal yellowing, a disease of an unknown etiology but probably caused by a mycoplasma-like organism (MLO) (Holliday, 1989). Should the disease spread to the Old World there would have to be a massive replanting with immune, high yielding cultivars for plantations to remain productive. Unfortunately 95% of the coconut producers are small holders and may be unable to bear the cost of replanting.

MINOR EDIBLE NUTS 3

Other relatively minor edible nuts and seeds, as listed below, are also marketed commercially (Rosengarten, 1984); *Sesamum indicum* is not considered here as it is regarded as an oil seed. They are:

pili or Philippine nuts	*Canarium ovatum,* Burseraceae
pumpkin, squash seeds and gourd seeds	*Cucurbita pepo,* Cucurbitaceae
American beechnuts	*Fagus grandifolia,* Fagaceae
shagbark hickory nuts	*Carya ovata,* Juglandaceae
butternuts or white walnuts	*Juglans cinerea,* Juglandaceae
soy, soja or soya beans	*Glycine max,* Leguminosae
water or horn chestnuts, Jesuit nuts or water calthrops	*Trapa natans,* Trapaceae
stone pine or parasol nuts or pignolias	*Pinus pinea*, Pinaceae

Pumpkin seeds, although ranked as a minor nut, are regarded as an agricultural crop and are not included here apart from the discussion regarding its effect on the marketing of other edible nuts. The inclusion of soybeans as a nut-producing plant may be considered somewhat surprising. However, Rosengarten (1984) considers that the fairly recent development of the soynut in North America as an alternative to the peanut will offer very strong competition to traditional nuts in the future. However, since it is regarded as an agricultural crop, like pumpkin seeds, it is not described in detail here although it is discussed in as far as its marketing affect other edible nuts.

PILI OR PHILIPPINE NUT: *Canarium ovatum,* Burseraceae

"The most important of all the nuts in the world to the millions of people who depend on it for food, is the PILI NUT of the Philippines and its relatives." (Menninger, 1977.)

Distribution and ecology

Native of the Philippines, abundant in southern Luzon; intolerant of frost. Trial introductions under investigation in Honduras (Menninger, 1977; Rosengarten, 1984).

Description

Evergreen, dioecious tree to 25 m high with trunk *ca.* 40 cm in diameter. Leaves imparipinnate. Fruit oblong-ovoid, black; pulp thin; nuts slender, ovoid-acute, 6-7 cm long, 2-2.5 cm wide, triangular in cross-section; 1-seeded, shell thick, very hard (Menninger, 1977; Rosengarten, 1984).

Cultivation

Not widely cultivated on a large-scale commercial basis, production mainly from wild trees and small plantings near coconut and hemp plantations. Female trees begin to yield in sixth year with full production at 12-15 years (Rosengarten, 1984).

Harvesting

Yield 32 plus kg per annum (Menninger, 1977).

Post-harvest treatments

Pericarp removed by dipping fruits in hot water (Menninger, 1977).

Production and consumption/utilization

Kernels very popular in the Philippines, eaten raw or roasted and salted after first removing the seed coat. Roasted, oily kernel have a delicious flavour that is claimed superior to almonds and easily digested; used in confectionery; nutritious emulsion of the kernels occasionally used as substitute milk for infants (Menninger, 1977; Rosengarten, 1984).

Nutritional value

Kernel contains 71.1% fat, 11.4% protein and 8.4% carbohydrates (Rosengarten, 1984).

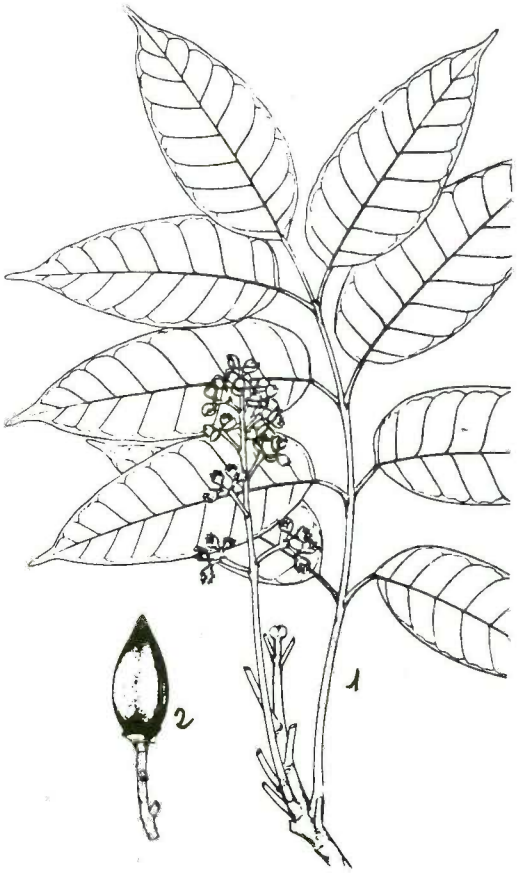


Figure 11
Canarium ovatum. 1: branch with leaves and flowers. 2: fruit.

By-products and other uses

Raw nuts purgative. Seeds are source of a sweet oil suitable for culinary purposes. Oil extracted from pulp is occasionally used for cooking and as an illuminant. An odorous soft resin with the texture of honey formerly exported for the European pharmaceutical trade as Manila or Philippine gum elemi for use as an ointment for healing wounds and as a plaster; also used by Spaniards for ship repairs (Menninger, 1977; Rosengarten, 1984).

Marketing

Pili nuts formerly exported to USA on a fairly large scale but trade has now declined; 1 186 173 kg exported from Manila in 1913 (Menninger, 1977; Rosengarten, 1984).

Discussion

A promising minor nut but the thick, hard shell is hard to crack and is believed to be an obstacle for expansion. There is a need to select for shells that are thinner and easier to crack and to consider such selections for vegetative establishment in future orchards (Rosengarten, 1984). Other species (see Appendix A) should also be investigated either for development or as a genetic source for improving *C. ovatum*.

PUMPKIN, SQUASH OR GOURD SEEDS: Cucurbita pepo, Cucurbitaceae

Discussion

Widely eaten as a dessert nut in Asia either raw or roasted, fried in deep fat and salted or made into a confection and becoming increasingly important as a health food in the Western World.

The seeds of other widely cultivated pumpkins and squashes are also eaten, including the cold tolerant winter *Cucurbita maxima*, the cold intolerant *C. mixta* and the humid tolerant *C. moschata*, as well as the watermelon, *Citrullus lanatus* (Purseglove, 1987).

According to FAO (1994) the world production of pumpkins and squashes has risen steadily from 5.7 million tonnes in 1979-81 to 8 million tonnes in 1993, with the largest production from Asia with 3.5 million tonnes. The proportion grown for their edible seed, however, is not known but is believed to be increasing.

AMERICAN BEECHNUT: *Fagus grandifolia*, Fagaceae

Distribution and ecology

Eastern USA, from the Allegheny mountains south to Florida and Texas, especially at higher elevations; calcareous soils preferred (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Description

Slow-growing tree, with a life span of 400 years or more (Rosengarten, 1984). Deciduous, up to 25 m tall and trunk up to 1 m in diameter. Leaves simple, ovate-acute, around 7.5 cm long, margins serrated. Fruit a woody burr; seeds 2-3, triangular, *ca.*0.75-3.7 cm wide (Rosengarten, 1984). Woody capsules dehisce on ripening and nuts fall to the ground in autumn; they soon spoil unless collected and dried (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Figure 12
Fagus grandifolia. : branch with leaves and fruits.

Cultivation

No information available.

Harvesting

No information available.

Post-harvest treatments

None given apart from drying.

Production and consumption/utilization

Beechnuts gathered from the wild eaten fresh, dried or roasted, usually sweet but the flavour varies from tree to tree; much appreciated by native Americans.

Nutritional value

Beechnuts contain *ca.* 15% fat, 19.4% protein, 20.3% carbohydrates and have an energy value of 1 169 calories per kilogram (Rosengarten, 1984).

By-products and other uses

Timber is good, dark to reddish brown, strong, heavy and hard; excellent for furniture and flooring, also used for clothpegs. A good ornamental tree for landscaping (Rosengarten, 1984).

Marketing

Although liked, little potential for food and feed; the oil potential has not been developed as in Europe with *F. sylvatica*.

Discussion

Neglected as a source of edible nuts, with little attempt to develop suitable cultivars. This may be due to the small size of the nut and variability in flavour, the frequent presence of blind nuts, the irregularity of bearing and difficulty of harvesting (Rosengarten, 1984).

SHAGBARK HICKORY NUT: *Carya ovata,* Juglandaceae

Distribution and ecology

Distribution covers southeastern Canada and eastern USA west to the Mississippi except for Florida and the coastal plains of the southern states; prefers the upland plains (Howes, 1984; Menninger, 1977; Rosengarten, 1984).

Description

Deciduous tree up to more than 30 m tall with trunk up to 60 cm in diameter, bark exfoliating in long narrow plates but remaining attached by the middle, trunk clear of branches to half its height, with small, open crown. Leaves imparipinnate, 5 leaflets. Nut enveloped in an outer, green and fleshy husk, becoming black, dry and splitting open at maturity; nut ellipsoidal, somewhat flattened laterally, with four prominent longitudinal ridges (sutures of the valves), *ca.* 2.5 cm long, shell thin but hard, light tan; kernel deeply divided into 2 halves, longitudinally ridged (Menninger, 1977).

Cultivation

Occasional trees preserved when land is cleared (Menninger, 1977). Trees difficult to transplant, slow-growing, late-bearing and low-yielding. Seedling trees yield at *ca.* 15 years, grafted trees produce much earlier. Interspecific hybrids readily occur. Those between *C. ovata* or *C. laciniosa* and *C. illinoinensis* are known as hicans (Rosengarten, 1984).

Harvesting

Harvested largely from the wild, from hedgerows and wood margins where the branches are free to spread. Solitary trees tend to have higher yields and better developed nuts than trees growing close together (Howes, 1948).

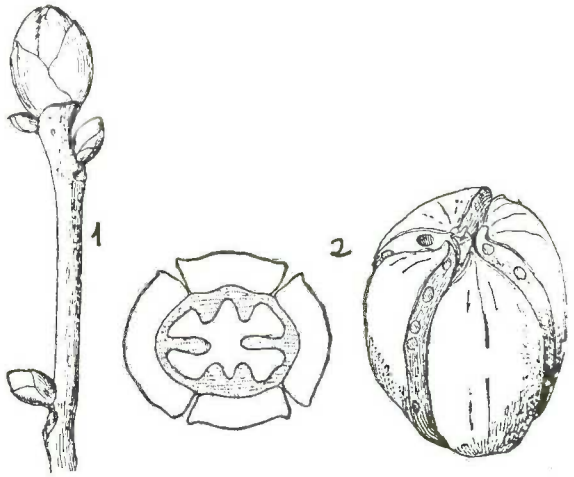


Figure 13
Carya ovata. 1: twig. 2: fruit and cross-section of fruit.

Post-harvest treatments

Nuts can be readily stored for 2-3 years with little or no deterioration (Howes, 1948).

Production and consumption/utilization

Nuts are delicious, considered the sweetest of the hickories, eaten by native Americans either dried and pounded into flour, boiled as a soup; source of a cooking oil (also used as a hair dressing); also pounded shells and kernels mixed in water for a nourishing beverage known as pawcohiccora or hickory milk (Menninger, 1977; Rosengarten, 1984).

Nutritional value

On a moisture-free basis the kernels contain 9.8% carbohydrates, 72.7% fat and 13.7% protein (Melville, 1947).

By-products and other uses

The tough, elastic wood ideal for tool handles and agricultural implements, and also a good fuelwood. Hicans often are attractive ornamental trees (Rosengarten, 1984).

Marketing

A neglected, minor nut, not commercially important. The relative high proportion of shell compared with other better-known nuts probably restricts long-distance marketing prospects; sold in the local markets and occasionally sold in England (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Discussion

A more marketable nut with higher proportion of kernel to shell is required. Considerable research will be required before any hybrid hican clones could be developed for commercial nut production (Howes, 1948; Rosengarten, 1984). Presumably any commercial development will follow that of the pecan.

BUTTERNUT OR WHITE WALNUT: *Juglans cinerea*, Juglandaceae

Distribution and ecology

Eastern North America, from New Brunswick to Manitoba south; butternut represents the most northern and cold resistant member of the family (Rosengarten, 1984).

Description

A deciduous tree to 18 m tall, with a trunk up to 1 m in diameter. Leaves imparipinnate with 11-17, glutinous leaflets. Fruits oblong-cylindrical, *ca.* 6.5 cm long and 3 cm in diameter, apex acute, surface rough, shell bony and thick, 1 kernel (Howes, 1948; Rosengarten, 1984).

Figure 14
Juglans cinerea. Pistillate flowers.

Cultivation

Superior cultivars available for grafting but not commercialized (Howes, 1948).

Harvesting

No information given, presumably as for *Juglans regia.*

Post-harvest treatments

No information given, presumably as for *Juglans regia.*

Production and consumption/utilization

Immature fruit makes an excellent pickle. Kernels are highly esteemed and used by native Americans, eaten raw, ground to flour for baking or to thicken their pottage; seed oil also used for cooking, and dressing hair (Menninger, 1977; Rosengarten, 1984).

Nutritional value

Nuts are highly nutritious with 23.7% protein, 61.2% fat and an energy value of *ca.* 1 360 calories per kg. The protein value is one of the highest in edible nuts (Rosengarten, 1984).

By-products and other uses

Oil from nut used medicinally by the Narragansett native Americans. The boiled or distilled hairy, sticky indumentum of young twigs, leaves, buds and fruits are source of a light brown dye. Close-grained, satiny wood, known as white walnut, used for furniture, boats and carving. Grown as a shade tree (Menninger, 1977; Rosengarten, 1984).

Marketing

Butternuts are highly regarded by those that know them but are largely unknown by the present generation. Market is mainly limited to home consumption, primarily in southern Canada and New England (Menninger, 1977; Rosengarten, 1984).

Discussion

Despite the delectable flavour of the nuts, its reputation for being slow-growing and short-lived, its susceptibility to butternut dieback from the fungus *Melanconis juglandis*, difficulties with propagating cultivars plus the nut being hard to crack, limit the potential for commercial expansion (Rosengarten, 1984).

SOY, SOJA OR SOYA BEAN: *Glycine max,* Leguminosae subfamily Papilionoideae

Discussion

The soynut industry is a fairly recent development in USA. The seeds are processed to resemble nuts in appearance, flavour and utilization. With a crunchy texture, low moisture content, absence of cholesterol and twice the protein content of tree nuts together with all-year round availability and low price, they are an ideal health food. With only 2% moisture, they have a shelf life of 6-8 months. Their price is competitive with peanuts and, since the soynuts occupy *ca.* 30% more volume than the same weight of peanuts, their price per unit of volume is even more economical. Their major disadvantages are that their flavour is not to everyone's taste and, unlike many other nuts, they cannot be sliced for use in the confectionery trade. The less expensive, readily available and highly nutritious soynuts undoubtedly offer strong future competition to traditional tree nuts and peanuts. The percentage of the crop used for soynuts is small but not known (Rosengarten, 1984).

WATER OR HORN CHESTNUT, JESUIT NUT OR WATER CALTHROP: *Trapa natans,* Trapaceae

Distribution and ecology

A standing water, aquatic species with a wide and discontinuous range through Europe, Asia and Africa. It is naturalized in northern America and Australia with var. *natans* distributed through Europe, Asia and North Africa and var. *bispinosa* ranging from India eastward to China and Japan and widely scattered in tropical Africa. A var. *africana* is endemic to Lake Victoria (Brenan, 1963).

Description

Annual aquatic herb with a rosette of floating leaves and submerged, paired but not opposite, pinnatisect and leaf-like adventitious roots. Fruit a 1-seeded, top-shaped drupe; pericarp soon disappearing; endocarp very hard, *ca.* 3-5 cm across, variously 2-4 horned, the horns 1-1.8 cm long, derived from the persistent sepals (Brenan, 1963).

Cultivation

In India fruit is broadcast in 30-69 cm deep nursery ponds and pressed into the mud, transplanted at the 4-5-leaf stage and replanted when 4-5 months old. Lateral pruning is

carried out to accelerate flowering and fruiting. In China, according to Menninger (1977), the water chestnut is cultivated in running water. A soft, thin-skinned, sweeter cultivar known as Kota Sudhar has been selected in Kashmir which ripens 20 days earlier and yields up to 6 200 kg per ha compared to 4 800 kg per ha for other cultivars (CSIR, 1976).

Harvesting

Nuts are gathered or scooped up from the depths in small nets; in China nuts are collected in autumn by people in boats seeking ripe fruits as they pull themselves through the surface vegetation. Depending on the weather harvesting in India commences some time during September to December (-February), initially harvesting every 15 days and eventually daily. Average yields range from 1 760 to 4 440 kg per ha, with a good crop yielding 13 200 kg (Hedrick, 1972; CSIR, 1976; Menninger, 1977; Rosengarten, 1984).

Post-harvest treatments

Removal of the hard endocarp to yield the edible, starchy, white seed (Menninger, 1977).

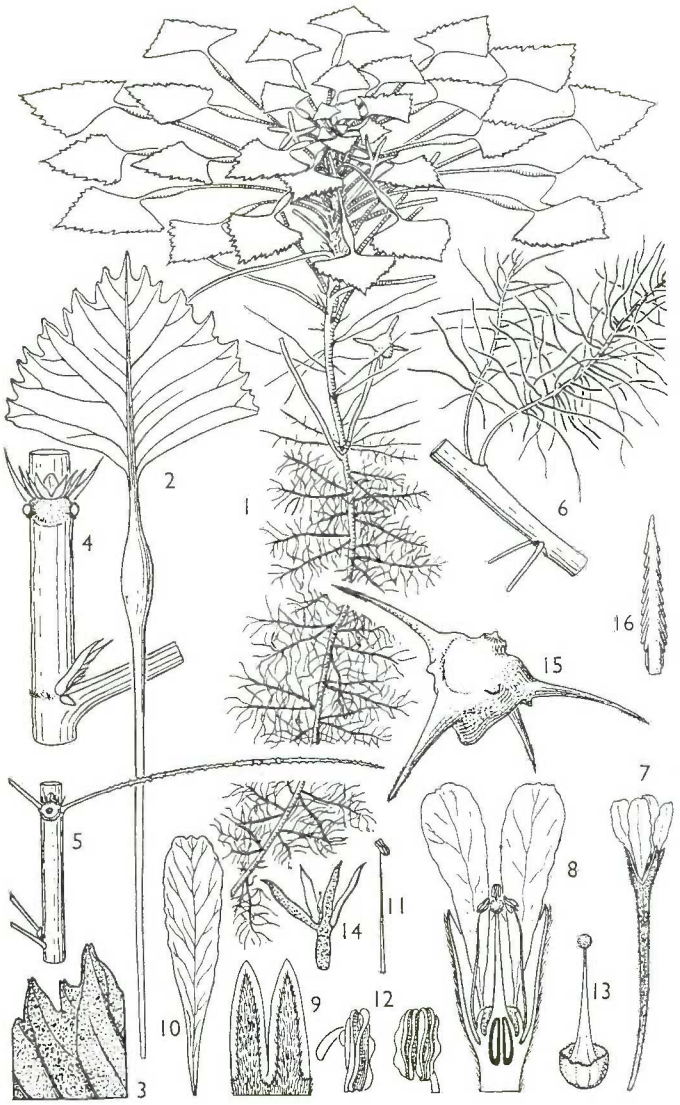


Figure 15
Trapa natans var. *africana*. 1: part of plant showing floating leaves and submerged adventitious roots. 2: floating leaf. 3: marginal part of leaf, lower side. 4: nodes showing stipules. 5: nodes showing first stage of adventitious roots. 6: nodes showing fully developed adventitious roots. 7: flowers. 8: longitudinal section of flower. 9: two sepals. 10: petal. 11: stamen. 12: anther, two views. 13: ovary and disc. 14: ovary and calyx enlarging after anthesis: 15: endocarp. 16: apex of one of the horns of the fruit.

Production and consumption/ utilization

Nuts are eaten raw, boiled, fried. preserved in honey and sugar, candied or ground into flour for making bread. A staple food for as much as five months of the year in Kashmir, where the starchy kernels are eaten raw (cv. Kota Sudhar), or cooked as a porridge (Howes, 1948; Hedrick, 1972; CSIR , 1976; Menninger, 1977; Rosengarten, 1984).

Nutritional value

Kernels are not particularly nutritious compared to other nuts, they contain *ca.* 70% moisture, 4.7% protein, 0.3% fat, 0.6% fibre and 3% protein (CSIR, 1976; Rosengarten, 1984).

By-products and other uses

Hard fruits (endocarp) are strung into necklaces (Menninger, 1977).

Marketing

Formerly widely eaten in southern Europe but its use has declined although still used in the Loire region of France and parts of Italy; still an important food in Asia where it is sold in the local markets. It has been introduced into North America and is naturalized in some areas, however, it is doubtful if it will become commercially important (Menninger, 1977; Rosengarten, 1984; Bianchini *et al.*, 1988).

Discussion

Little appreciated in the western world but obviously an important crop in Asia and its use should perhaps be encouraged in the lakes of East Africa.

STONE OR PARASOL PINE NUT OR PIGNOLIA: *Pinus pinea*, Pinaceae

Distribution and ecology

Northern Mediterranean region and Portugal; altitudes up to 1 000 m. Locally cultivated (Tutin *et al.*, 1964; Menninger, 1977).

Description

Evergreen, needle-leaved tree to 30 m, crown umbrella-shaped. Leaves borne in pairs, 10-20 cm long. Male and female reproductive structures, strobili, borne separately on the tree. Seeds borne in cones 8-14 cm x 10 cm, maturing in the third year; seeds 15-20 mm x 7-11 mm, wing less than 1 mm, caducous (Tutin *et al.*, 1964; Menninger, 1977).

Cultivation

Grown in pine groves. Unlike some species of *Pinus*, it does not hybridize readily with other species. A thin-shelled form is known in Italy where it is possible to break the shell with the fingers (Howes, 1948; Menninger, 1977; Rosengarten, 1984).

Harvesting

Green cones are harvested by pickers armed with long hooked poles and piled into heaps to dry in the sun in order that the cone scales may open and loosen the seeds. The harvest can last from autumn to spring without any problems as the nuts store very well in their cones on the tree (Menninger, 1977; Rosengarten, 1984).

Post-harvest treatments

Nuts are extracted by beating the cones by hand or thrashed mechanically. The seeds are then dried before passing through a milling machine to separate the kernel from its hard outer covering. The kernels and shells are then sorted by sifting, after which the testa is removed from the kernel. Kernels are graded according to size (Menninger, 1977; Rosengarten, 1984).

Production and consumption/ utilization

Pinus pinea is the largest producer of pine nuts commercially; known as pignolias (English), pignons (France), piñones (Spain) or pinoli (Italy). Both the large and small, superior, unblemished, shelled kernels are packed for export. Pine nuts may be eaten whole, either raw or roasted; the shell cracked by the teeth and spat out; usually marketed without their shells. Nuts may be made into flour for cakes, pressed into sweetmeats and used to garnish pastries, etc. (Menninger, 1977; Rosengarten, 1984).

Nutritional value

Pine nuts contain 47.4% fat, 11.6% carbohydrates, 31.1% protein, 4.3% ash, 0.9% fibre and an energy value of 556 Kcal. per 100 kg (Farris, 1983).

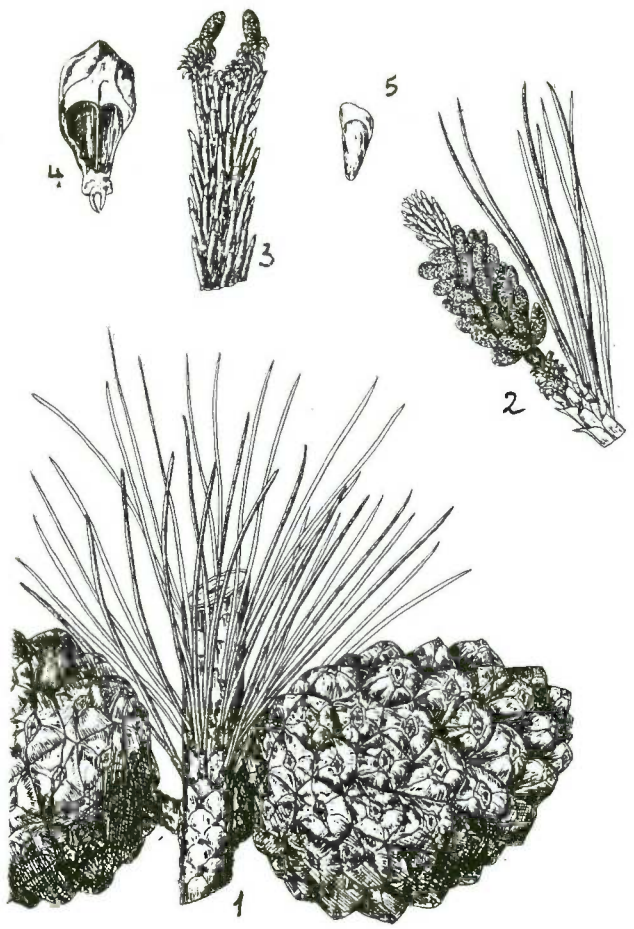


Figure 16
Pinus pinea. 1: branch with mature cones. 2: male inflorescence. 3: female inflorescences. 4: scale. 5: winged seed.

By-products and other uses

Broken nuts are source of oil used for making soap. It is also a source of timber. Cultivated as an ornamental tree (Menninger, 1977; Rosengarten, 1984).

Marketing

Figures for world production are not available. In USA, between 1976 and 1980 an annual average of *ca.* US$ 800 000 worth of pine nuts were imported of which 41% were pignolias from Portugal and 27% from Spain while China supplied 26% from *P. koraiensis*. The imported nuts from *P. pinea* rank second to macadamia nuts as being the most costly, while the Chinese pine nuts are less expensive and inferior to those from Europe. They are becoming increasingly important in the American market. The unspecified uneven supply of indigenous pine nuts in USA certainly favours the more reliable importations (Rosengarten, 1984; Prescott-Allen and Prescott-Allen, 1986).

Discussion

The other species of *Pinus* with edible seeds have been largely neglected due to establishment of *P. pinea* as the prime source of pine nuts for the past 2 000 or more years. The Colorado pine, *P. edulis*, is an additional important source of pine nuts in USA, while those of *P. sabiniana*, a relatively little known species from California, have been demonstrated as having

very similar nutritional properties to pine nuts from *P. pinea* and, if developed, could be a strong contender for the pine nut market (Farris, 1983; Prescott-Allen and Prescott-Allen, 1986). Doubtless further research will reveal other possible species for commercial plantations with high-yielding cultivars throughout North America and elsewhere.

POTENTIAL EDIBLE NUTS 4

There are a number of species producing edible nuts that are relatively little known and appear to have a potential for development. From past experience, an in-depth investigation of a species requires a minimum of one month's work spread over several months in order to allow time for exchange of correspondence, obtain obscure literature references, etc.; laboratory investigations are not included in this estimate (Lucas and Wickens, 1988). The discussion that follows on potential nut species will therefore be confined to the limited literature available and bearing in mind that the primary sources have not been consulted.

The Bambara and Hausa groundnuts, *Macrotyloma geocarpum* and *Vigna subterranea*, although being classified with the groundnut, *Arachis hypogea*, as nut-bearing plants are not further considered here since they are regarded as agricultural crops and their development lies with agronomists and not silviculturalists. However, they are entered in Appendix A.

The trees and shrubs bearing edible nuts listed below are provisionally considered worthy of further investigation. The selection is somewhat arbitrary and is initially based on the available data presented in Appendix A. Doubtless further investigation could reveal additional and possibly more suitable species.

marula or maroela	*Sclerocarya birrea* subsp. *caffra*, Anacardiaceae
Guyana or Malabar chestnuts or saba nuts	*Pachira aquatica,* Bombacaceae
Java almond, kanari or galip nut	*Canarium indicum*, Burseraceae
pequí; piquí or piquia-oil plant	*Caryocar brasiliense*, Caryocaraceae
castanha de galinha	*Couepia longipedula*, Chrysobalanaceae
Indian or tropical almond	*Terminalia catappa*, Combretaceae
okari nut	*Terminalia kaernbachii,* Combretaceae
cacay, inchi, tacay, taccy, nogal, etc., nuts	*Caryodendron orinocense,* Euphorbiaceae
cream, paradise or sapucaia nut	*Lecythis pisonis*, Lecythidaceae
yicib, ye-eb or yeheb	*Cordeauxia edulis*, Leguminosae
tara	*Lemuropisum edule,* Leguminosae
galo or promising nut	*Anacolosa frutescens,* Olacaceae:
avellano or Chilean nut or hazel	*Gevuina avellana,* Proteaceae
quandong or native peach	*Santalum acuminata,* Santalaceae
argan	*Argania spinosa*, Sapotaceae:
shea butter tree	*Vitellaria paradoxa*, Sapotaceae
bitter cola, kola nut	*Cola nitida*, Sterculiaceae
sugar plum, areng palm, ejow, gomuti, kaong	*Arenga pinnata,* Palmae
tucumá	*Astrocaryum vulgare*, Palmae
peach plum, palm chestnuts, pupunha, etc.	*Bactris gasipaes*, Palmae
babassu, babacu palm or aguassú	*Orbignya phalerata,* Palmae

MARULA OR MAROELA: *Sclerocarya birrea* subsp. *caffra*, Anacardiaceae

Distribution and ecology

Angola, Zaire and Kenya to Namibia, Transvaal and Natal, also in Madagascar. Mixed deciduous woodland and wooded grassland (Kokwaro, 1986).

Description

Dioecious, deciduous tree to 18 m. Leaves alternate, imparipinnate, leaflets 7-13(-17). Inflorescence appearing before the leaves. Fruit an obovoid drupe 3.5 cm long, 3-3.5 cm in diameter, yellow, with strong odour when ripe; mesocarp very juicy; stone obovoid, 2-3 cm long, 2.5 cm in diameter, hard; seeds (1-)3(-4), 1.5-2 cm long, 0.4-0.8 cm wide (Arnold *et al.*, 1985; Kokwaro, 1986).

Cultivation

Seeds soaked overnight prior to sowing. Propagated by seedlings and cuttings, gregarious root suckering (von Maydell, 1986 re subsp. *birrea*). Trees set fruit after 3 years in Israel (Cherfas, 1989).

Harvesting

A single female tree can yield 2 100-9 100 fruits in a season, fruits falling while still green and ripening on the ground (Arnold *et al.*, 1985).

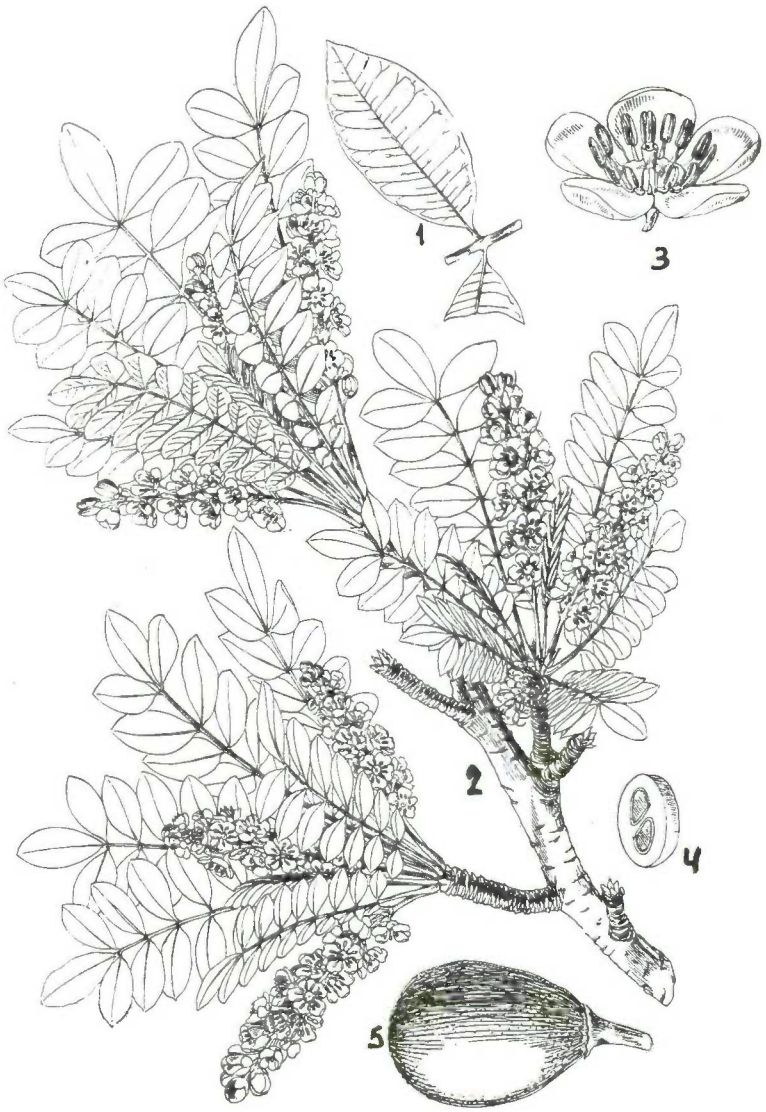


Figure 17
Sclerocarya birrea subsp. *caffra*. 1: leaflet showing venation. 2: habit. 3: flower. 4: cross section of ovary. 5: fruit.

Post-harvest treatments

Fruits cannot be stored for more than a week, they bruise easily and therefore are difficult to transport. The Venda mix the kernels with lean meat, shape into cakes and dry for storage (FAO, 1988).

Production and consumption/utilization

Fruit skin is hard and bitter, flesh has a turpentine-mango flavour although flavour is reported to vary from tree to tree, some sweet, some dry, others aromatic; flesh is eaten fresh or dry, made into jams and jellies; it is source of an alcoholic beverage, also non-alcoholic fruit juices; the juice sometimes thick and grainy, others more liquid depending on the fruit; the juice is often source of 80% of the vitamin C in the local diet; kernels difficult to extract, with hazel-like flavour, eaten; seed oil expressed and used by the Venda to preserve meat for up to a year; fermented fruit liked by elephants (Menninger, 1977; Arnold *et al.* 1985; Cherfas, 1989).

Subsp. *birrea* from northern tropical Africa bears fruits which are similarly utilized. Unripe kernels reported to be milky and have flavour of groundnuts (Menninger, 1977).

Nutritional value

Kernels are highly nutritious, with 28.3% protein, 57.3% oil, high in minerals, especially magnesium, iron, copper, zinc and phosphorus, with 462, 4.87, 2.81, 5.19 and 808 mg per 100 g respectively and an energy value of 2 703 kJ per 100 g (Arnold *et al.*, 1985).

By-products and other uses

Timber is soft, coarse grained, not very durable, used for pestles and mortars, bowls, furniture, saddles and carvings; bark is a source of fibre, gum exudate is mixed with soot for a black ink. The species is grown for shade and as an ornamental tree (FAO, 1988).

Marketing

Sold in the local markets.

Discussion

A high-yielding tree with nutritious fruit, but the small kernel and the difficult extraction from the stone make it an unlikely commercial proposition as far as the kernels are concerned, although worthy of development for its fleshy fruits.

GUYANA OR MALABAR CHESTNUT OR SABA NUT: *Pachira aquatica,* Bombacaceae

Distribution and ecology

Probably originated in the Amazon estuary, now widely distributed through the whole of northern South America and the Antilles, either naturally or by man; widely cultivated in the tropics. Occurs naturally on sparsely vegetated, marshy riverine, clay soils; also grows well on sandy or sandy-clay soils of terra firma. Flowering and fruiting throughout the year. Drought resistant, it tolerates a wide range of temperatures and humidity (Menninger, 1977; FAO, 1986).

Description

Evergreen tree up to 10(-23) m tall, trunk 25-60 (-90) cm in diameter. Leaves pedately palmate, clustered towards the ends of branches. Flowers bisexual, solitary or 2-3, terminal.

Fruit an oblong-ellipsoid capsule, 12-30 cm long, 10-20 cm in diameter, woody, 5-valved, dehiscent; pericarp rather thick, spongy and fibrous; seeds 10-25, globular, 1.2-3 cm in diameter (Menninger, 1977; FAO, 1986).

Cultivation

Grown from seed, with germination in 6-8 days with rapid initial growth; also grows readily from truncheons. First flowers produced in 4-5 years. Flowering and fruiting throughout the year (FAO, 1986; Arkoll and Clement, 1989).

Harvesting

Nuts may be left on the ground to dry in the sun but must be protected from showers as they sprout readily (Menninger, 1977).

Post-harvest treatments

No information.

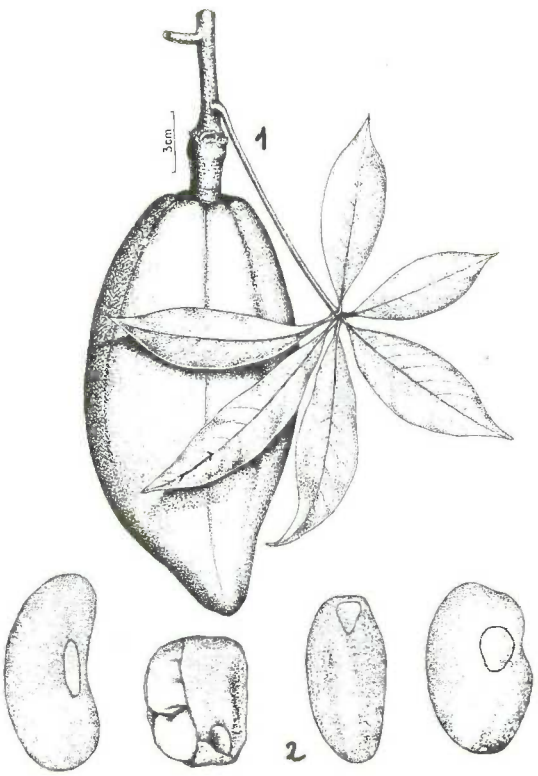


Figure 18
Pachira aquatica. 1: leaf and fruit. 2: seeds

Production and consumption/utilization

Only the seeds are edible, chestnut-flavoured; eaten raw, roasted or fried in oil; after roasting, seeds taste like cocoa and are sometimes used for the preparation of beverages. Regarded as a useful supplement to the diet in many regions. Seeds yield 58% of a white, inodorous fat which, when refined, is suitable for cooking (Kedrick, 1972; Menninger, 1977; Burkill, 1985; FAO, 1986; Mabberley, 1987; Arkoll and Clement, 1989).

Nutritional value

Seed contains 9% water, 10% starch, 16% protein and 40-50% fat; the yellow fat possesses physical and chemical characteristics resembling those of palm oil but containing toxic and possibly carcinogenic cyclopropenic fatty acids (Burkill, 1985; Arkoll and Clement, 1989).

By-products and other uses

Seed oil with industrial potential for manufacturing soap. Young leaves and flowers are eaten as a vegetable. Wood is white and soft, suitable for manufacturing paper, yielding 36% cellulose paste. Bark is used for caulking boats and cordage and yields a dark red dye. Bark is also used medicinally to treat stomach complaints and headaches while a tisane from the boiled bark is used for blood tonic. Suitable for live fence posts and street trees, it is also planted as an ornamental species (Hedrick, 1972; FAO, 1986; Arkoll and Clement, 1989; Barrett, 1994).

Marketing

No information, presumably traded locally.

Discussion

A potentially useful, easily cultivated tree producing big fruits containing large quantities of nuts. However, toxicological studies will be required before this species can be recommended for wider distribution and use. Indeed, such studies are required for all new food plants.

JAVA ALMOND; KANARI OR NGALI NUT: *Canarium indicum*, Burseraceae

Distribution and ecology

Indonesia, Papua New Guinea, Solomon Islands and surrounding islands; often cultivated in Melanesia and elsewhere in the tropics, especially Java. Naturally found in low altitude rain forests, but cultivated up to 600 m (Howes, 1948; Verheij and Coronel, 1991).

Description

Tall, buttressed, deciduous tree to 40 m tall. Leaves with 3-7 pairs of leaflets, leaflets oblong-ovate to oblong-lanceolate, 5.5-28 cm x 2-11 cm, herbaceous to coriaceous, base oblique to broadly cuneate, apex bluntly acuminate. Inflorescence terminal, laxly paniculate. Drupe ovoid, slightly triangular in cross section, 3-6 cm x 2-3 cm, green, turning black when ripe; endocarp hard, thin and brittle, *ca.* 3 g, seeds 3 or 1 by abortion in cultivated trees. (Howes, 1948; Leenhouts, 1956; Verheij and Coronel, 1991; Macrae *et al.*, 1993).

Figure 19
Canarium indicum. 1: branch with leaves and flowers, 2: fruit.

Cultivation

Propagated by seed. Asexual reproduction by patch-budding, as recommended for *C. ovatum* should also be tried (see under Minor nuts).

Harvesting

In Moluccas leaves shed when fruit ripe and bunches of fruit then clearly visible. Trees climbed and fruit beaten down with sticks (Howes, 1948).

Post-harvest treatments

Treatment presumed to be as described for *C. ovatum* (see under Minor nuts). Pulp is removed by hand after soaking in water for 2-3 days, less if water heated to 40-50°C. Nuts are thoroughly washed, any floating nuts are discarded. Nuts are sun-dried and bagged for

storage. Kernels are extracted by hand, washed in warm water to loosen the testa before removal by hand.

Production and consumption/utilization

After removal of testa the oily "pili" nuts (seeds) eaten raw or roasted, may be used as an almond substitute, eaten in Sri Lanka as a dessert nut, made into bread in the Celebes, highly esteemed in Melanesia where several races are cultivated; a strained emulsion of crushed, well-ripened seeds may be used as milk substitute for infants. Seed oil is used as a substitute for and usually preferred to coconut oil for cooking; fresh seed oil mixed with food (Howes, 1948; Leenhauts, 1956; Hedrick, 1972; Menninger, 1977; Verheij and Coronel, 1991; Macrae *et al.*, 1993).

Nutritional value

Nut contains 70-80% oil, 13% protein, 7% starch (Howes, 1948; Macrae *et al.*, 1993).

By-products and other uses

Shells are used for carvings. Seed oil also used as an illuminant. Wood is soft, mainly used for firewood, also for canoes. Grown as a shade tree, especially for nutmeg groves, roadside or street tree (Howes, 1948; Leenhauts, 1956; Verheij and Coronel, 1991).

Marketing

Nuts do not keep well, consequently not suitable as an export crop.

Discussion

Highly esteemed for food in Melanesia (Verheij and Coronel, 1991). If the nut production is to be expanded in Southeast Asia, there is a need to develop mechanization for nut extraction in addition to selecting elite trees.

PEQUÍ, PIQUÍ, PIQUIA-OIL PLANT: *Caryocar brasiliense*, Caryocaraceae

Distribution and ecology

Brazil, extending westwards from the state of Maranhão to Bolivia, eastern Paraguay to northern Argentina, it forms pure groves in the plateaux and valleys of the cerrado, elsewhere usually scattered individuals. Adapted to nutrient poor, heavy clays, especially iron and aluminium rich soils in areas with an annual rainfall of 1 000-1 500 mm and 3-5 months dry season with a relative humidity as low as 13% (FAO, 1986; Dantas de Araujo, 1995).

Description

A twisted, small tree or shrub or suffrutex to *ca.* 10 m tall, trunk *ca.* 30 cm in diameter and a deep taproot; crown spreading, to 10 m in diameter. Leaves 3-foliate, leaflets elliptic-ovate, up to 18 cm x 12 cm, apex and base rounded. Inflorescence a terminal raceme. Fruit irregularly ovoid-globose, 4-5 cm in diameter, usually 1-locular, 4-5 cm in diameter, occasionally 2-locular and larger; exocarp more or less smooth; pericarp thick, fleshy and ± attached to the mesocarp, the mesocarp and endocarp enveloping the seed to form an oval

stone *ca.* 2.5-3 cm in diameter; mesocarp surface smooth, interior with thin, hard, woody, endocarp spines up to 2-3 cm long; kernel white, oily (FAO, 1986; Dantas de Araujo, 1995).

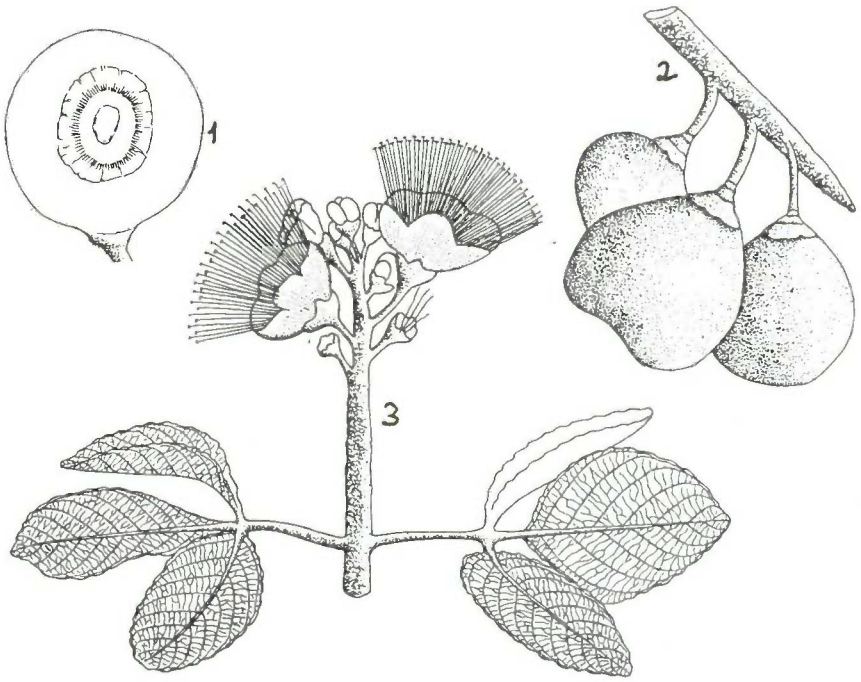


Figure 20
Caryocar brasiliense. 1: longitudinal section of fruit. 2: fruiting branchlet. 3: leaves and inflorescence.

Cultivation

Seeds may take one year to germinate; stratification of the endocarp with mesocarp removed is recommended. Good results obtained from grafting and marcottage. Irrigation in the nursery essential. Seedlings can be planted out when 25 cm tall. Growth is slow but the trees show good response from irrigation and fertilizers. After 5 years non-irrigated plants are 25 cm tall while irrigated plants may attain 3 m (FAO, 1986; Dantas de Araujo, 1995).

Harvesting

Despite their accessibility, the difficulty in determining the ripeness of the fruit results in fallen fruit being usually gathered. Large trees may yield up 2 000 fruit (FAO, 1986; Dantas de Araujo, 1995).

Post-harvest treatments

No information.

Production and consumption/utilization

The oily, mucilaginous fruit is nutritious, eaten as a famine food. Mesocarp is oily, sweet but acquired taste, eaten, mainly used as a flavouring, laxative; source of an edible oil, used to flavour the alcoholic liqueur, lico de piquí; kernel rarely eaten because of endocarp spines; source of an edible oil mainly used for flavouring (Hedrick, 1972; Menninger, 1977; FAO, 1986; Clay and Clement, 1993; Dantas de Araujo, 1995).

Nutritional value

No information regarding nutritional value of the kernels. Mesocarp contains 81% water, 2.7% protein, 8% fats and oils (dry pulp *ca.* 42% oil), 1% ash, 6.7% carbohydrates; 120 mcg carotene, also rich in vitamin C, thiamin, riboflavin and niacin (FAO, 1986).

By-products and other uses

Kernel oil used in the cosmetic industry and locally for making soap, as an illuminant, lubricant. Wood used for construction, wooden machinery parts, furniture, fences, fuelwood and charcoal. Flowers, fruits and seeds used in local medicine. Leaves, bark and fruit pulp a tannin source. Tree grown as an ornamental (FAO, 1986; Dantas de Araujo, 1995).

Marketing

Sold in the local markets for local oil and soap making (Dantas de Araujo, 1995).

Discussion

Currently being over-exploited due to an increase in restaurants serving regional food and small-scale oil production industries. Potential as an oil crop for the drier regions of the world, being well-adapted to nutrient poor soils and long dry seasons. Local demand will have to be met by developing plantations of improved stock, better management of wild stock, including possible improvement by grafting from elite trees. There is a need for improved germplasm for larger fruit, higher oil yields. The high melting point of the kernel oil may have a potential as a cocoa butter substitute (FAO, 1986; Dantas de Araujo, 1995).

CASTANHA DE GALINHA: *Couepia longipendula*, Chrysobalanaceae

Distribution and ecology

Occurs throughout central and western Amazonia and the western Guiana shield. Adapted to heavy, infertile, clay oxisols of lowland rainforests, also occurring in periodically inundated, low lying areas (FAO, 1986; Clay and Clement, 1993; Prance, 1972, 1994).

Description

Large tree to 30 m or more high, trunk up to 1.8 m in diameter. Leaves simple, oblong elliptic to lanceolate, up to 16 cm long and 7.5 cm wide. Inflorescence of pendulous panicles of bisexual, white flowers. Fruit obovoid to ellipsoid drupe, 4-6 cm long, 4 cm in diameter, pubescent; epicarp peeling to reveal hard, woody, fibrous, 6 mm thick pericarp; seed with white to light green kernel, 3 cm long, 2 cm wide, testa thin, pubescent, surrounded by a thin membrane (FAO, 1986; Clay and Clement, 1993; Prance, 1972, 1994).

Cultivation

Occasionally cultivated, especially around Manaus; more commonly protected when swidden is opened up. Seeds germinate within weeks of falling from tree onto moist ground; viability is rapidly lost and seeds do not store easily. Early growth is rapid, later slowing and tree attaining 2-3 m in height when 4-5 years old and producing first flowers. Trials are being carried out with fertilizers and shade in order to try and overcome slow early growth (Prance, 1971; FAO, 1986; Clay and Clement, 1993).

Harvesting

Fallen mature fruits must be quickly harvested before they can germinate, rot or removed by small rodents and wild pigs; sometimes plucked from small trees. Trees *ca.* 20 years old and

7 m high yield over 1 000 nuts per year, mature trees will yield over 100 kg; kernels weigh 4-7 g and represent *ca.* 30% of the whole nut (FAO, 1986; Clay and Clement, 1993; Prance, 1994).

Post-harvest treatments

Seeds (nuts) easily extracted from the mesocarp with a knife. Dry nuts can be stored for several months but rapidly deteriorate under moist conditions and high temperatures (FAO, 1986).

Production and consumption/utilization

Kernels nut-like and eaten roasted or pounded and mixed with sugar and cassava flour which has a pleasant flavour resembling Brazil nuts and pomegranate pips when fresh, a Brazil nut-like flavour after short storage, date-like after a few weeks if stored moist or months if stored dry, eventually becoming rancid. Kernels also utilized by local people to extract an oil for use in cooking; seed cake slightly sweet, used in local pastries (FAO, 1986; Clay and Clement, 1993; Prance, 1994).

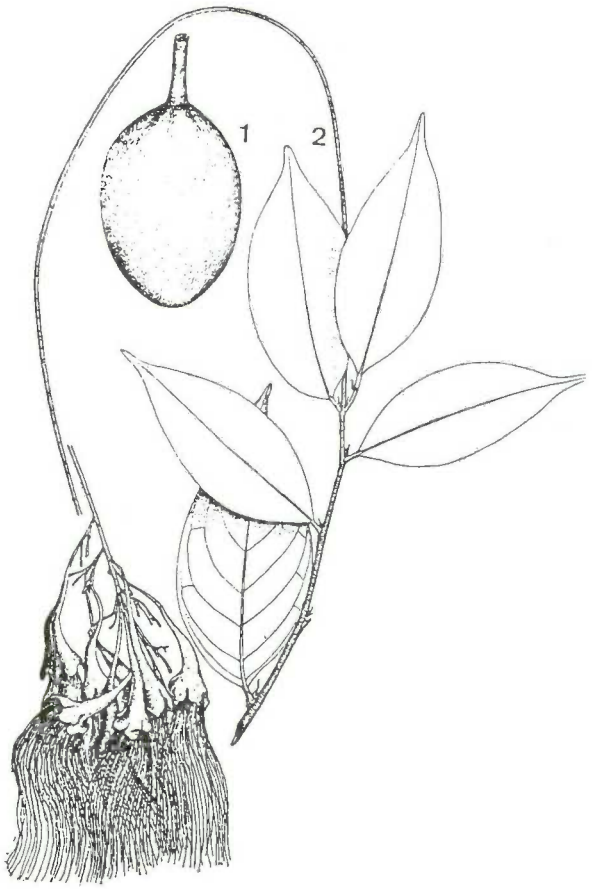


Figure 21
Couepia longipendula. 1: fruit. 2: leaves and flowering branchlet.

Nutritional value

Kernels are a rich source of energy and protein, containing 18% moisture when harvested and 75% of a light greenish-yellow semi-drying oil that quickly turns rancid. Oil residues contain 32.5% protein, 10.6% fibre and 8% ash (FAO, 1986; Clay and Clements, 1993).

By-products and other uses

Seed oil also used for soap-making. Timber heavy, hard and difficult to work, used for building, carpentry and roofing tiles. Bark source of a rough fibre. Bark and pericarp extracts used in local medicine (FAO, 1986; Prance, 1994).

Marketing

Nuts collected from the wild and used in rural areas. Surprisingly the nuts rarely found in the local markets despite their local abundance in the forests, their high yields and popularity. A market needs to be created (FAO, 1986; Clay and Clement, 1993).

Discussion

Considered worthy of future domestication (Prance, 1994). Possibility being investigated of growing the tree for nuts before cutting for hardwood (FAO, 1986).

INDIAN OR TROPICAL ALMOND: *Terminalia catappa,* Combretaceae

Distribution and ecology

Malesia and western Pacific seashores; cultivated and sometimes naturalized throughout the tropics and near-tropics. A gregarious pioneer species of sand banks and shores. Salt and drought tolerant but intolerant of wind and frost (Exell, 1954; FAO, 1982; Rosengarten, 1984; Morton, 1985).

Description

A deciduous or sometimes semi-evergreen tree to 15(-25) m tall with trunk to 1.5 m in diameter, often buttressed. Leaves alternate, obovate, 15-36 cm long, 8-24 cm wide, subcordate at the base and usually with 2 glands, petiole short; leaves turning red before falling and quickly replaced. Inflorescence spicate, male flowers towards the apex with hermaphrodite flowers below; flowers greenish, apetalous. Fruit a somewhat compressed-ellipsoid drupe, 4-7 cm long, 2.5-3.8 cm wide, prominently keeled along the margins; epicarp thin, green turning yellow with a reddish blush; mesocarp fleshy, 3-6 mm thick, adherent to the fibrous husk of the hard-shelled stone containing the spindle-shaped seed; seed 3-4 cm long, 3-5 mm thick, testa very thin, brown, enveloping the coiled cotyledons or kernel (Exell, 1954; Rosengarten, 1984; Morton, 1985).

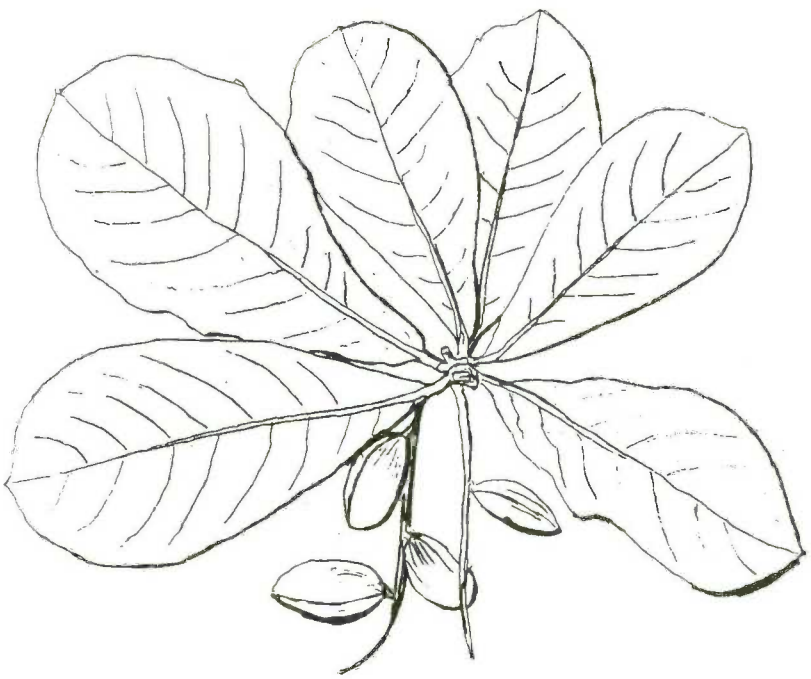


Figure 22
Terminalia catappa. Branchlet with leaves and fruits.

Cultivation

Sweet fleshed and more palatable fruits selected for cultivation. Seeds have good viability and germinate readily (25% germination) when raised in nurseries. Transplanted when seedlings leafless. Fertilizers can be beneficial. Growth rate 1 m or more in *ca.* 2 years (Morton, 1985).

Harvesting

Two crops a year possible in some areas or even more or less continuous fruiting. A tree may yield *ca.* 5 kg of kernels per year (Morton, 1985).

Post-harvest treatments

Fruit hard, difficult to crack, kernels extracted by cracking the defleshed and sun-dried nuts along the keel (Menninger, 1977; Morton, 1985).

Production and consumption/ utilization

Outer flesh commonly eaten by children. Kernels may be eaten raw or roasted, or used in cooking as an almond substitute. Sun-dried kernels yield 38-54% of an edible, bland, yellow, semi-drying oil known as Indian almond oil, which becomes turbid and rancid on standing (Howes, 1948; Hedrick, 1972; Rosengarten, 1984; Morton, 1985).

Nutritional value

Air-dried kernels contain 52.0% fat, 25.4% protein, 14.6% fibre, 6% glucose and a small percentage of ash. Indian almond oil contains glycerides of palmitic acid 34.4%, oleic acid 32.1%, linoleic acid 27.5% and stearic acid 6%; it closely resembles sweet almond, cotton seed, kapok and groundnut oils and could substitute for them for dietetic and industrial uses (Morton, 1985).

By-products and other uses

Oilcake used as pig feed. Kernel oil used for making soap but its industrial use is limited by the difficulty in extracting the kernel. Oil is also used medicinally as are also the leaves and bark. Leaves and bark astringent and variously used medicinally; leaves also sudorific if taken internally. Bark is a source of dye; bark (25% tannin), roots and green fruits (known as myrobalans) are used for tanning. Timber tough and fairly hard, durable in water although not durable in the ground, susceptible to drywood termites; used for construction, furniture, carpentry, carts, boats, plywood and pulp. Cultivated as an ornamental and shade tree (Exell, 1954; FAO, 1982; Rosengarten, 1984; Burkill, 1985; Morton, 1985).

Marketing

Fruit marketed locally.

Discussion

A multi-purpose tree suitable for selection and further development. If the kernel market is to expand an improved method for defleshing the fruits and extracting the kernel needs to be developed (Morton, 1985). The quality of the nut needs to be compared with that of the following, *T. kaernbachii*.

OKARI NUT: *Terminalia kaernbachii,* Combretaceae

Distribution and ecology

From New Georgia in the Solomon Islands through New Guinea to the Aru Islands of Indonesia; relatively common and frequently cultivated tree in the lowland rain forests up to 1 000 m altitude (Coode, 1969; Verheij and Coronel, 1991).

Description

Tree to 45 m with trunk up to 2.8 m in diameter, flange-buttressed up to 3 m; crown spreading; leaves clustered at end of branches, obovate-elliptic, narrowly obovate elliptic to obovate-oblong, 12-35 cm x 5-12 cm, base cuneate with 2 conspicuous black glands, apex rounded to acuminate. Fruit ellipsoid, more or less laterally compressed, 6.3-18 cm x 14.5-8.2 cm x 3.3-6.3 cm, apex slightly beaked, tomentose becoming glabrescent, plum red when ripe, slightly succulent; endocarp in cross-section with a broad band of very hard sclerenchymatous tissue including within it some large irregularly shaped and spaced air-chambers and a large cell containing the kernel; kernels white, varying in size from spindle shaped, 3 cm x 1 cm to size of small hen's egg; cotyledons 3-4, wrapped around each other (Exell, 1954; Coode, 1969; Macrae, 1993).

Figure 23
Terminalia kaernbachii. 1: branchlet with leaves and inflorescence. 2: branchlet with fruits.

Cultivation

Easily raised from seed, but viability soon lost; attempts to introduce seed into Hawaii failed. Because of its value as food for the local inhabitants the species is usually excluded from timber agreements (Verheij and Coronel, 1991).

Harvesting

Fruits picked from the trees or collected from the ground (Verheij and Coronel, 1991).

Post-harvest treatments

No information.

Production and consumption/utilization

Kernels the largest known in the Combretaceae, 1.5-10 g in weight, one of the best-flavoured of the tropical nuts and a favourite article of diet among the natives, almond flavoured, mild and pleasant, source of *ca.* 50 g of a sweet, colourless, non-drying, edible oil, considered less oily than *Canarium* (Exell, 1964; Coode, 1969; Menninger, 1977; Mabberley, 1987; Verheij and Corondel, 1991; Macrae *et al.*, 1993). Although Macrae *et al.* (1993) state that

it can be eaten raw it is uncertain as to whether it may be eaten raw without preliminary treatment as Morton (1985) states that, unlike *T. catappa,* all other species of *Terminalia* require preliminary washing and cooking.

Nutritional value

Kernel contains 12.5% protein and 70% fat (Morton, 1985).

By-products and other uses

Wood is used for furniture but not exploited due to value of the fruit (Exell, 1954; Verheij and Coronel, 1991).

Marketing

Marketed locally during the fruiting season (Verheij and Coronel, 1991).

Discussion

A little known species of which *T. okari* is regarded as a synonym by Morton (1985). Further studies are required regarding its value as a potential nut crop. Other species (see Appendix 1) also have edible kernels but this is said to be the best flavoured. Morton (1985) recommends the more widely distributed and introduced *T. catappa* as worthy of further development. Verheij and Coronel (1991) consider the species has a potential as a multipurpose species, grown for its edible kernels and ultimately for its timber.

CACAY, INCHI, TACAY, TACCY, NOGAL, ARBOL, ARBOL DE NUEZ, PAN DE CADA DIA OR ORINOCO NUT: *Caryodendron orinocense,* Euphorbiaceae

Distribution and ecology

Venezuela, Colombia and Ecuador in the headwaters of the Orinoco; plantations in Colombia and Ecuador. Thrives in areas with temperatures ranging between 12°C and 29°C and 800-5 000 mm annual rainfall and occurs on a wide range of soils at altitudes from sea level to 2 300 m. Tolerates a few months of mild drought and withstands brief waterlogging (Reckin, 1983; FAO, 1986).

Description

Tree to 20(-40) m tall with small, dense and flattened crown in wild or, under cultivation, to 15 m tall with large, rounded crown. Both monoecious and dioecious trees reported. Leaves elliptic, *ca.* 25 cm long, 10 cm broad, somewhat leathery. Male flowers in terminal racemes, female flowers in terminal panicles, wind pollinated. Fruit a dehiscent or sometimes semidehiscent, woody capsule, 3.7-6.5 cm long, 3.2-4.5 cm in diameter, pericarp thin and brittle, seeds 3, 3-sided (Reckin, 1983; FAO, 1986).

Cultivation

Seeds should be preferably sown within 10 days of harvesting, reputed to fail to germinate after 35 days; distribution of plants otherwise by potted seedlings or vegetative reproduction. Shade is required in the first year, followed by full exposure to the sun on transplanting when

ca. 50 cm high at onset of the following rainy season. Recommended spacing 6–10 m x 6–10 m; interplanting with *Azadirachta indica* and *Derris* spp. for source of ant-repellent insecticides is recommended (Reckin, 1983). In Colombia caterpillars are an extremely serious pest causing complete defoliation of the trees several times in a year (Clement and Villachica, 1994).

Plant growth is rapid, with fruiting usually in the seventh year when trees are *ca.* 7 m tall, although fruiting at 4–5 years has been reported. Average weight of nut is 8.5 g, attaining 12.5 g or more in superior selections. A 10 year old tree can yield 100-250 kg of nuts per annum, an old specimen has given *ca.* 800 kg. Potential for an annual production of 3 500-5 000 kg of oil per ha from trees bearing nuts with an oil content of 57% (Reckin, 1983; FAO, 1986).

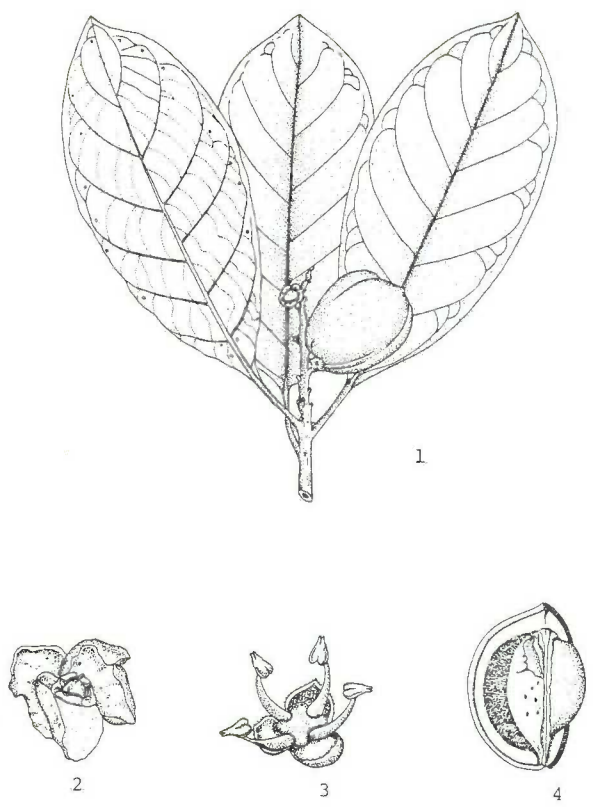


Figure 24
Caryodendron orinocense. 1: leaves and fruit. 2: female flower. 3: male flower. 4: longitudinal section of fruit to show seed.

Harvesting

Nuts ripen at the onset of the rains and either fall or are shaken off. They tend to ripen all at once and must be gathered quickly before they germinate, rot or are eaten by animals. A 10-year old tree can yield 50-90 kg of capsules per tree and large trees produce over 200 kg, although yields may vary considerably from year to year. A capsule consists of 42% seed and 29-36% edible kernel (Reckin, 1983; FAO, 1986).

Post-harvest treatments

Under dry conditions nuts keep for *ca.* 30 days in the capsule; shell damage or a moist environment can initiate enzyme reaction leading to acidification and rancidity of the oil. The nuts are easily separated from the thin shell and, when dried and roasted, they can be safely stored for a long time in sealed plastic bags (Reckin, 1983; FAO, 1986).

Production and consumption/utilization

Crushed nuts and milk fed to weaned children. Nuts have a pleasant flavour resembling hazel nuts. After removal of the leathery testa kernels are eaten raw, roasted, fried or ground for a drink or sweets. Nuts are source of an edible oil rich in linoleic acid (34.4%) and, once extracted, can be safely stored for a long time without turning rancid (Reckin, 1983; FAO, 1986).

Nutritional value

Kernel contains (33.7-)37.4-54% edible oil, 33.6% starch, 2.6% glucose, 20.0% protein, 4.5% crude fibre and 3.2% ash with a calorific value of 585 kcal per 100 g (Reckin, 1983). According to FAO (1986) the kernel contains 54-60% of a clear, light, edible oil containing 73% linoleic acid, 4% moisture and *ca.* 18% protein.

By-products and other uses

Grown as a shade tree for coffee and cacao in Colombia. Oil from shells, nuts and bark latex used as an illuminant. Nuts and oil an excellent cure for pulmonary complaints and dermatitis. Wood is not regarded as valuable or durable, used for furniture and excellent charcoal (Reckin, 1983; FAO, 1986).

Marketing

Nuts are sufficiently attractive to be sold in the local markets. Interest in Colombia in developing the crop to overcome the shortfall between existing production of edible oil and domestic demand (Reckin, 1983; FAO, 1986).

Discussion

The species is widely distributed and plantations established with little selection. Provenance surveys and trials are required for improved performance and to establish priority areas in the forest for genetic conservation (Reckin, 1983). Small germplasm collections exist at University of Naro and by Corporación Araracuara at San José de Guaviare, Colombia (Clement and Villachica, 1994). The reason for the annual variation in yield requires investigation and solution if the crop is to develop commercially.

CREAM, PARADISE OR SAPUCAIA NUT: *Lecythis pisonis*, Lecythidaceae

Distribution and ecology

Throughout Brazilian Amazonia, Colombia, Orinoco basin of Venezuela and the Guyanas; also cultivated. It occurs in the rain forest on fertile flood plains and tolerating several months of waterlogging as well as growing on the drier oxisols of terra firma, the latter at densities between 0.2-11 trees per ha. The minimum annual rainfall requirement is 2 000 mm (Prance and Mori, 1979; FAO, 1986; Macrae *et al.*, 1993).

Description

Tall deciduous tree, 30-40 m tall, trunk 60-80 cm in diameter. Leaves petiolate, simple, blade narrowly ovate to widely elliptic, 2.5-12 cm long, 1.5-5 cm wide, chartaceous to coriaceous. Flowers bisexual in small, terminal racemes. Fruit a large, woody, dehiscent, bell-shaped, pendent capsule up to 25 cm long; pericarp woody, 1-2 cm thick; a large operculum becomes detached at maturity, leaving the seeds (nuts) dangling by a slender, fleshy funicle until the funicle decays and allows the seeds to fall; seeds 30-40, irregularly oblong, resembling Brazil nuts but more rounded with thinner and softer shell, kernel white, creamy texture (Prance and Mori, 1979; Rosengarten, 1984; FAO, 1986; Mori and Prance, 1990; Macrae *et al.*, 1993).

Cultivation

Seeds germinate within 7-10 days and growth is rapid, attaining 60 cm after 1 year and 4 m after 5 years. Trees begin to bear when 8-10 years old. Flowering is sporadic, some trees bearing every other year, others at 5 year intervals. Yields may be 12-20 fruits in the first fruiting year, with 81 fruits reported 2 years later. Average seed weight 5.5 g, mature trees may yield *ca.* 80 kg annually. Average yield for mature trees on terra firma is less than 50 fruits per year, probably more on the fertile flood plains. There are no commercial plantations reported. Attempts at grafting sapucaia onto the closely related Brazil nut and *vice versa* have failed (Prance and Mori, 1979; Rosengarten, 1984; FAO, 1985; Clay and Clement, 1993).

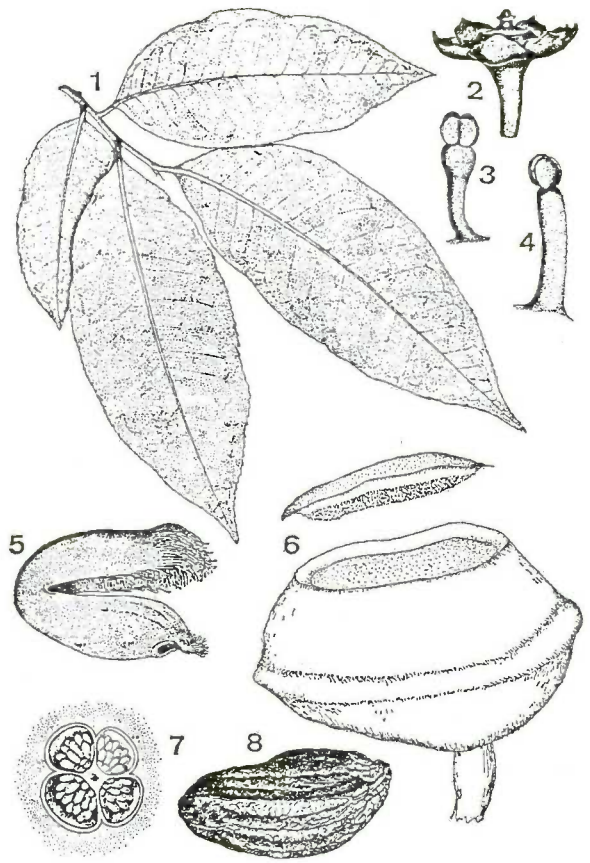


Figure 25
Lecythis pisonis. 1: leaves. 2: ovary. 3-4: stamens. 5: androecium. 6: fruit and operculum. 7: transverse section of ovary. 8: seed.

Harvesting

Fruit mature in *ca.* 18 months after flowering, when the capsule lid drops off, eventually releasing the nuts after the funicle has decayed. While suspended from the capsule the nuts are liable to be eaten by bats, parrots and monkeys, although less liable to predation around homesteads. The capsules remain attached to the tree for a long time before they too fall. The nuts can, with some difficulty, be cut down from the open capsules or gathered up from the ground, although in the latter case the majority of nuts are eaten by animals, especially monkeys and wild pigs. Average yield of nuts per tree is *ca.* 75 kg; fruit weigh 1-2.5 kg and contain 30-50 nuts, each weighing *ca.* 4-14 g. (Howes, 1948; Rosengarten, 1984; FAO, 1986; Clay and Clement, 1993).

Post-harvest treatments

Seed coat thin and offers little protection to disease and insects. Nuts laid on mats to dry; the kernels are rather moist and must be dried quickly, otherwise they do not store well (Howes, 1948; FAO, 1986).

Production and consumption/utilization

Kernels are delicious, and considered to have a superior sweet flavour to that of the Brazil nut, also more digestible; eaten raw, roasted or in confectionary, highly nutritious. Kernel yields a light yellow, almond flavoured, edible oil, the harmful seed coat being removed before extraction (Howes, 1948; Prance and Mori, 1979; Rosengarten, 1984; FAO, 1986; Macrae *et al.*, 1993).

Nutritional value

Nuts contain 60% kernel. Highly nutritious, kernel contains 60% dry matter consisting of 51-64% oil, 16% protein, 8% fibre, 4.2% ash. Seeds likely to contain toxic quantities of selenium when grown on soils high in selenium (Prance and Mori, 1979; FAO, 1986).

By-products and other uses

Oil used locally for making soap and as an illuminant. The capsules (monkey pots) are used for domestic utensils; when tethered and baited with sugar they are used to trap monkeys who, when disturbed, are unable to open and withdraw their hands. Nuts fed locally to chickens (the vernacular "sapucaia" means chicken). The wood is not extensively used as it is tough and difficult to work; used for railway sleepers, roofing shingles, construction and general carpentry. The tough and fibrous bark consists of a succession of thin layers which can be peeled off and used locally as cigarette wrappers. Infusions of bark and pericarp used in local medicine for liver complaints. Cultivated as an ornamental (Howes, 1948; Prance and Mori, 1979; Rosengarten, 1984; FAO, 1986).

Marketing

Marketed locally (Howes, 1948).

Discussion

The enormous loss of nuts to animals has limited the exploitation of nuts from the wild. If sufficient quantities were available at the right price there would be a potential in the confectionery nut industry. Shell of fresh nuts reputed to contain a toxic substance which may affect its commercial exploitation for extracting the edible oil. There is a possibility of nut and timber production from the floodplains but more information is first required on growth rates and production (Howes, 1948; Rosengarten, 1984; FAO, 1986). Selection for high and consistent yields is required.

YICIB (new Somali orthography), YE-EB OR YEHEB: *Cordeauxia edulis,* Leguminosae subfamily Caesalpinioideae

Distribution and ecology

Central Somalia extending into the Ogaden of Ethiopia, in semi-arid scrub; intolerant of waterlogging. Introduced on an experimental scale to Israel, Kenya, Tanzania, Sudan, Yemen and USA for trials. The plantation established near Voi, Kenya is largely neglected but, due to the Somali political situation, is currently the sole source of germplasm. Grows in Somalia at 100-1 000 m altitude on coarse, deep red sands with a water table at 6.5-25.5 m. The daily temperature is in excess of 25°C and the mean annual temperature 26.3-30°C. The mean annual rainfall is 85-400 mm, bimodal with the two rainy seasons of varying reliability (Baumer, 1983; Wickens and Storey, 1984; Booth and Wickens, 1988; FAO, 1988).

Description

Many-stemmed, evergreen shrub to 2.5(-4) m tall with deep taproot. Leaves paripinnate, leaflets (1-3)4(5-6) pairs, with numerous red glands below. Flowers bisexual, yellow. Fruit

a 1-4-seeded indehiscent pod, 4-6 cm long, shell fragile; seeds (nuts) globose to ovoid, *ca.* 12 mm in diameter (Baumer, 1983; Wickens and Storey, 1984; Booth and Wickens, 1988; FAO, 1988).

Cultivation

Only recently subjected to domestication. Early aerial growth slow until the massive root system is established. Nodulation observed on young plants but rhizobia not identified. Good germination with fresh seed, low viability if kept for a few months; however, seeds coated in wood ash and stored in a sack are reputed to remain viable for at least a year. Vegetative propagation possible. Direct seeding is recommended as problems exist with moving seedlings from nursery due to rapid tap-root development - in Israel roots 15 cm deep developed with only 1 cm of aerial growth.

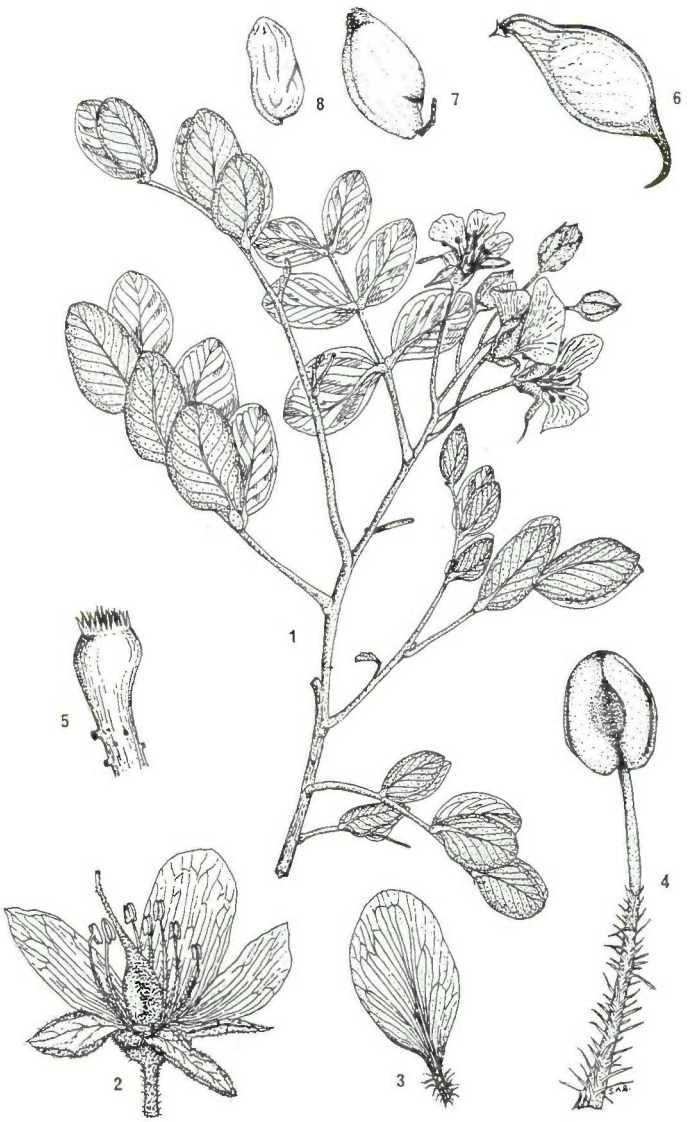


Figure 26
Cordeauxia edulis. 1: flowering branch. 2: flower, partly dissected. 3: petal. 4: stamen. 5: apex of style and stigmas. 6: fruit. 7: fruit (nut). 8: seed with outer coat removed.

Shrubs begin to bear well after 3-4 years. Water harvesting techniques will increase yields, however humid conditions will result in only vegetative growth. Depending on the rainfall, fruits can develop within 2 weeks from the start of the rains; fruit development is arrested when the rainfall ceases and is completed 4-5 months later when the rains start again. Note, these observations refer to Somalia where the rainfall is bimodal (Baumer, 1983; Wickens and Storey, 1984; Booth and Wickens, 1988; FAO, 1988; Cherfas, 1989; Aronson *et al.*, 1990).

Harvesting

Yield *ca.* 5 kg of seeds per shrub. Such is the demand and free access to all range plants that the fruits often collected from the shrubs before they are fully mature (Wickens and Storey, 1984; Booth and Wickens, 1988; FAO, 1988).

Post-harvest treatments

Pods are opened and seeds roasted or boiled before storage to kill any insects present and to harden the shell against further insect attack (Baumer, 1983; Wickens and Storey, 1984; Booth and Wickens, 1988; FAO, 1988).

Production and consumption/utilization

Can be the sole sustenance in times of dearth. The delicious, chestnut flavoured seeds may be eaten raw, roasted or boiled as a vegetable; seeds may also be boiled for a sweet liquor (Menninger, 1977; Wickens and Storey, 1984; FAO, 1988).

Nutritional value

Seeds nutritious, with *ca.* 13% protein, 37% carbohydrates, *ca.* 11% fat, *ca.* 24% sugars; protein rich in lysine; fat a mixture of the saturated acids: 26-32% palmitic, *ca.* 12% stearic and the unsaturated acids *ca.* 32% oleic and 25-30% linoleic. A trypsin inhibitor is present which is inactivated on cooking. The energy value, 446 Kcal per kg, is twice that of the carob, *Ceratonia siliqua*, and as much as that of soya, *Glycine max* (National Academy of Sciences, 1979; Baumer, 1983; Wickens and Storey, 1984; Booth and Wickens, 1988; FAO, 1988).

By-products and other uses

A tea is brewed from the leaves. Browsed by sheep, goats and camels; when eaten as the sole diet it is reputed to cause intestinal disorders in goats. The bones of browsing animals become pink caused by cordeauxiaquinone, a brilliant red dye which is unknown elsewhere in the plant kingdom. Cordeauxiaquinone produces fast, insoluble dyes with some metals and is used as a mordant in dyeing factories. The wood is used for firewood ((Wickens and Storey, 1984; Booth and Wickens, 1988; FAO, 1988).

Marketing

Marketed locally with production less than demand. The yicib has the potential for development as a food resource for the semi-arid regions and a very high potential as a dessert crop (Booth and Wickens, 1988).

Discussion

The agronomy is little understood. There is an urgent need for a survey of the genetic potential and establishment of gene bank and provenance trials of this potentially very desirable food species. The long term effect of cordeauxiaquinone on human teeth and bones requires investigation (Booth and Wickens, 1988).

TARA: *Lemuropisum edule,* Leguminosae subfamily Caesalpinioideae

Distribution and ecology

Native to south west Madagascar; the precise distribution is not known due to difficulty of access but apparently confined to two disjunct populations some 60 km apart, from near Itampolo and around Lake Tsimanampetsotsa. It appears to be confined to the exposed

seaward facing rocky limestone escarpment and the sandy soils immediately below, growing at altitudes between 15-100 m.

The local rainfall is bimodal, very erratic, with an annual average less than 400 m; the average temperatures of 27.4°C in summer and 19.9°C in winter. The species is currently under investigation as a potential nut crop in Western Australia (Willing,1989).

Description

Unarmed, multistemmed, much branched, spreading shrub up to 4-6 m tall, crown dense, branchlets sometimes spine-like. Leaves sparse, semi-persistent, paripinnate, with 1-4 pairs of oval to suborbicular leaflets, 3.5-6 mm wide. Inflorescence a raceme; flowers bisexual, with 4 white petals and 1 tinged yellow. Fruit pendent, subcylindric, depressed between the seeds, 20-30 cm long, 2 cm wide, 2-valved, valves membraneous, dehiscent; seeds 6-12, ovoid-reniform, 2.5 cm long, 1.6 cm across, testa thin and brittle (Willing,1989).

Cultivation

Not cultivated in Madagascar. Seeds require storage under conditions of low temperature and low relative humidity. In Australia seed sown in 20 cm long tubes; germination rapid after soaking for 10 hours. Aerial growth characteristically zigzag with rapid development of side branches requiring plants to be well spaced in nursery to prevent entanglement; root growth rapid. Plant at 4 m x 4 m spacing after 3 months. Alkaline soils preferred. After 1 year, two growth forms are noted, a spreading open bush or the less common compact, somewhat fastigiate bush (Willing, 1989).

Harvesting

Nuts (seeds) are harvested from the ground following dehiscence (Willing,1989).

Post-harvest treatments

None required (Willing, 1989).

Production and consumption/utilization

Nuts (seeds) eaten raw, discarding the brittle testa, the cotyledons agreeably sweet with a cashew-like flavour, smooth consistency and a flexible, rather plastic texture. Apparently not used in cooking; when eaten green the flavour reminiscent of fresh garden peas (Willing,1989).

Nutritional value

The nuts contain 38-43% available carbohydrates, 26-32% unavailable carbohydrates, 14-16% protein and 6-9% fat, comparing favourably with those of *Cordeauxia edulis*. However, the ingestion of 100 g kernels, *ca.* 84 raw seeds, may inhibit human production of chymotrypsin and cause digestive upsets, although this could possibly be reduced by cooking or roasting the seeds (Willing, 1989).

By-products and other uses

Browsed by goats when little else to eat, they also eat the seeds. Possible potential for windbreaks and hedges (Willing,1989).

Marketing

Apparently not sold in the local markets (Willing,1989).

Discussion

Survey of extent of natural populations and genetic variability, and applying measures for its *in situ* and *ex situ* conservation is required as well as investigation of its autecology. Establish provenance trials; select high-yielding, toxin-free trees and evaluate the two life forms; investigate potential for micropropagation and agronomic requirements; investigate possible potential for Mediterranean regions in addition to the arid tropics (Willing,1989).

GALO OR PROMISING NUT: *Anacolosa frutescens*, Olacaceae

Distribution and ecology

Myanmar, Andaman and Nicobar Islands, eastern Thailand, Peninsular Malaysia, Sumatra, Java, Kalimantan, north-eastern Sulawesi, Moluccas and the Philippines. Found in low to medium altitude forests, occurrence rare (Sleumer, 1984; Verheij and Coronel, 1991).

Description

Erect shrub or tree to 25(-30) m. Leaves elliptic to elliptic-oblong or lanceolate, (6.6-)7-15(-22) cm x (3-)4-6.5(-12) cm. Inflorescence in leaf axils. Fruit a drupe, obovoid-ellipsoid to oblongoid, 1.5-2.5 cm long, 1.2-2 cm in diameter, yellow or orange, thin shelled; pulp 3.5-5.9 mm thick; seed 1 (Howes, 1948; Menninger, 1977; Sleumer, 1984; Verheij and Coronel, 1991).

Cultivation

Not even grown experimentally as an orchard crop. Propagated by seed, germination takes more than 100 days. Cleft grafting of selected parent trees highly successful. Seedlings take one year to reach grafting stage (Howes, 1948; Verheij and Coronel, 1991).

Harvesting

Generally harvested when mature green (Verheij and Coronel, 1991).

Post-harvest treatments

No information.

Production and consumption/utilization

Nut resembling a filbert, kernel of good flavour and quality, eaten raw or roasted. Pulp eaten raw or boiled (Howes, 1948; Menninger, 1977; Verheij and Coronel, 1991).

Nutritional value

Highly nutritious, containing 10-38.5% water, 2.9-3% ash, 10.7-11.1% protein, 7.5-8% fat, 39.5-75.5% carbohydrates, 3.7% fibre, providing 2 733 calories per kilo (Menninger, 1977; Verheij and Coronel, 1991).

By-products and other uses

Timber heavy but not durable, used for house posts (Sleumer, 1984; Verheij and Coronel, 1991).

Marketing

Not known, presumably marketed locally. Found locally in backyards and forests as volunteer trees (Verheij and Coronel, 1991).

Discussion

Species considered to have a potential for domestication (Mabberley, 1987). Its potential for commercial cultivation is only now being considered. There is no information regarding its cultural requirements or yields. Trees appear to be highly variable but some high yielding trees have been noted.(Verheij and Coronel, 1991).

AVELLANO, CHILEAN NUT, CHILEAN HAZEL: *Gevuina avellana*, Proteaceae

Distribution and ecology

Chile, growing in the shelter of taller trees from the snowline of the Pacific slopes of the Andes to the coast; introduced into Ireland, southwest England and California in areas with mild, moist climates. Due to the weight of foliage it requires protection from strong winds (Rosengarten, 1984; Benoit, 1989).

Description

An evergreen tree up to more than 15 m. Leaves pinnate, leaflets oval with toothed margins. Inflorescence racemose; flowers snow- to ivory-white, appearing from February to May in the late Chilean summer and early autumn. Fruit a drupe, coral-red, the previous year's fruits ripening at flowering time; seeds 1, globular, with smooth, tough shell (Menninger, 1977; Rosengarten, 1984).

Cultivation

Difficult to establish due to the weak root system making it extremely sensitive to transplanting outside its native habitat (Rosengarten, 1984).

Harvesting

Mainly from the wild. Yield *ca.* 4.5 kg per tree (Rosengarten, 1984).

Post-harvest treatments

No information.

Production and consumption/utilization

Kernel similar to hazel in appearance and flavour, eaten fresh or roasted (Howes, 1948; Mabberly, 1987).

Nutritional value

No information.

By-products and other uses

Timber pale brown, light, strong and easily worked, used locally for picture frames, furniture, oars and shingles. Tree grown as an ornamental (Rosengarten, 1984; Mabberly, 1987).

Marketing

Marketed locally, sold roasted, in bags like peanuts. Virtually unknown elsewhere (Rosengarten, 1984).

Figure 27
Gevuina avellana. 1: branch with leaves and inflorescence. 2: fruit. 3: cross section of fruit.

Discussion

An interesting tree with a wide altitudinal range from which it should be possible to select high yielding potential cultivars. Both pulp and kernel are edible with only the thin shell of no immediate use. Verheij and Coronel (1991) consider the species ripe for commercial development.

QUANDONG OR NATIVE PEACH: *Santalum acuminata,* Santalaceae

Distribution and ecology

Disjointed distribution throughout southwest and extending into desert areas of central Australia; salt tolerant, grows in areas with an annual rainfall of 125-275 mm (Brand and Cherikoff, 1985; Rivett *et al.*, 1989).

Description

Semi root parasite shrub or small tree up to 10 m tall. Leaves opposite, grey-green, ends tapering, apex shortly hooked when young. Fruit: outer flesh red, pulpy, enveloping a large, wrinkled stone (Rivett, *et al.*, 1989).

Cultivation

Seeds germinate within 2 months of removal from ripe fruit. Potential for grafting and tissue culture as alternative means of propagation. Trees begin to bear in their third year with a maximum production in seventh year of 10 kg; yields up to 23 kg per tree are known. Kernel represents 40% of the total fruit weight (Rivett *et al.*, 1989).

Harvesting

Fruits rattle when ripe. No information as to whether picked from the tree or collected when fallen (Brand and Cherikoff, 1985).

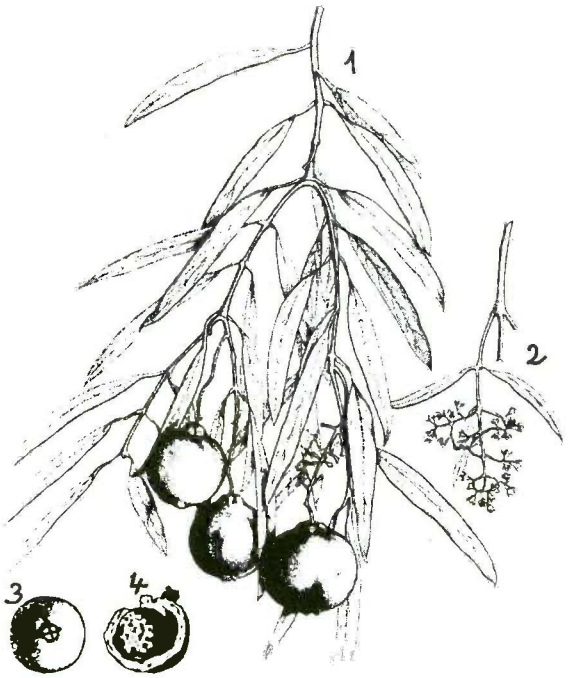


Figure 28
Santalum acuminata. 1: branch with leaves and fruits. 2: branchlet with flowers. 3: fruit. 4: open fruit showing the seed.

Post-harvest treatments

Unpleasant volatile methyl benzoate contained in kernels will decrease during storage; loss can be further reduced by placing kernels in a vacuum oven (Rivett *et al.*, 1989).

Production and consumption/utilization

Fruit pulp may be eaten fresh but usually cooked, made into pies, jams and chutneys; kernels eaten mainly by Aborigines. Kernels eaten either raw and salted after roasting in coconut oil not considered very palatable due to the somewhat unpleasant aroma from the volatile methyl benzoate. (Rivett *et al.*, 1989).

Nutritional value

Kernels have an energy value of 3 000 kJ and contain *ca.* 67% oil, *ca.* 15% protein, fibre, free sugars, together with adequate quantities of essential amino acids but some samples deficient in sulphur amino acids. High levels of santalbic acids, plus doubts about the safety of the acetylene fatty acids present, suggest that considerable caution needs to be exercised before the quandong kernels can be safely recommended for human consumption (Brand and Cherikoff, 1985; Rivett *et al.*, 1989).

By-products and other uses

Timber utilized by Aborigines; used for fuel (Maconochie, 1985; Lazarides and Hince, 1993).

Marketing

Not marketed and product currently unsuitable for marketing without further selection for edible kernels.

Discussion

Very few indigenous Australian food plants have been considered for cultivation. It is currently being investigated by CSIRO with a view to commercial cultivation. Considering that the kernel accounts for 40% of the fruit and that there are problems regarding its palatability and digestibility it is doubtful whether the quandong has a potential for domestication unless improved strains can be selected or developed. Should suitable cultivars be developed there would certainly be a potential for introduction to other arid regions.

ARGAN: *Argania spinosa*, Sapotaceae

Distribution and ecology

Southwestern Morocco, introduced in other Mediterranean countries; locally dominant in almost pure stands in areas receiving 100-300(-400 max) mm annual precipitation and growing on a wide range of soils, including slightly saline but not drifting sands and water-logged soils; the altitude range is from sea level to 1 500 m. Drought resistant, shedding foliage and remaining in a state of dormancy for several years during prolonged drought (Baumer, 1983; Morton and Voss, 1987; Bouachrine, 1994).

Description

Spiny, normally evergreen tree, 4-8(-10) tall, occasionally attaining 21 m with main trunk 1 m in diameter. Leaves clustered, lanceolate. Inflorescence axillary; flowers greenish, bisexual. Fruit an ovoid drupe, greenish-yellow; epicarp thick, bitter, gummy; mesocarp plus endocarp fleshy, containing an unpleasant (for humans) milky latex; seeds 2-3, *ca.* 2 cm long, united in a pseudo-kernel (Baumer, 1983; Morton and Voss, 1987; Bouachrine, 1994).

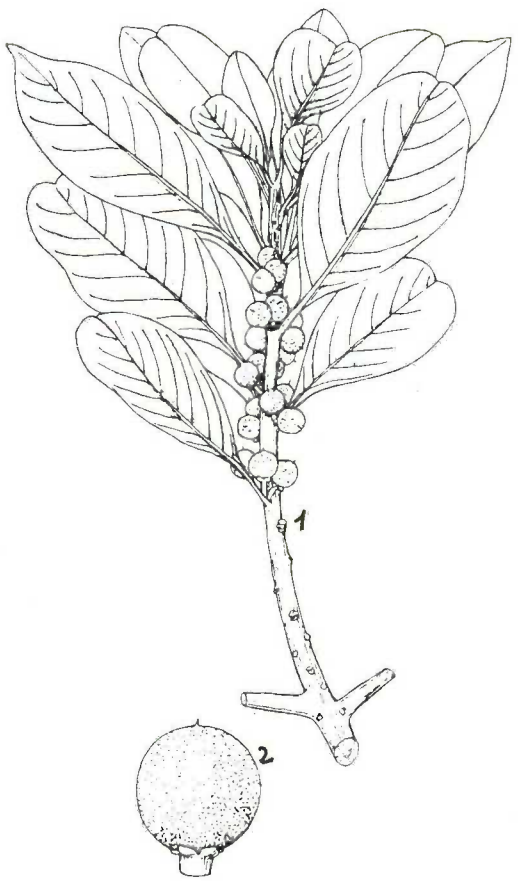


Figure 29
Argania spinosa. 1: fruiting branch. 2: fruit.

Cultivation

Seed polyembryonic, germinating readily and producing several shoots. Trees start to bear when 5-6 years old with maximum production at 60 years. Trees long-lived, to at least 200-250 years with some individuals believed to be over 400 years old. Trees coppice readily when cut (Baumer, 1983; Morton and Voss, 1987; Bouachrine, 1994).

Harvesting

Fallen ripe fruits dehydrate and pericarp becomes tough, wrinkled and difficult to remove. Fallen fruits are eaten by goats, who digest the subacid rind and eject the hard seeds during rumination, when they are gathered up. Average yield of fruit is *ca.* 8 kg per annum (Hedrick, 1972; Baumer, 1983; Morton and Voss, 1987).

Post-harvest treatments

None recorded.

Production and consumption/utilization

Kernels are source of an edible argan oil. After first roasting to eliminate saponins, the seeds are ground and mixed with tepid water. The oil floats and is separated by decantation. The resulting brownish, acrid and unpleasant tasting oil is allowed to stand for any residues to be deposited. The oil is then lighter in colour, strong flavoured. It may be further purified either by emulsion with water or by adding bread to produce an oil as sweet as walnut oil. Approximately 100 kg of seed yield 1-2 kg of oil and 2 kg of press cake plus 25 kg of dried "husk" (Baumer, 1983; Morton and Voss, 1987).

Nutritional value

Argan oil contains *ca.* 80% poly-unsaturated fatty acids of which 31.5% is linoleic, making it nutritionally interesting as it is one of the most important essential fatty acids in the human diet (Morton and Voss, 1987; Bouachrine, 1994).

By-products and other uses

Argan oil is used as an illuminant and for making a hard, yellowish soap. The sun dried cake residue after the oil has been expressed may be fed to livestock but it is not accepted by horses; it contains the slightly toxic, haemolytic saponin sapoarganine which does not harm ruminants and passes out with the urine. However, cake fed to dairy cattle will contaminate the milk, which may cause diarrhoea in children. Foliage is a valuable dry season fodder source for livestock; fruit also eaten by livestock. Timber very hard, heavy and durable, suitable for agricultural implements and building poles; the wood makes good charcoal. Brushwood used for fences. The species coppices well; a valuable shade tree, also used for soil conservation and windbreaks (Hedrick, 1972; Göhl, 1981; Baumer, 1983; Morton and Voss, 1987; Bouachrine, 1994).

Marketing

Argan oil was imported into Europe during the eighteenth century but, being stronger flavoured was unable to compete with olive oil (Morton and Voss, 1987).

Discussion

Tree endangered due to exploitation for fuel and land clearance for agriculture, with natural regeneration limited due to herbivore pressure (Morton and Voss, 1987).

SHEA BUTTER TREE: *Vitellaria paradoxa*, Sapotaceae

Distribution and ecology

From Senegal to Cameroon through to the drier parts of equatorial central Africa and Uganda; in savannas, preferably with a shallow water table, generally between 500-1 000 (-1 200) m altitude. Grows in areas with an annual rainfall 600-1 000 mm and a marked dry season of 6-8 months or 900-1 800 mm and a shorter dry season of 4-5 months but subjected

to annual burning. An annual average temperature of 24-32°C, with a minimum of 21°C and a maximum of 36°C preferred. Yields best on cultivated lands but occurs naturally on dry lateritic slopes and stony soils, it prefers dry alluvial-sandy soils rich in humus; intolerant of alluvial hollows and areas subjected to flooding (Booth and Wickens, 1988; FAO, 1988).

Description

Deciduous, spreading tree 15(-25) m tall, trunk up to 2 m in diameter, bark corky, fire resistant. Leaves oblong, clustered at the end of branches. Flowers bisexual, produced in the dry season before the leaves. Fruits subglobose to ovoid, 4-5 cm in diameter, with fleshy pericarp *ca.* 1 mm thick, exuding latex when green and turning brown when ripe; seeds 1(2–4), shiny brown with fragile husk; kernel white (Menninger, 1977; Booth and Wickens, 1988; FAO, 1988).

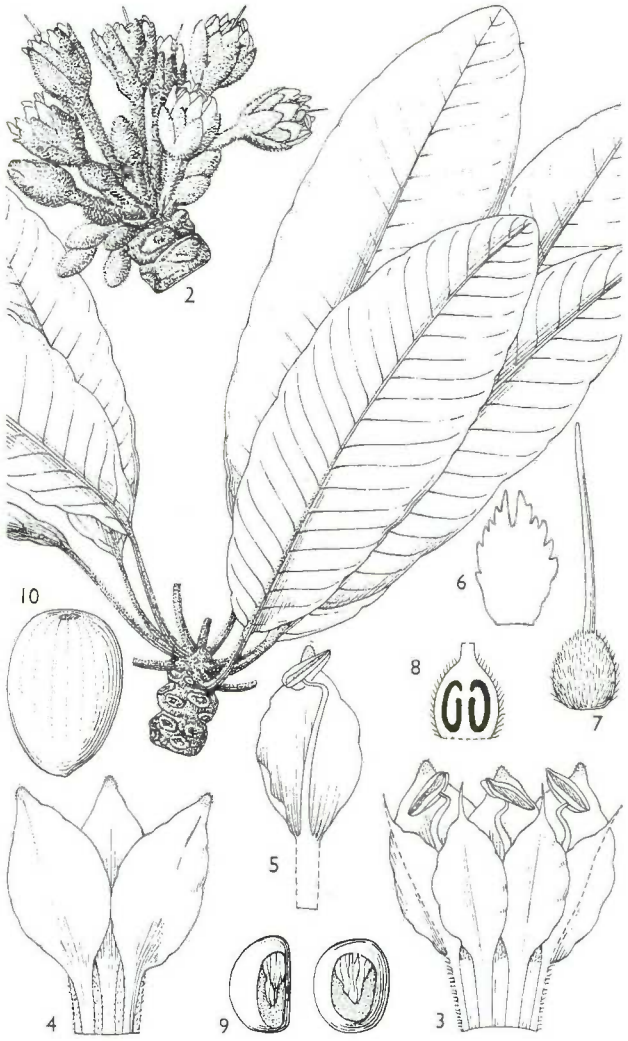


Figure 30
Vitellaria paradoxa. 1: leafy shoot. 2: inflorescence. 3: section of corolla. 4: section of corolla with stamens and staminodes removed. 5: corolla segment and stamen. 6: staminode from another flower, showing variation in shape. 7: ovary. 8: longitudinal section of ovary. 9: seeds. 10: fruit.

Cultivation

Natural populations are often left when land is cleared for cultivation and relatively little attention has been paid to its cultivation. Propagation by direct sowing of seed recommended as nursery seedlings do not transplant well due to the development of a long tap root. Seedlings initially slow growing due to development of root system. Recommended spacing 2 m x 8 m to 15 m x 15 m or in an 8 m triangular pattern with final stocking thinned to 30-50 trees per ha. Fertilizers possibly beneficial. Yield variable, 15–20(-45) kg per tree of fresh fruit. Annual yields in a range of 9-17 tonnes per ha optimistically predicted. In Nigeria only one tree in three produces each year. Trees start to fruit at 10-15 years, with full bearing by 20-25 years with individual yields ranging from 20-200 kg. The fruit takes 4-6 months to ripen (Booth and Wickens, 1988; FAO, 1982, 1988).

Harvesting

Harvest from the ground as soon as fruits fall. One person can gather *ca.* 45 kg in a day. The fleshy pulp rots and splits to expose the nut, the process can be hastened by burying the freshly gathered fruit for a few days in a pit. As harvesting takes place during the rainy season, a period which favours early germination, the nuts (in the shell) are often stored in huts until the dry season or when required. The amount harvested each year appears to be dependent on the price of shea butter (Menninger, 1977; Booth and Wickens, 1988).

Shea butter tree, *Vitellaria paradoxa*. (Photo: G. Blaak)

Flowers of *Vitellaria paradoxa*. (Photo: G. Blaak)

Post-harvest treatments

Depulped nuts sun-dried for *ca.* 12 days or dried in an earth oven; the drying process results in 30-40% loss of weight. Alternatively the fruits are fermented by being kept moist for weeks or months in large earthenware jars, after which the nuts are roasted. The skin is removed to expose kernel. Decorticated kernel contains 40-60% by weight of the kernel oil known as shea butter (Menninger, 1977; FAO, 1988).

Production and consumption/utilization

Shea butter usually extracted by women, who pound the usually roasted kernels and then grind them to an oily, chocolate-coloured paste. The paste contains tannins and is not edible until it has been boiled and the oil skimmed off, the bulk of the impurities being removed in the scum. About 50 kg of fresh nuts will give 12 kg of dry kernels, required to yield 4 kg of shea butter.

Shea butter prepared from unroasted kernels is light yellow or sometimes tinted with a yellow dye, with a strong odour, especially when warmed. Properly prepared shea butter keeps perfectly unless adulterated with water or yam flour. The deeper the colour the stronger the odour and taste resulting from decomposition of proteins which occur in proportion to the degree of fermentation of the nuts and to over-roasting. Butter prepared from nuts subjected to little fermentation, as when nuts are lightly sun-dried without previous maceration of the pulp, is almost tasteless and odourless.

Purified shea butter is edible, used in cooking, also suitable as cocoa butter equivalent (CBE) for chocolate manufacture (Menninger, 1977; FAO, 1988)).

Fruit pulp is eaten raw, when slightly overripe, or lightly cooked after removal of seed and husk (FAO, 1988).

Nutritional value

Whole seed, including husk, contains 34-44% fat, the kernel 45-60% fat. The main fatty acids present in shea butter are 5-9% palmitic, 30-41% stearic, 49-50% oleic and 4-5% linoleic. The fruit pulp is rich in carbohydrates, is a good source of iron, and contains small amounts of B vitamins (FAO, 1988).

By-products and other uses

Fruit pulp sometimes eaten, but usually eaten by elephants, etc. Shea butter used commercially in soap, cosmetics and candles with a potential for pharmaceutical preparations. Used locally in ointments, hair dressing, waterproofing hut walls and as a soap. Oil cake residue is bitter and contains saponins but can be used as a filler for feed stuffs. Seed husk used as mulch and fertiliser. Timber heavy, difficult to work, takes a fine polish, termite resistant, used for stakes, house posts, shipbuilding and tool handles, also as source of firewood and charcoal (Menninger, 1977; FAO, 1982; Booth and Wickens, 1988; FAO, 1988).

Marketing

Shea butter is used mainly for home consumption especially in rural communities and is sold in the local markets as balls or pats weighing *ca.* 2.3-3.7 (-10) kg. In urban areas there is increasing competition from alternative imported oils such as sesame and groundnut oils. For export shea butter requires clarifying by steam to remove volatile acids and some of the odorous matter. Lightly sun-dried nuts without previous maceration of the pulp are preferred for export. Any variation in free fatty acids in the fat is mostly due to faulty handling after leaving the producer (Menninger, 1977; Booth and Wickens, 1988).

Discussion

Research is required on methods of establishment and general agronomy, especially with regard to plantations. Due to changing agricultural practices there is a danger that with increasing cultivation and lack of protection the natural regeneration will be inhibited. With present aging populations of trees there is a danger of a future reduction of this resource. There is a need to encourage protection and to establish plantations. Plantations could encourage more efficient, fuel-saving methods of extraction. It could lead to the establishment of large-scale oil mills in Africa, provided the current unpredictability of annual yields could be overcome (Booth and Wickens, 1988).

BITTER COLA, KOLA NUT: *Cola nitida*, Sterculiaceae

Distribution and ecology

Native of Sierra Leone, Côte d'Ivoire eastward to Ghana, often cultivated elsewhere in West Africa and obscuring the natural distribution. Constituent of the lowland forest. Requires a hot, humid climate although capable of withstanding 3 or more months of dry season. It may be cultivated in drier areas where ground water is available. Introduced in Jamaica and Brazil (FAO, 1982; Purseglove, 1987).

Description

Evergreen tree to 15-20(-25) m tall, trunk 20-30 cm in diameter with narrow buttresses. Leaves simple, broadly oblong to broadly elliptic, up to 33 cm x 13 cm, apex abruptly and shortly acuminate. Inflorescence of axillary cymes; flowers male or hermaphrodite, apetalous, cream, usually with dark reddish markings within. Fruit consisting of 5 ellipsoid, warty follicles, up to *ca.* 13 cm long, 7 cm wide, each follicle containing 4-8-(10) seeds arranged in 2 rows; seeds ellipsoid, *ca.* 2.5 cm in diameter, red or white depending on the variety (Keay, 1958; FAO, 1982).

Cultivation

Propagated by seed (germination is slow, taking 2-3 months) or, preferably by cuttings. Final spacing is 10 m. Initial growth slow, reaching only 3 m in 4 years. Initial weeding is essential and interplanting with a shade tree recommended (FAO, 1982).

Harvesting

Ripe fruits harvested before the follicles split open, using knives mounted on long poles. Yields of 300 nuts per tree are considered good (FAO, 1982; Purseglove, 1987).

Post-harvest treatments

Follicles split and seeds are removed. Seeds are fermented in heaps for 5 days, after which the testa is removed and the nuts washed and cleaned. Nuts are stored in baskets lined with green leaves, which are regularly changed. Nuts may be thus stored for several months without spoiling but will require regular checking for weevil damage (Purseglove, 1987).

Production and consumption/utilization

The bitter tasting seeds are much appreciated by Moslems in the drier regions of West Africa, especially after Ramadan. Used as a stimulating masticatory, a beverage is prepared by boiling powdered seeds in water (FAO, 1982; Rosengarten, 1984; Purseglove, 1987).

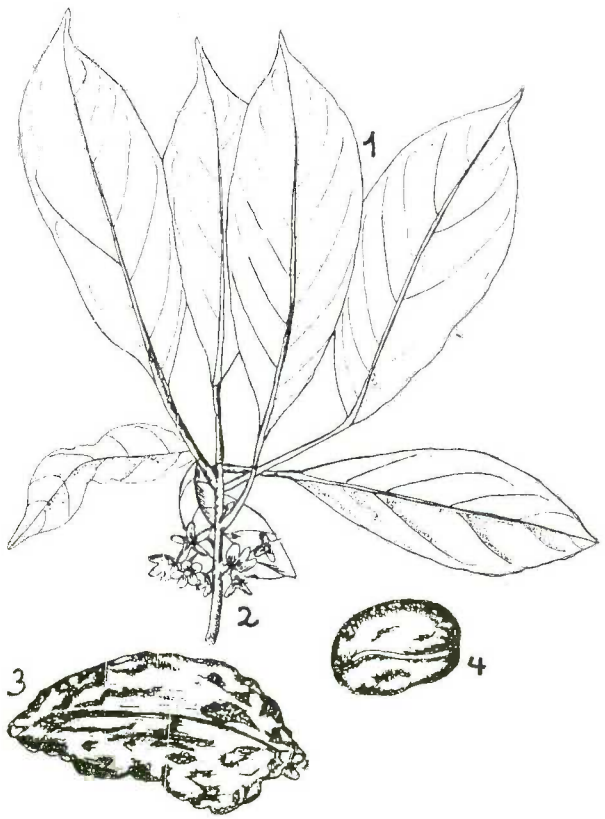


Figure 31
Cola nitida. 1: leaves. 2: inflorescence. 3: fruit. 4: seed.

Nutritional value

Seeds consist of 13.5% water, 9.5% crude protein, 1.4% fat, 45% sugar and starch, 7.0% cellulose, 3.8% tannin, 3.0% ash, also rich in alkaloids, caffeine (2.8%), theobromine (0.05%) and kolatine (FAO, 1982).

By-products and other uses

Widely used in West Africa for social ceremonies. A non-addictive stimulant used medically for diarrhoea and to prevent vomiting in cases of high fever; reputed to act as a water purifier. The red nuts are a potential source of food colorant. Wood is susceptible to borers; suitable for furniture, joinery and carvings (FAO, 1982; Rosengarten, 1984).

Marketing

Seeds important in local and international commerce, the white-seed strain preferred by the market. Industrial exploitation is mainly for the caffeine, which is used in decoctions and non-alcoholic drinks. World production of cola nuts from *Cola nitida* and allied species estimated as *ca.* 180 000 tonnes of which *ca.* 120 000 tonnes is produced by Nigeria and used either internally or in neighbouring countries (FAO, 1982; Rosengarten, 1984).

Discussion

Considering how much cola nuts are appreciated in West Africa while being virtually unknown elsewhere, there would appear to be reasonable expectations for expanding the market.

SUGAR PLUM, ARENG PALM, EJOW, GOMUTI, KAONG: *Arenga pinnata*, Palmae

Distribution and ecology

Assam to Malaysia, possibly introduced in the Philippines; widely cultivated (Menninger, 1977; FAO, 1984; Uhl and Dransfield, 1987).

Description

A solitary, unarmed, pleonanthic, monoecious feather palm to 15 m tall, stem 40 cm in diameter. Leaves pinnate, long, ascending, up to 8.5 m long. Inflorescences large, axillary, pendulous; inflorescences appearing in descending order from the uppermost leaf axil and continue for *ca.* 2 years until the palm is exhausted and dies. Fruit turn yellow when mature, *ca.* 5 cm in diameter; seeds 2-3 (FAO, 1984; Purseglove, 1985; Uhl and Dransfield, 1987).

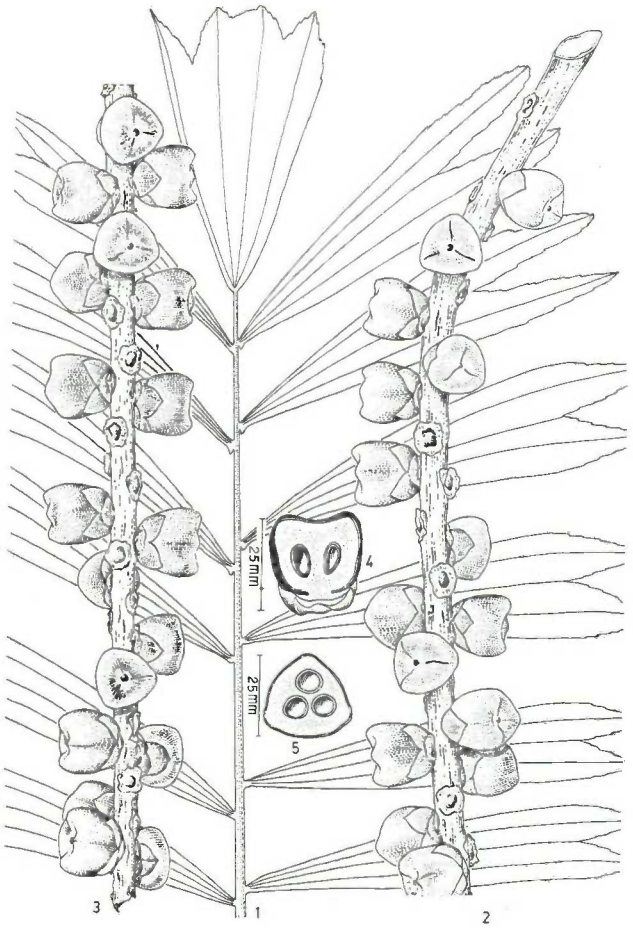


Figure 32
Arenga pinnata. 1: part of pinnate leaf. 2-3: sections of inflorescence bearing fruits. 4: longitudinal section of fruit. 5: transverse section of fruit.

Cultivation

No information.

Harvesting

Propagated by seed or suckers. Flowering at 7-10 years (FAO, 1984).

Post-harvest treatments

No information.

Production and consumption/utilization

Immature kernels cooked and eaten in the Philippines, or boiled in sugar and made into a sweetmeat (Hedrick, 1972; Menninger, 1977; FAO, 1984).

Nutritional value

Fruits contain 6.8% moisture, 7.9% ash, 16.2% crude fibre, 10.0% crude protein, 1.5% fat (FAO, 1984).

By-products and other uses

Stem is a source of a form of sago, which is converted into sugar when the palm first begins to flower. The male spadix tapped daily for 2-3 months for its sugary sap (*ca.* 3.5 litres daily), of which 9 litres is evaporated to produce *ca.* 1 kg of palm sugar (jaggery), palm wine

or toddy, distilled for arrak; palm cabbage eaten raw as a salad or cooked. Leaf sheath source of a tough, black fibre (gomuti or yunot fibre) used chiefly for a durable rope tolerant of both fresh and salt water and fire, used for marine work and thatching; fibre also used for brushes. Leaves used for thatching; the split petioles for basketry and a form of marquetry work (Hedrick, 1972; Menninger, 1977; FAO, 1984; Purseglove, 1985; Mabberley, 1987).

Marketing

Sweetmeats marketed (Menninger, 1977).

Discussion

Regarded as the most useful of all palms (Hedrick, 1972), however, its chief economic importance is for its fibre.

TUCUMA: *Astrocaryum vulgare,* Palmae

Distribution and ecology

Amazonia. Occurrence abundant, especially in disturbed sites (Prance, 1994).

Description

Tall, single-stemmed, spiny, pleonanthic, monoecious, feather palm. Fruit more or less globose (Uhl and Dransfield, 1987).

Cultivation

No information.

Harvesting

Method presumably as for *A. aculeatum* (FAO, 1986). Bunches pulled down with a hooked stick soon after first fruit ripens and falls.

Post-harvest treatments

Treatment presumably as for *A. aculeatum* (FAO, 1986). Nuts stored for 3 days in sacks to ripen and pulp soften slightly. They must be eaten within 3-4 days before they dry and rot where bruised.

Production and consumption/utilization

Mesocarp edible, juice extracted from the pulp. Kernel produces an excellent oil for cooking and soap-making (FAO, 1986; Uhl and Dransfield, 1987; Prance, 1994).

Nutritional value

Mesocarp rich in vitamin; fresh pulp contains 31 mg of carotene per 100 g (FAO, 1986; Prance, 1994).

By-products and other uses

Seed oil is used for making soap. Source of fibre from leaf epidermis, the strongest in Amazonia and possibly commercially viable, used by the Amerindians for fishing lines (Mabberley, 1987; Uhl and Dransfield, 1987; Prance, 1994).

Marketing

No information.

Discussion

Because of its abundance in disturbed areas it could have a potential for easy domestication (Prance, 1994). A genus of 50 species of which at least 40, including *A. aculeatum, A. ayri, A. jauari* and *A. murumuru* deserve further attention by economic botanists (FAO, 1986). See FAO (1986) for further information regarding *A. aculeatum*, which is not discussed here since its potential as an oil crop depends on the oily mesocarp, the kernel being hard and inedible.

PEACH PLUM, PALM CHESTNUT, PUPUNHA, PEJIBAY(E) OR PEJIVALLE: *Bactris gasipaes*, Palmae

Distribution and ecology

Caribbean and Central America to Ecuador; widely cultivated, not truly known in the wild, the inferred original distribution from the Colombian Andes, eastern Peru and northwest Brazil where it occurs on slopes too steep for cultivation. Occurs in tropical rain forest to elevations of 700 (-1 500) m in areas with 2 000-4 000 mm annual rainfall and not more than 2-3 months dry season; optimum temperature 18-24°C (Menninger, 1977; Johnson, 1983; FAO, 1986; IBPGR, 1986).

Description

Suckering, unarmed, pleonanthic, monoecious, feather palm to 20 m after 10-15 plus years, often 4-5 stems are allowed from the base; flush of suckers produced from old stems after felling; shallow rooted. Nodes densely armed with 5-10 cm long black spines, leaf sheath normally with spines; a new leaf normally produced every 2-4 weeks, typically 10-13 fronds per main stem. Flowers insect pollinated. Fruit *ca.* 5 cm in diameter, firm textured, dry and mealy, pale orange to yellow or red when ripe, skin soft; 1-seeded, seed conical and somewhat angular, *ca.* 2 cm long; mesocarp thin, dry, mealy; endocarp thin, hard, black; kernel white, hard (Menninger, 1977; Johnson, 1983; Purseglove, 1985; FAO, 1986; IBPGR, 1986; Uhl and Dransfield, 1987).

Cultivation

Suited to the wet tropics. Propagation by seed or from basal suckers, spacing at 5.5 m x 5.5 m. Palms for palm heart production planted at 1.5-2 m spacing. It begins bearing at 3-4 (-8) years and continues production for 50-75 years. Usually only 2-4 basal suckers are allowed to develop, the others being removed. The palm, once established, requires little care and yields well, with up to five bunches of fruit per tree, each weighing *ca.* 14 kg. Fruit takes about 6 months to mature and will remain on the tree for long periods in good

condition; individual fruits weigh 29-100 g, nuts *ca.* 3 g. Yield of edible fruit 3.4 t dry fruit per ha per year. Domesticated seedless varieties exist, the fruits (pejibaye macho) composed entirely of fibrous pulp (Menninger, 1977; Johnson, 1983; Purseglove, 1985; FAO, 1986; IBPGR, 1986). Palms are grown as shade trees for cocoa and coffee (IBPGR, 1986).

Harvesting

Bunches of fruits are cut using knives on long poles or by climbing up the spiny trunk. Yields can be as high as 250 kg per tree and 30 tonnes per ha. Stems may be tapped for a palm wine (coquillo) and suckers (ratoons) for palm hearts (FAO, 1986; IBPGR, 1986; Duke, 1993).

Post-harvest treatments

Fruits can be stored for 10-14 days in a dry room. Fruit is sometimes canned. Seed separates readily from pulp after boiling (Menninger, 1977; IBPGR, 1986).

Production and consumption/utilization

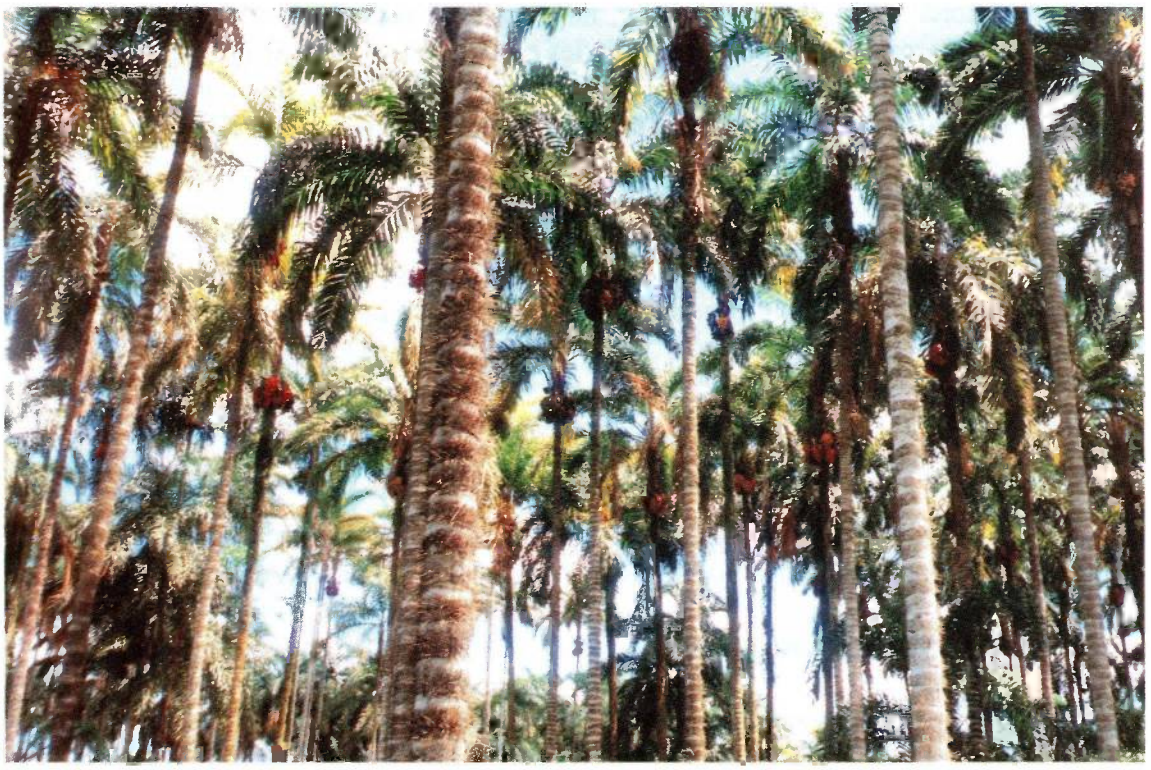
Staple food for tribes in lowlands of Colombia, Venezuela and Ecuador. Fruits are boiled in salty water for *ca.* 3 hours, peeled and after removal of the seeds, eaten, strongly resemble chestnuts in appearance and flavour; highly nutritious and an important item of diet for rural people. Extracted starch is used as a substitute for maize flour for making tortillas, a staple food in Central America; cooked flesh may also be fermented to produce a beer (chicha). Kernel is starchy and oily, resembles coconut in flavour. The oily kernels may be eaten; also a commercial source of oil on boiling. Poor quality fruits may be fed to pigs (Menninger, 1977; Purseglove, 1985; IBPGR, 1986; FAO, 1986; Mabberley, 1987; Uhl and Dransfield, 1987).

Nutritional value

The chestnut-like fruit is regarded as probably the most nutritionally balanced of tropical fruits; has twice the protein content of the banana and can produce more carbohydrate per ha than maize. The composition of the fruit varies enormously from 19-93% mesocarp, 18-66% dry matter, 3.1-14.7% protein, 2.6-61.7% oil, 33.2-88.8% starch, 1.8% ash and 1.6% fibre. The boiled flesh contains *ca.* 48% water, 3% protein, 7% fat, 41% carbohydrate and 0.8% ash. Oil composition is similar to that of oil palm (Menninger, 1977; Purseglove, 1985; FAO, 1986).

By-products and other uses

Canned palm hearts exported from Costa Rica. Leaves used for thatching. Fibre (palmiti) is of commercial importance in Costa Rica. Outer 2.5-5 cm of stem are a source of a very hard timber used for carpentry and building, the split stems used for reinforcing concrete; hardened stems are used for long bows and attractive black floor slabs. It has potential as an energy crop from developing combustible oil and alcohol from the starch (Johnson, 1983; FAO, 1986; IBPGR, 1986; Duke, 1993).



A grove of *Bactris gasipaes*. (Photo: G. Blaak)

Fruits of *Bactris gasipaes* ready for market. (Photo: G. Blaak)

Marketing

Fruit marketed locally. The fresh fruit has a shelf life of 1 week, suggesting some form of preservation necessary for longer storage (10-14 days in a dry room, IBPGR, 1986). Canned fruit introduced in Costa Rica, but a more desirable and improved product required if canning is to develop further (Johnson, 1983; FAO, 1986).

Discussion

Despite its qualities, pejibaye is a minor crop cultivated by the small-holder rather than on a plantation scale; rarely grown outside Central and northern South America and the Caribbean (IBPGR, 1986). Its local importance as a staple food suggests that it could be introduced elsewhere in the humid tropics (FAO, 1986). Fruit quality and absence of spines were characters selected during domestication, otherwise very little work has been done on improvement. Priority in any breeding programme is suggested for fibre production because it is already a commercial proposition. Other programmes may consider oil production, protein and carotene rich pulp for human and animal consumption, and flavour (IBPGR, 1986).

BABASSU, BABACU PALM OR AGUASSÚ: *Orbignya phalerata*, Palmae

Distribution and ecology

Babassu palm grows wild in disturbed areas throughout more than 100-150 000 km^2 from the Atlantic Ocean to Bolivia and especially in Maranhao, Bahia and northern Minas Gerais and Mato Grosso. The annual rainfall is 1 200-2 500 mm with a 4-6 months dry season. Soils range from well-drained upland soils to gallery forest, although in severely flooded areas it occurs in elevated, non-flooded areas. A high light demander, and therefore only dominant in disturbed areas (Menninger, 1977; FAO, 1986; Clay and Clement, 1993)

Description

Solitary, unarmed, pleonanthic, monoecious, feather palm with trunk up to 30 plus m tall. Leaves 10-25, pinnate, up to 9 m long. Inflorescences variously male, female or bisexual. Bunches of fruit up to 1 m long, weighing 14-90 kg and containing (100-)200(-600) fruits; fruit ellipsoid, 5-15 cm long, 4-9 cm, in diameter resembling a small coconut, weighing 150-200 g; epicarp fibrous, 1-4 mm thick; mesocarp mealy, dry, 2-12 mm thick; endocarp woody, 35-75 mm in diameter, containing (1-)3-6(-11) seeds; seeds ellipsoid, flattened, 2–6 cm x 1-2 cm (Menninger, 1987; FAO, 1986; Uhl and Dransfield, 1987; Clay and Clement, 1993).

Cultivation

Collected solely from the wild. Groves thinned to *ca.* 100 trees per ha in order to increase yields. Seeds may remain dormant within the nut for years provided they are not attacked by Coleopteran larvae. Fire or heat may be necessary to break dormancy; separate kernels may germinate within a few months. Early growth is slow, concentrating initially on an extensive root system and consequently requiring large bags if grown in a nursery. The palms begin to bear when 8-12 years old. Populations reduced to 80 juvenile and young fruiting palms considered suitable for intercropping and grazing by livestock. The use of

fertilizers to increase productivity is still at the trial stage (FAO, 1986; Clay and Clement, 1993).

Harvesting

Fallen nuts collected after drying for a few weeks; they may also be dislodged from the bunches with sticks or the whole bunch cut down. The fine silicate crystals falling off the fruit can cause serious eye damage to the collectors. Wild groves can yield 1.5-2.5 tonnes per ha but, where the groves are thinned yields range from 7–30 tonnes per ha with an average of 16 tonnes. Individual trees with 7 bunches, each bunch of 600 nuts and weighing up to 90 kg are known (FAO, 1986; Clay and Clement, 1993).

Present harvesting practice results in only *ca.* 25% of a potential 8 million MT fruit crop being harvested. More efficient harvesting involves cutting the mature infructescences just after the fruits have begun to fall, in addition to the gathering of fallen fruit. The introduction of a more effective transport system involving transport to collecting points by pack animals and onward by trucks to the village processing area is necessary (Pinheiro and Ferro Franzão, 1995).

Post-harvest treatments

Nuts extremely hard, difficult to crack. Skilled workers manually place nut in a cleft of stones and split open with a heavy hatchet, the operation repeated several times to release all kernels. In an alternative method nut is rested on an axe head held between the feet and hit with a heavy cudgel. A skilled worker can obtain 5-8 kg of whole kernels (Pinheiro and Ferro Franzão, 1995) or 2.3 kg of clean kernels (Clay and Clement, 1993) a day by this method (Menninger, 1977; FAO, 1986).

A village scale cooperative industry is being developed using simple dehusking machines to separate the husk and mesocarp from the endocarp, and a breaking machine to crack the endocarp to extract the seeds, and a machine to separate broken endocarp from the kernels. Local presses are then used to extract the oil and small kilns to make charcoal and to extract tars (Clay and Clement, 1993; Pinheiro and Ferro Franzão, 1995).

Production and consumption/utilization

Whole kernels sometimes are chewed but usually pounded for the cold extraction of a milk substitute or hot extraction with boiling water for oil. Kernel contains 60-70% oil which is rich in lauric acid, similar in composition to that of *Cocos nucifera* (coconut) and *Elaeis guineensis* (African oil palm). Fresh oil is used for cooking, refined oil for margarine. The starchy mesocarp is used locally as an emergency flour substitute (FAO, 1986; Clay and Clement, 1993).

Nutritional value

Kernels contain 1.2% water, 66.1% oil, 7.2% protein, 6% fibre, 2% ash and 14.5% carbohydrates (FAO, 1986).

Babassu (*Orbignya phalerata*) palm in fruit. (Photo: G. Blaak)

Crude process of making charcoal from babassu shell. (Photo: G. Blaak)

By-products and other uses

Broken kernels are fed to pigs as they are unsuitable for oil extraction by the oil factories because the oil quickly becomes rancid. Most of the industrial meal is exported to Europe for dairy cake. Seed oil is excellent for soap production because of its high (45%) lauric acid content. The epicarp (*ca.* 15% of the fruit) is a primary fuel source. The mesocarp (*ca.* 20% of the fruit) is a potential source of industrial starch, glucose or alcohol. The endocarp (*ca.* 59% of the fruit) is an important source of high grade charcoal for the steel industry as well as source of distillation by-products such as tar, acetic acid, methane, etc.; also has a potential use as a substrate for hydroponics. Nut waste is also used locally as a fuel for cooking and to repel insects. Palm hearts edible, the waste being fed to horses. Peduncle can be tapped for palm wine. Trunks used for construction purposes. Leaves used for thatch and basketry; leaf petioles used for laths for windows and adobe walls; unfortunately the reduvid or kissing bug that transmits the vector of Chagas disease that normally shelter in the crevices of the leaf petioles would move to the house walls. Decayed stems and leaves used for mulch. Leaves and liquid endosperm used in local medicine (Menninger, 1977; FAO, 1986; Clay and Clement, 1993; Pinheiro and Ferro Franzão, 1995).

Marketing

Present kernel production is insufficient for developing an efficient seed oil industry (Pinheiro and Ferro Franzão, 1995).

Discussion

An important source of oil for margarine and cooking oil during the First World War and again during the Second World War, when kernel exports peaked at 40 000 tonnes (26 000 tonnes oil). Exports fell to zero by the mid-1960s, although, depending on the international prices, occasional exports are still processed. Since 1965, the Brazilian soap and cosmetic industries have absorbed all babassu oil production (*ca.* 150 000 tonnes in 1985). It is also Brazil's major source of lauric acid. The potential for developing babassu plantations to provide charcoal for the pig-iron foundries requires investigation; the fine grained charcoal has the disadvantage of requiring pressing and gluing into briquettes before shipping and use. It is an extremely important palm in the subsistence economy, being a source of income, food and oil, timber, fibre, medicine, etc., for the indigenous population. Little attention has been paid to developing the species because of the availability of large, albeit low yielding, natural populations. There is a considerable potential for improving yields by selection and develop appropriate agronomic practices, especially in the drier areas that are unsuitable for other oil producing palms. The labour intensive, low productivity kernel extraction is the limiting factor in developing a commercial oil industry (FAO, 1986; Mabberley, 1987; Clay and Clement, 1993; Pinheiro and Ferro Franzão, 1995).

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APPENDIX A

SPECIES WITH EDIBLE "NUTS" LISTED BY FAMILIES[1]

ANGIOSPERMS

DICOTYLEDONS

ANACARDIACEAE; fruit drupaceous or dry, 1-plurilocular, 1-5 seeded stone

Species and distribution	Common name	Details	References
Anacardium giganteum Amazonia	cajui; cajuaçu; caju-da-mata; oloi	forest tree; drupe with enlarged, edible peduncle and kernel, former fresh or for juice, latter roasted	FAO, 1986
Anacardium humile Brazil	monkey-nut	nut edible, conserves made of the fruit	Hedrick, 1972
Anacardium nanum Brazil		nut edible, conserves made of the fruit	Hedrick, 1972
Anacardium occidentale tropical America; widely cultivated	cashew nut	kidney-shaped nut with hard, acrid pericarp around seed (promotion nut, coffin nail); pedicel swells into edible, pear-shaped body (cashew apple) used in preserves, chutneys, etc. also cashew apple juice; roasted kernel eaten as a dessert nut, also in confectionery; pericarp yields the toxic cashew nut-shell liquid - caustic nut shell liquid used in brake linings, clutches, plastic resins, etc.	Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1982; Rosengarten, 1984; FAO, 1986; Mabberley, 1987; Purseglove, 1987; Bianchini et al.,1988; Verheij and Coronel, 1991
Anacardium rhinocarpus South America	wild cashew	edible fruit, eaten like cashew	Hedrick, 1972

[1] Some agricultural crops (e.g. some species of the Cucurbitaceae) are included in this list for their potential as agroforestry species.

Species and distribution	Common name	Details	References
Antrocaryon micraster West Africa		fruit pulp edible, may be made into a fermented beverage; seeds difficult to extract, kernel edible, rich in oil; timber for planks and furniture	Menninger, 1977; Mabberley, 1987; Peters et al., 1992
Buchanania latifolia India, Myanmar, Laos, Thailand, Vietnam, Yunnan	almondette; cheronjee; Cuddapah almond; Hamilton mombin	medium sized tree; fruit black, 1-seeded, kernels pear-shaped, 1 cm long, oily, edible, delicious with a combination of almond and pistachio flavours - known as "almondettes" occasionally imported into Europe, eaten raw or roasted or in sweetmeats, pounded and dried fruits made into bread in India, seed oil a substitute for almond or olive oil; bark and fruit yield a varnish; bark used in tanning; browsed; gum used in traditional medicine against leprosy; wood for fuel; trees grown for erosion control kernel 51.8% oil, 12.1% protein, 21.6% starch, 5% sugars	Howes, 1948; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Verheij and Coronel, 1991; Macrae et al., 1993
Gluta elegans Malaysia	rengas	seeds edible; sap can cause dermatitis	Menninger, 1977
Gluta renghas Malesia	rengas	roasted seeds eaten; timber useful but sap can cause dermatitis	Menninger, 1977; Mabberley, 1987; Purseglove, 1987
Gluta velutina Malaysia	rengas	seeds edible; sap can cause dermatitis	Menninger, 1977
Lannea schweinfurthii var. *stuhlmannii* East Africa		raw fruit eaten, seeds crushed, boiled with salt and eaten as a relish, bark made into a tisane	Menninger, 1977; Peters et al., 1992
Mangifera altissima Solomon Islands to Philippines; cultivated	medang	evergreen tree; immature fruit eaten raw, pickled or mixed with vegetables; ripe fruit eaten or used in preserves; seeds salted and pounded for an edible meal; wood for general construction and indoor woodwork, not durable; locally marketed	Verheij and Coronel, 1991

Species and distribution	Common name	Details	References
Mangifera indica Indo-Malesia; widely cultivated in the tropics and subtropics	mango	evergreen tree; drupe flesh eaten or made into chutney, pickles, squashes, commercially marketed; starchy kernels eaten roasted or dried and pickled, a source of flour and famine food; seed kernel meal fed to cattle and poultry; young leaves eaten as a vegetable; timber for fuel (excellent charcoal), tea-chests and floor-boards	Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Purseglove, 1987; Verheij and Coronel, 1991
Mangifera kemanga Peninsular Malaysia, Sumatra, Borneo; commercially cultivated	kemang	tree; ripe fruit eaten fresh, pickled or made into a juice; fresh, grated seeds sometimes eaten; young leaves eaten	Verheij and Coronel, 1991
Mangifera odorata not known in wild; cultivated in Sumatra, Borneo and Java	kuwini	tree; fruit peeled to remove acrid skin, eaten fresh or made into chutneys and pickles; seed kernel made into a flour; bark used in traditional medicine; thrives in areas too wet for *M. indica*	Verheij and Coronel, 1991
Pistacia mexicana S. Mexico to Guatemala		seeds edible	Hedrick, 1972; Menninger, 1977
Pistacia terebinthus Mediterranean	terebinth; Cyperus turpentine	kernel sweet, edible; source of tan galls; formerly source of turpentine	Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Pistacia texana Texas to central Mexico	Texas pistacio	dioecious shrub or tree; with small, nut-like drupe <1 cm long	Krochmal, 1982
Pistacia vera Iran to central Asia; widely cultivated in Mediterranean and USA	pistachio	seed eaten as dessert nut, the pistachio nut of commerce, used in ice-cream and confectionery	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988;
Pleiogynium timoriense Queensland	Burdekin or sweet plum	fruit used in jams and jellies; timber good; ornamental street tree	Hedrick, 1972; Menninger, 1977; Mabberley, 1987

Species and distribution	Common name	Details	References
Sclerocarya birrea		dioecious tree	
subsp. *birrea*		fruit flesh used to make alcoholic beverage; kernel oily, eaten	Hedrick, 1972; Menninger, 1977
N. tropical Africa		dioecious tree; fruit eaten, flesh rich in vitamin C, stone contains 2-3 highly nutritious embryos	
subsp. *caffra*			Hedrick, 1972; Menninger, 1977; Arnold et al. 1985; Peters et al. 1992
E. and southern Africa	marula		
Semecarpus anacardium India; cultivated in tropical Asia, Australia and Africa	marking nut; varnish tree; Australian corkscrew; oriental cashew	ripe fruit collected, acrid and astringent when fresh, juice of which a strong skin irritant, kernels eaten roasted flavour of roasted apples, dried with taste like dates; roasted pedicel eaten; sap of unripe fruit mixed with lime used for marking linen, hence vernacular name; pericarp contains *ca.* 9% of an irritating oil used in traditional medicine and industrially in lacquers, paints and insulating material; wood used for charcoal	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Tow, 1989; Verheij and Coronel, 1992
Semecarpus vitiensis New Caledonia, Fiji		kernel eaten, care required to avoid fruit blistering latex,	Hedrick, 1972; Menninger, 1977
Spondias mombin tropical America; occasionally cultivated	yellow Spanish or yellow mombin; jobo; hog plum	fresh fruit pulp eaten raw, cooked, in confectionery or fermented; seed eaten; young leaves eaten as a vegetable; wood used for boxes, pulp or fuel; browsed by cattle and pigs; melliferous; grown as shade tree	Hedrick, 1972; Menninger, 1977; Mabberley, 1978; FAO, 1982, 1986 Verheij and Coronel, 1991
Trichoscypha longifolia West Africa		oily kernel eaten	Menninger, 1977; Peters et al., 1992
ANISOPHYLLEACEAE; fruit indehiscent, woody to drupaceous			
Poga oleosa W. tropical Africa	inoi nut, African Brazil nut, m'poga	nuts with hard, bony shell, marketed locally; seed kernel eaten; seed oil used for cooking; formerly exported to Liverpool as oilseed	Howes, 1948; Menninger, 1987; Mabberley, 1987; Peters et al., 1992
ARALIACEAE; fruit usually a drupe or berry			

Species and distribution	Common name	Details	References
Panax trifolius E. North America	groundnut	herb with slightly pungent, edible, subglobose rootstock	Howes, 1948
BIGNONIACEAE; fruit a 2-valved capsule, rarely fleshy and indehiscent			
Crescentia alata W. Central America	Mexican calabash	ripe seeds a popular festival food	Menninger, 1972
Crescentia cujete tropical America and Caribbean; cultivated	calabash tree	young fruit pickled, flesh not very palatable; seeds cooked and eaten and used to make a drink in Nicaragua, source of a syrup and oil; woody pericarp used for bowls, etc.	Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Purseglove, 1987
Kigelia africana tropical Africa	sausage tree	fruit pulp and bark used for making beer; roasted seeds famine food; fruit purgative	Hedrick, 1972; Menninger, 1977; Mabberley 1987; Peters et al., 1992
Oroxylum indicum Philippines	midnight horror; pinkapinkahan	seeds eaten; leaves cooked as a vegetable; bark bitter, used medicinally; bark and fruits source of dye used in rattan basketry, also for tanning; wood used for fuel	Menninger, 1977; FAO, 1986; Mabberley, 1987
Parmentiera cereifera Panama; cultivated	candle tree; cuachilote	fruit and seeds eaten in Mexico; fodder source	Menninger, 1977; Mabberley, 1987; Purseglove, 1987
BOMBACACEAE; fruit a locucidal capsule, rarely fleshy and indehiscent			

Species and distribution	Common name	Details	References
Adansonia digitata tropical Africa; occasionally cultivated	baobab	Pulp eaten raw, seed kernel eaten raw, roasted or boiled; bark for cloth and cordage; all parts of the tree utilised; grown as an avenue tree and ornamental	Hedrick, 1972; Menninger, 1977; FAO, 1982; Wickens, 1982; Mabberley, 1987; Purseglove, 1987; Verheij and Coronel, 1991; Peters et al., 1992
Adansonia gregorii West Australia	baobab	seeds eaten by Aborigines; source of fibre	Menninger, 1977; Lazarides and Hince, 1993
Ceiba pentandra tropical South America; widely cultivated	kapok or silk cotton tree	young fruit edible; seeds eaten pounded in soup or roasted, source of edible oil; oil used as lubricant, illuminant, soap and paints; hairs from carpel walls the kapok of commerce; wood used for matches	Menninger, 1977; Mabberley, 1987
Durio ziberthinus W. Malesia; widely cultivated in Malaysia	durian; civet fruit	malodorous but highly esteemed fruit, aril of unripe fruit eaten as a vegetable; boiled or roasted seeds eaten; rind used for fuel; wood light, used for cheap furniture, etc.; plant used in traditional medicine	Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Purseglove, 1987
Pachira aquatica tropical America, estuaries; cultivated	Guyana or Malabar chestnut	delicious chestnut-flavoured seeds roasted and eaten, contain *ca.* 50% oil; young leaves and flowers eaten as vegetable; bark source of red dye, fibre for cordage; wood suitable for paper-making	Hedrick, 1972; Menninger, 1977; FAO, 1986; Mabberley, 1987
Pachira insignis Central America	maranhao nut	seeds eaten; young leaves and flowers also eaten	Hedrick, 1977; Menninger, 1977
Rhodognaphalon schumannianum tropical Africa		seeds cooked and eaten	Peters et al., 1992

Species and distribution	Common name	Details	References
BURSERACEAE; fruit a drupe with 1-5 1-seeded stones or 1 stones with all seeds, rarely a capsule			
Boswellia serrata India; cultivated	Indian olibanum	tree; flowers and seeds eaten; wood used to make paper and tea chests, fuel; cultivated for its fragrant gum-resin	Menninger, 1977; Mabberley, 1987
Canarium album S. China, Vietnam; cultivated	canarium; Chinese olive	tree; fruit pulp and seeds edible, sold on the world market; wood and resin sometimes used; grown as an ornamental	Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991
Canarium harveyi Solomon Islands	Santa Cruz Ngallinut	oily nut edible; oil used locally for cosmetics; potential for development	Pelomo, 1993
Canarium indicum Malaysia to Melanesia; cultivated	Java almond; kanari or ngali nut	tall buttressed tree, drupe, endocarp hard, thin and brittle, triangular in cross section, c 3 g, seeds 3; oily "pili" nuts (seeds) eaten after removal of testa raw or roasted, eaten in Sri Lanka as a dessert nut, made into bread in the Celebes, highly esteemed in Melanesia where several races cultivated; fresh seed oil mixed with food, also used as an illuminant; grown as a shade tree	Hawes, 1948; Leenhouts, 1956; Hedrick, 1972; Menninger, 1977; Verheij and Coronel, 1991; Macrae et al., 1993; Pelomo, 1993
Canarium littorale Malaysia		nuts small, hard-shelled, kernel edible	Menninger, 1977
Canarium luzonicum S.E. Asia	Java almond, pili nut, elemi	"oily pili" nuts edible; seed oil source of "Manila elmi" for varnishes, etc.	Howes, 1948; Menninger, 1977; Mabberley, 1987
Canarium muelleri Queensland		deciduous tree; nuts very small, eaten by Aborigines	Menninger, 1977; Lazarides et al., 1993
Canarium ovatum Philippines; cultivated	pili or Philippine nut	evergreen tree; oily "pili" nuts eaten raw or roasted as a dessert nut or used commercially in confectionery, emulsion of kernels used as milk substitute; seed oil edible, source of "Manila elmi" for varnishes, etc., also used as an illuminant; young shoots edible; shell used for fuel and carving; grown as an avenue tree and windbreak	Howes, 1948; Leenhouts, 1956; Menninger, 1977; Rosengarten, 1984; Verheij and Coronel, 1991

Species and distribution	Common name	Details	References
Canarium pateninervium Thailand, Peninsular Malaysia; Sumatra, Borneo	kedondong	tree; seeds eaten; soft, light wood used for fuel	Verheij and Coronel, 1991
Canarium pilosum Indonesia, Malaysia, Brunei	damar lilin	tree; seeds sweet, eaten; wood durable used for houses; resin used to close wounds	Verheij and Coronel, 1991
Canarium pimela S. China, Hainan, Indo-China, Borneo; cultivated	Chinese black olive	tree; oily "pili" nuts edible, fruit candies or pickled; sold on the world market; wood and resin sometimes used; fruit and leaves used in local medicine	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991
Canarium salomonense Solomon Islands, New Guinea	adoa	oily nut edible; oil used locally for cosmetics; potential for development	Pelomo, 1993
Canarium schweinfurthii tropical Africa	African elemi; incense or bush candle tree	oily nut edible, marketed locally; oily pericarp eaten raw, seeds cooked and eaten, seed oil substitute for shea butter from *Vitellaria paradoxa;* stained timber used as mahogany substitute; oleo-gum exudate source of incense	Menninger, 1977; Burkill, 1985; Mabberley, 1987; Peters et al., 1992
Canarium sylvestre Ambon		oily "pili" nuts edible	Hedrick, 1972
Canarium vrieseanum Indonesia, Philippines	solo	tree; seeds edible; resin burnt as an illuminant; tough wood used in construction	Verheij and Coronel, 1991
Canarium vulgare Moluccas; cultivated	Chinese olives, Java almond, wild almond	oily "pili" nuts eaten in Sri Lanka as a dessert nut, made into bread in the Celebes; fresh seed oil mixed with food, also used for lamps; grown as a shade tree and in plantations;	Howes, 1948; Menninger, 1977
Santira trimera West Africa		fruits smelling of turpentine, edible, marketed locally; oily seeds edible	Menninger, 1977; Burkill, 1985

Species and distribution	Common name	Details	References
Canarium pateninervium Thailand, Peninsular Malaysia; Sumatra, Borneo	kedondong	tree; seeds eaten; soft, light wood used for fuel	Verheij and Coronel, 1991
Canarium pilosum Indonesia, Malaysia, Brunei	damar lilin	tree; seeds sweet, eaten; wood durable used for houses; resin used to close wounds	Verheij and Coronel, 1991
Canarium pimela S. China, Hainan, Indo-China, Borneo; cultivated	Chinese black olive	tree; oily "pili" nuts edible, fruit candies or pickled; sold on the world market; wood and resin sometimes used; fruit and leaves used in local medicine	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991
Canarium salomonense Solomon Islands, New Guinea	adoa	oily nut edible; oil used locally for cosmetics; potential for development	Pelomo, 1993
Canarium schweinfurthii tropical Africa	African elemi; incense or bush candle tree	oily nut edible, marketed locally; oily pericarp eaten raw, seeds cooked and eaten, seed oil substitute for shea butter from *Vitellaria paradoxa;* stained timber used as mahogany substitute; oleo-gum exudate source of incense	Menninger, 1977; Burkill, 1985; Mabberley, 1987; Peters et al., 1992
Canarium sylvestre Ambon		oily "pili" nuts edible	Hedrick, 1972
Canarium vrieseanum Indonesia, Philippines	solo	tree; seeds edible; resin burnt as an illuminant; tough wood used in construction	Verheij and Coronel, 1991
Canarium vulgare Moluccas; cultivated	Chinese olives, Java almond, wild almond	oily "pili" nuts eaten in Sri Lanka as a dessert nut, made into bread in the Celebes; fresh seed oil mixed with food, also used for lamps; grown as a shade tree and in plantations;	Howes, 1948; Menninger, 1977
Santira trimera West Africa		fruits smelling of turpentine, edible, marketed locally; oily seeds edible	Menninger, 1977; Burkill, 1985

Species and distribution	Common name	Details	References
CAPPARACEAE; fruit often a berry, rarely a nut or drupe			
Boscia angustifolia tropical Africa to Saudi Arabia	kursan	evergreen tree; berries bitter, edible, cooked seeds eaten; leaves and bark used in tisanes; browsed; wood hard, used for local carpentry; variously used in local medicine	Menninger, 1977; Burkill, 1985; Peters et al., 1992
Boscia senegalensis Sahel		evergreen shrub; berries marketed locally, fruit pulp, seeds and leaves eaten after leaching for 3-4 days and cooked, regarded as famine food, roasted seeds used as coffee substitute; wood used for huts; smoky firewood	Hedrick, 1972; Menninger, 1977; Burkill, 1985; Peters et al., 1992
Buchholzia coriacea West Africa; rain forest	musk tree	evergreen tree; fruit thick-skinned, with disagreeable odour, boiled and eaten, seeds used as condiment, aril chewed; seeds used medicinally; bark and leaves used medicinally	Menninger, 1977; Burkill, 1985; Peters et al., 1992
CARYOCARACEAE; fruit a drupe, stone separating into 4 1-seeded pyrenes			
Caryocar amygdaliferum Colombia	suari nut; sawarri nut; caryocar; almendron	seeds woody; almond-flavoured kernels roasted and eaten, source of pleasant-tasting sawarri or suari fat used in cooking; fruit used for treating leprosy; fruit pulp used as fish poison	Uphof, 1968; Hedrick, 1972; Prance and Freitas, 1973; Usher, 1974; Menninger, 1977; Mabberley, 1987
Caryocar amygdaliforme Peru	caryocar	almond-flavoured kernels edible	Hedrick, 1972; Menninger, 1977
Caryocar brasiliense Brazil; occasionally cultivated	pequí; piquí; piquia-oil plant	tree, drupe 2-seeded, mesocarp fleshy, endocarp woody, muricate, stewed kidney-shaped; fruit pulp eaten, mainly as a flavouring, laxative, source of an edible oil; kernels source of an edible fat; wood used for construction, fences and fuel	Hedrick, 1972; Menninger, 1977; FAO, 1986; Clay and Clement, 1993; Dantas de Araujo, 1995

Species and distribution	Common name	Details	References
Caryocar coriaceum N.E. Brazil		fruit pulp oily, eaten; spiny seed shell difficult to remove, kernel oily, highly esteemed for food; fruit oil extracted and used in cooking	Prance and Freitas, 1973; Menninger, 1977
Caryocar glabrum N.E. South America; cultivated	almendro; piquia-rana	kernels eaten fresh, boiled or roasted by natives; timber used for shipbuilding; epicarp used as fish poison; inner bark used for washing hair and clothes	Howes, 1948; Hedrick, 1972; Prance and Freitas, 1973; Menninger, 1977; FAO, 1986; Clay and Clement, 1993
Caryocar nuciferum Guianas; cultivated in the Caribbean, Surinam, Malaysia	souari or swarri nut; butternut	large tree; fruit globose, soft wooded capsules *ca.* 15 cm in diameter; pulp yellow, edible; 2-5 pyrenes kidney-shaped, up to 5 cm long with very hard, woody shell up to 1 cm thick, hard to crack; seeds white, almond flavoured, eaten raw or roasted, source of pleasant-tasting fat. Nuts occasionally marketed in Europe, used for billiard balls; timber for shipbuilding	Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1982; Prance and Freitas, 1973; Rosengarten, 1984; Mabberley, 1987; Verheij and Coronel, 1991; Clay and Clement, 1993; Macrae et al., 1993
Caryocar villosum N.E. South America, Atlantic Brazil to French Guiana	amêndoa de espinho; arbre à beurre; bats sauari; pekea; pequiá; piquiá	rainforest; kernel, seed pulp and cotyledons edible, kernel and surrounding tissue source of oil; timber for heavy construction and shipbuilding; introduced into Malaysia but plantations low yielding. Potential for development of fruit and oil	Howes, 1948; Prance and Freitas, 1973; Menninger, 1977; FAO, 1986; Clay and Clement, 1993; Prance, 1994
CHRYSOBALANACEAE; fruit a 1-seeded drupe			
Chrysobalanus icaco tropical America and Africa; cultivated	cocoplum; icaco	shrub or small tree; cultivated for its edible fruit; kernel delicious, fruit eaten raw, boiled or candied; seed oil used as an illuminant in West Africa; source of timber and fuel; fruit used in tanning and traditional medicine; grown as an ornamental	Hedrick, 1972; Menninger, 1977; Burkill, 1985; Mabberley, 1987; Verheij and Coronel, 1991; Peters et al., 1992

Species and distribution	Common name	Details	References
Couepia edulis Amazonia; occasionally cultivated	cutia nut; castanha de cutia	large forest tree; fruit with hard, woody epicarp, very difficult to crack, ovoid; nut-like kernels, eaten raw or roasted, contains 73% oil, used for cooking and soap-making	Mabberley, 1987; FAO, 1986; Clay and Clement, 1993; Prance, 1994
Couepia longipendula Brazilian, Colombia and Peruvian Amazonia; formerly cultivated around Manaus, some experimental plantations	pendula nut; castanha de galinha; castanha pêndula	forest tree, bushy tree in open under cultivation; drupe 4-6 cm long, epicarp thin, mesocarp fibrous, woody; nut 3-5 cm long, sweet, eaten raw or roasted; edible seed oil semi-drying, easily rancifies, used as an illuminant; seed cake edible. Wood heavy, difficult to work, used in civil and naval construction. Excellent potential oil plant.	Clay and Clement. 1993; Prance, 1994
Parinari campestris Trinidad, Guyana to N. Brazil		drupe small, kernel edible	Hedrick, 1972
Parinari curatellifolia tropical Africa	mbula; mupunda	evergreen tree; drupe 3-4 cm long, eaten raw, source of a fermented beverage, oily kernel eaten raw, used as an almond substitute or pounded in soup; drying seed oil used in making varnish or paint; timber for railway sleepers, mine props, fuelwood	Menninger, 1977; FAO, 1982, 1983; Burkill, 1985; Mabberley, 1987; Peters et al., 1992
Parinari excelsa tropical Africa	rough skinned or grey plum	evergreen tree; drupes marketed locally, insipid pulp eaten raw or fermented, oily kernels eaten raw	Hedrick, 1972; FAO, 1983; Burkill, 1985; Peters et al., 1992
Parinari montana Guyana, N. Brazil		drupe large, fibrous, with thick, acrid rind, kernel sweet, edible	Hedrick, 1982

COMBRETACEAE; fruit usually indehiscent, 1-seeded, drupaceous

Species and distribution	Common name	Details	References
Terminalia bellerica Indo-Malesia; cultivated	myrobalm	kernels eaten, possibly toxic or narcotic; seed source of tannin and black dye; timber good, source of firewood and charcoal; fruit source of commercial myrobalm, used for tanning, source of a black dye	Exell, 1954; Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Terminalia bentzoë Mascarine Islands	false benzoin	kernels eaten	Hedrick, 1972; Menninger, 1972
Terminalia catappa Peninsular Malaysia; widely planted in tropics	Barbados, Indian, Malabar or tropical almond	kernel enclosed in fibrous flesh and difficult to open, limiting its commercial exploitation; kernels eaten raw or roasted, delicious, source of Indian almond oil; oil cake fed to pigs; timber used for general construction; bark for tanning; grown as shade tree and ornamental; oil, leaves and bark medicinal	Howes, 1948; Coode, 1969; Hedrick, 1972; Thaman, 1976; Menninger, 1977; FAO, 1982; Rosengarten, 1984; Morton, 1985; Mabberley, 1987; Tow, 1989
Terminalia chebula India, Sri Lanka, Myanmar	myrobalan	fruit difficult to open, kernel edible; dried fruit for tanning	Menninger, 1977; Mabberley, 1987
Terminalia copelandii East Indies, Philippines		kernels edible; source of timber	Exell, 1954
Terminalia glabrata Pacific Islands		kernels eaten, almond flavoured	Hedrick, 1972; Menninger, 1977
Terminalia impediens New Guinea		kernels edible	Coode, 1969
Terminalia kaernbachii Papuasia; cultivated	okari nut	tree; kernels excellent, one of the best-flavoured, tropical nuts and a favourite article of diet among the natives; wood used for furniture	Exell, 1964; Coode, 1969; Mabberley, 1987; Verheij and Coronel, 1991; Macrae et al., 1993
Terminalia latifolia Caribbean		kernels eaten, almond flavoured	Hedrick, 1972

Species and distribution	Common name	Details	References
Terminalia litoralis Fiji, Tonga		kernels edible, sometimes eaten by children; useful timber	Smith, 1971; Hedrick, 1972; Menninger, 1977
Terminalia microcarpa Philippines	kalumpit	fruit 3 cm in diameter; fleshy, acidic kernels eaten raw or boiled; timber for general construction, ship planking, furniture and cabinet making	FAO, 1984
Terminalia nitens Philippines	sakat	fruit oval, 3 cm long; raw kernel eaten; timber for construction and ship planking	FAO, 1984
Terminalia pamea Guyana; cultivated		kernels eaten, almond flavoured	Hedrick, 1972; Menninger, 1977
Terminalia platyphylla N. Australia	wild plum	kernels eaten	Smith, 1971; Hedrick, 1972
COMPOSITAE; fruit usually a cypsela, usually with persistent pappus, rarely a drupe			
Helianthus annuus North America; widely cultivated	sunflower	seeds eaten as a dessert nut and health food, boiled or roasted, ground to a flour or in soup; source of a commercial seed oil used in cooking and margarine; stem a flax substitute; oilcake and leaves used as fodder; cultivated as an ornamental	Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Purseglove, 1985; Mabberley, 1987
CORYLACEAE; fruit a nut			
Corylus americana E. North America; cultivated	American filbert or hazelnut	nuts with edible seeds,well flavoured but smaller and thicker shelled than *C. avellana*; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; Krochmal, 1982; Mabberley, 1987

Species and distribution	Common name	Details	References
Corylus avellana Eurasia, cultivated	filbert, hazel or cob nut	shrub bearing nuts with edible seeds, seeds marketed commercially, source of edible filbert oil; coppice poles used for hurdles, wattle and daub and firewood; basketry; hybridizes readily with *A. maxima*	Bobiov, 1936; Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988;
Corylus chinensis China	Chinese hazelnut, Chinese filbert	Nuts with edible seeds	Howes, 1948
Corylus colurna S.E. Europe, S.W. Asia; cultivated	Turkish or Indian hazelnut, Turkish filbert,	tree bearing hard-shelled nuts with edible seeds, nuts marketed commercially as cobnuts, kernels sometimes processed for oil; wood used for furniture and turnery, formerly used for spinning wheels	Bobiov, 1936; Howes, 1948; Hedrick, 1972; Mabberley, 1987; Rathore, 1993
Corylus cornuta N.E. North America	beaked filbert; beaked hazel	nuts with well-flavoured, edible seeds; more cold hardy than *C. americana*	Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 19982
Corylus ferox Himalayan region	Himalayan hazelnut, curri	nuts small, thick shelled with edible seeds but bristly involucre limits its commercial exploitation for food	Howes, 1948; Hedrick, 1972
Corylus heterophylla E. Mongolia, Manchuria, N. China; cultivated Japan	Siberian hazelnut	nuts with edible seeds, marketed commercially	Bobiov, 1936
Corylus maxima S.E. Europe; cultivated	giant filbert, Lambert's or Lombardy filbert,	shrub or small tree bearing nuts with edible seed; seed oil for cooking, confectionery, especially nut-chocolate, formerly used for paint, soap, etc.; charcoal used for gunpowder; hybridizes readily with *A. avellana*	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Bianchini et al., 1988;
Corylus sieboldiana (including var. *mandshsurica*) China, Japan	Japanese hazel	nuts edible but bristly involucre limits its commercial exploitation for food	Bobiov, 1936

Species and distribution	Common name	Details	References
Corylus tibetica China	Tibetan hazelnut, Tibetan filbert	nuts with edible seeds but bristly involucre limits its commercial exploitation for food	Howes, 1948; Roecklein and Ping Sun Leun, 1987
CORYNOCARPACEAE ; fruit a drupe			
Corynocarpus laevigata New Zealand	karaka nut, New Zealand laurel	tree, roasted seeds staple food of the Maoris, new seeds toxic unless steamed for a day and soaked; fleshy pulp eaten raw although embryo considered toxic unless soaked in salt water	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987
CUCURBITACEAE; fruit a berry (pepo if hard-walled), less often a capsule, rarely samaroid			
Acanthosicyos horrida Namib desert	nara; narram; narra melon; butter nut	spiny shrub; gourd pulp and seeds eaten by Hottentots; seeds oily, marketed in Cape Town as almond substitute	Howes, 1948; Menninger, 1977; Arnold et al., 1985; Mabberley, 1987
Citrullus lanatus tropical Africa and Asia; cultivated	watermelon	seeds eaten raw or roasted as a dessert nut; raw pulp also eaten, seed oil used for cooking, soap and as an illuminant; seedcake fed to livestock; also used as a masticatory and in local medicine	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Purseglove, 1987; Peters et al., 1992
Cucurbita maxima Central and South America; cultivated	pumpkin; winter squash	annual herb; flesh of mature fruits fine-textured, used as a table vegetable, in pies and jams; seeds eaten as a dessert nut	Rosengarten, 1984; Purseglove, 1987
Cucurbita mixta Central America; cultivated	pumpkin; winter squash; cushaw	annual herb; seeds eaten as a dessert nut, flesh stringy	Rosengarten, 1984; Purseglove, 1985

Species and distribution	Common name	Details	References
Cucurbita moschata Central America; cultivated	pumpkin, winter squash	annual herb; flesh of mature fruits fine-textured, used as a table vegetable, in pies and jams; seeds eaten as a dessert nut	Rosengarten, 1984; Purseglove, 1987
Cucurbita pepo Central America; cultivated	pumpkin; summer squash; vegetable marrow	annual herb; seeds eaten raw, roasted or fried as a dessert nut or in food; baked pulpy flesh eaten in pies; pulp fed to livestock; some cultivars grown as an ornamental; used as a vermifuge	Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Purseglove, 1987
Telfairia pedata E. Africa; cultivated	oyster nut; African pumpkin; Zanzibar oil vine	dioecious, woody stemmed, climbing vine; gourd large, <15 kg, deeply ridged, seeds discoid, 3-4 x 1.5 cm, up to 140, enveloped in fibrous, bitter husk; seeds washed, sundried and dehusked; kernel eaten raw or roasted and in cooking, Brazil nut flavour, seed oil used in cosmetics, soap- and candle-making; the bitter husk limits its commercial exploitation as an oilseed kernel *ca.* 6% fat, 27% protein, rich in edible oil	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Peters et al., 1992; Macrae et al., 1993
DIPTEROCARPACEAE; fruits, dry, indehiscent, 1-seeded with woody pericarp			
Anisoptera thurifera Philippines	palosapis	deciduous forest tree; fruit 2-15 mm in diameter; seeds eaten raw or roasted	FAO, 1984
Shorea sp. Malaysia, Borneo, New Guinea	Borneo illipe nut	emergent rainforest tree; kernels commercial source of speciality fats (cocoa butter equivalents) used as cocoa butter substitute in chocolate formulations also in cosmetics, formerly important for soap and candles; valuable timber tree	Blicher-Mathiesen, 1994; Howes, 1948; Menninger, 1977; Mabberley, 1987;
Vateria indica S. India	dammar	seeds used for making a bread; seed fat - "Malabar fat" or "dhupa fat" used for candles, etc.; resin - "white dammar" or "piney varnish" formerly important	Hedrick, 1972; Menninger, 1977; Mabberley, 1987

Species and distribution	Common name	Details	References
ELAEOCARPACEAE; fruit a capsule or drupe			
Elaeocarpus bancroftii Australia	karanda nut; Johnstone River almond; karanda quandong	nut edible, excellent flavour, equalling that of *Macadamia*; virtually unknown in cultivation, CSIRO interested in developing; timber	Mabberley, 1987; Tow, 1989; Lazarides and Hince, 1993
EUPHORBIACEAE; fruit a 3-lobed capsule			
Aleurites moluccana S.E. Asia; widely cultivated in the tropics	candle-nut; candleberry; balucanat; Indian or Otaheite walnut	fruit fleshy; nut 1, globose, *ca.* 3 cm in diameter, shell harsh, thick, kernel white, oily, *ca.* 5 g; kernels eaten when thoroughly dry or after roasting to destroy mild toxins, used in curries; source of the edible "China wood oil", "candle-nut oil", "lumbang oil", "walnut-oil" or "artist's oil", used in soaps, paints and quick-drying varnishes and as an illuminant; oily seeds strung together serve as candles, hence vernacular name; cultivated as an ornamental; wood not durable, used for fuel and matches	Howes, 1948; Hedrick, 1972; Rosengarten, 1984; Mabberley, 1987; Tow, 1989; Lazarides and Hince, 1993; Macrae et al., 1993; Burkill, 1994
Caryodendron amazonicum NW Brazil, Colombia, Peru		Possibly cospecific with *C. orinocense*; uses as for *C. orinocense*	Reckin, 1983; Clement and Villachica, 1994
Caryodendron orinocense Colombia, Ecuador, Venezuela; small plantations in Colombia and Ecuador	inchi; tacay or taccy nut; orinoco nut	kernel surrounded by thin shell, easily broken with fingers; roasted seeds eaten, flavour like *Corylus avellana* (hazel); source of edible oil.	Howes, 1948; Menninger, 1977; Reckin, 1983; Mabberley, 1987; Clement and Villachica, 1994

Species and distribution	Common name	Details	References
Cnidoscolus oligandrus Brazil		seeds with 40-50% oil, eaten in times of drought	Menninger, 1977
Elateriospermum tapos S. Thailand, Peninsular Malaysia	tapos	seeds large, oily, eaten after boiling to remove HCN	Menninger, 1977; Mabberley, 1987
Manniophytom fulvum Tropical Africa	gasso nut	seed kernel boiled and eaten, marketed locally; seed contains 50% oil, source of a drying oil formerly considered for paint manufacture; liane with fibres used for ropes and nets	Howes, 1948; Menninger, 1977; Mabberley, 1987; Peters et al., 1992
Omphalea diandra Caribbean	cobnut	seeds edible, embryo deleterious and requires removal	Howes, 1948; Hedrick, 1972; Menninger, 1977
Omphalea megacarpa Caribbean	Russell river nut	large nuts eaten raw	Menninger, 1977
Omphalea triandra tropical America	Jamaican cob nut	seeds eaten raw or roasted after removal of deleterious embryo, source of a sweet, fine-flavoured oil	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Phyllanthus emblica tropical Asia; cultivated	emblic; ambal	seeds edible, made into sweetmeats; dried fruit provides "emblic myrobalan", used in local medicine and source of tanbark and dyes	Hedrick, 1972; Menninger, 1977; Mabberely, 1987
Pimelodendron amboinicum Moluccas		seeds edible; bark purgative; milky latex used as a varnish	Menninger, 1977; Mabberely, 1987
Plukenetia conophora Sierra Leone to Zaire	owusa nut	liane cultivated for its oilseeds for use in cooking; kernels eaten raw	Howes, 1948; Menninger, 1977; Mabberely, 1987
Ricinodendron heudelotii tropical Africa	erimado	edible nuts and oilseeds; trade timber	Menninger, 1977; Mabberley, 1987

Species and distribution	Common name	Details	References
Schinziophyton rautanenii S. Angola and N. Namibia eastwards to Tanzania and N. Mozambique	manketti nut	Raw pulp and seed kernel eaten, a staple diet of the Kalahai bushmen; manketti nut oil used in food, varnishes, etc. timber used as a balsa *Ochroma lagopus*, substitute with possible use for paper-making	Howes, 1948; Menninger, 1977; Mabberley, 1987; Peters et al., 1992
Tetracarpidium conophorum West Africa; cultivated	conophor; awusa nut	lianne; seed eaten raw or roasted, marketed locally; fruit, leaves and young shoots edible; source of a drying oil	Menninger, 1977; Mabberley, 1987; Peters et al. 1992
FAGACEAE; fruit a nut			
Castanea crenata Japan; cultivated	Japanese chestnut	nuts variable in size, some 5 cm in diameter, edible but bitter due to tannin content; fed to pigs in Japan; timber used for sleepers, furniture, cabinet work, shipbuilding; cultivated, resistant to chestnut blight, grown as an ornamental	Camus, 1929; Howes, 1948; Uphof, 1968; Usher, 1974; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987
Castanea dentata E. North America	American or North American chestnut; sweet chestnut	nuts smaller and sweeter than *C. sativa*; best trees almost extinct due to chestnut blight, *Cryphonectria parasitica* and commercial market ruined; marketed and sold roasted in towns; eaten by native Americans, also leaf tea used to treat whooping cough, as sedative and tonic, bark for dysentery; important timber for furniture, fencing, pulp and source of tannin	Camus, 1929; Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987
Castanea henryi China coast		nuts excellent, small, edible; timber for building	Camus, 1929; Howes, 1948; Uphof, 1968; Usher, 1974
Castanea mollisima N.W. China; cultivated China, introduced North America	Chinese chestnut	nuts edible, sweeter than *C. sativa* but less sweet than *C. dentata,* resistant to chestnut blight; cultivated and sold in local markets; source of timber and fuel	Camus, 1929; Howes, 1948; Uphof, 1968; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984

Species and distribution	Common name	Details	References
Castanea ozarkensis central USA; limestone	ozak chinquapin	nuts small, edible	Krochmal, 19982
Castanea pumila E. North America; cultivated	Virginia chestnut; chinquapin; Allegheny chinquapin	evergreen tree; nuts small, sweet, very palatable but difficult to shell, eaten by local Americans, formerly sold locally; nuts used to fatten pigs; also strung to make necklaces; root astringent, used as tonic and to treat fevers; timber for railway sleepers	Camus, 1929; Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Mabberley, 1987
Castanea sativa Mediterranean to Caucasus; cultivated in mild temperate Europe and subtropical regions	Spanish or sweet chestnut	tree; nuts starchy, sold roasted, flour used in cooking, especially in Italy, candied (marrons glacés); timber used for sleepers, coppice timber for fencing, gates, walking sticks, cellulose; bark used in tanning; cultivated as ornamental and for erosion control	Camus, 1929; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Mabberley, 1987; Bianchini et al., 1988; Verheij and Coronel, 1991
Castanea seguinii E. and central China		nuts small, edible, used for flour	Camus,1929; Uphof, 1968; Usher, 1974
Castanopsis acuminatissima Myanmar	gon	nuts eaten raw or cooked	Menninger, 1977
Castanopsis argentea Indo-Malesia		seeds edible; bark source of dye; timber	Mabberley, 1987; Verheij and Coronel, 1991
Castanopsis argyrophylla India		nuts edible	Menninger, 1977
Castanopsis boisii N. Vietnam		nuts edible, marketed locally	Uphof, 1968; Usher, 1974
Castanopsis chinensis China		nuts edible	Menninger, 1977

Species and distribution	Common name	Details	References
Castanopsis chrysophylla S.W. USA	golden-leaved chestnut; golden or giant chinquapin	tree evergreen; nuts ripen in second year, 8-12 mm long, sweet, eaten by native Americans; wood used for agricultural implements	Howes, 1948; Uphof, 1968; Usher, 1974; Krochmal, 1982; Mabberley, 1987
Castanopsis costata Thailand, Peninsular Malaysia, Borneo, Sumatra; lowland to submontane forest	berangan duri	tree; nuts eaten parched, roasted or boiled, used in confectionery; wood hard, difficult to work; bark tannin source	Howes, 1948; Soepadmo, 1972; Menninger, 1977; Verheij and Coronel, 1991
Castanopsis cuspidatus Korea, S. China		acorns small, sweet, eaten boiled or roasted; planted in Japan as an ornamental; leaves formerly used as rice bowls	Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987
Castanopsis hysteris E. Himalayas		nuts eaten; timber for construction, , sleepers, cheap furniture, tools, etc. tannin potential; coppices well	Howes, 1948; CSIR, 1992
Castanopsis indica tropical Himalayas		nuts eaten; timber for construction, panelling, tools, fuel; browsed	Howes, 1948; CSIR, 1992
Castanopsis inermis Thailand, Peninsular Malaysia, Sumatra; cultivated	berangan	nuts eaten boiled, parched or roasted, used in confectionery, marketed in Sumatra; wood hard, difficult to work; bark tannin source	Camus, 1929; Uphof, 1968; Usher, 1974; Menninger, 1977; Verheij and Coronel, 1991
Castanopsis javanica Malesia; forests		cultivated in Java for its edible nuts; post timber; bark used for rice baskets	Howes, 1948; Soepadmo, 1972; Menninger, 1977; Verheij and Coronel, 1991
Castanopsis lucida Thailand, Peninsular Malaysia, Sumatra, Borneo	berangan papan	nuts eaten raw, boiled or roasted, used in confectionery; wood hard, difficult to work; bark tannin source	Menninger, 1977; Verheij and Coronel, 1991

Species and distribution	Common name	Details	References
Castanopsis malaccensis Thailand, Peninsular Malaysia, Sumatra	berangan gajah	nuts eaten raw, boiled or roasted, used in confectionery, causes diarrhoea if eaten to excess; wood hard, difficult to work; bark tannin source	Menninger, 1977; Verheij and Coronel, 1991
Castanopsis megacarpa Malaysia		nuts bitter, eaten	Menninger, 1977; Verheij and Coronel, 1991
Castanopsis philipensis Philippines		nuts eaten; timber	Uphof, 1968; Usher, 1974; Verheij and Coronel, 1991
Castanopsis sclerophylla E. and central China		nuts eaten locally	Uphof, 1968; Usher, 1974
Castanopsis sempervirens California	bush or Dudley sierra chinquapin	nuts eaten by native Americans, good roasted and served with butter and salt	Krochmal, 1982
Castanopsis tibetana China, Tibet		nuts eaten locally	Camus, 1929; Uphof, 1968; Usher, 1974
Castanopsis tribuloides subtropical Himalayas		evergreen tree; nuts roasted and eaten; timber durable, used for planks, shingles and fuel	Howes, 1948; Menninger, 1977; CSIR, 1992
Castanopsis wallichii Thailand, Peninsular Malaysia; forest	berangan duri	tree; nuts small, rind thick and difficult to open, eaten parched, roasted or boiled, used in confectionery; wood hard, difficult to work; bark tannin source	Howes, 1948; Soepadma, 1972; Menninger, 1977; Verheij and Coronel, 1991
Fagus grandifolia E. North America	American, Carolina, red, grey or white beech	nuts shaken from tree after frost has opened husks or raked from the ground; eaten roasted, considered delicious, also as coffee substitute; leaves eaten by some native Americans; leaf infusions used to treat burns, scalds and frost bite; leaves and bark source of tannin and dyes; timber source; cultivated as ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987
Fagus sylvatica Europe; cultivated	European beech	nuts eaten fresh, dried or roasted, in cooking or as coffee substitute, oil source of salad oil and butter substitute, also as an illuminant; timber; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987

Species and distribution	Common name	Details	References
Lithocarpus cornea S. China		evergreen tree; ground acorns eaten, marketed locally; wood used for poles, carpentry, utensils, wagons,	Camus, 1936-54; Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Rosengarten, 1984
Lithocarpus densiflorus Asia, introduced W. USA	tanoak; tanbark oak	acorns mature end of second season; acorns leached in hot water to remove tannins, dried, ground and eaten by native Americans	Krochmal, 1982
Lithocarpus philippinensis Philippines	ulayan	tree; acorns eaten roasted or boiled, also used in candies	FAO, 1984
Nothofagus procera Chile	rauli roble	deciduous tree; acorns edible; timber used for furniture	Menninger, 1977; Hoffmann, 1978; Mabberley, 1987
Quercus aegilops subsp. *persica* Iran, Iraq	manna oak	deciduous tree; acorns used for making bread	Camus, 1936-54; Howes, 1948; Hedrick, 1972; Menninger, 1977
Quercus agrifolia S.W. North America	coast live or Californian field oak	evergreen tree; acorns eaten raw or roasted by native Americans, also ground for baking	Howes, 1948; Hedrick, 1972; Saunders, 1976; Menninger, 1977
Quercus alba E. North America	white or Quebec oak	deciduous tree; acorns sweet, eaten dried, boiled or roasted by native Americans, also ground for baking or used as coffee substitute; important source of construction timber and fuel; basketry	Camus, 1936-54; Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987
Quercus coccifera Mediterranean	kermes oak	evergreen shrub, acorns ripening in second year, formerly eaten	Howes, 1948; Hedrick, 1972; Menninger, 1977;

Species and distribution	Common name	Details	References
Quercus emoryi S. Arizona, New Mexico	Emory or blackjack oak; bellota	evergreen tree; acorns sweet and palatable, eaten by native Americans and Mexicans; timber source; good watershed protection; browsed	Howes, 1948; Kearney and Peebles, 1951; Hedrick, 1972; Menninger, 1977; USDA, 1988
Quercus frainetto Balkans	Hungarian oak	tree; ground acorns used as a coffee substitute; cultivated as an ornamental	Davison, 1994
Quercus gambelii W. North America	Gambel or shin oak	deciduous tree; ground acorns edible, used as flour; browsed by game and livestock	Howes, 1948; Uphof, 1968; Usher, 1974; Mabberley, 1987; USDA, 1988
Quercus garryana British Columbia to California	Garry, western or Oregon white oak	tree; acorns highly palatable, eaten by native Americans; important timber tree; browsed by cattle and sheep	Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Mabberley, 1987; USDA, 1988
Quercus glabra Japan		acorns eaten locally	Camus, 1936-74; Uphof, 1968; Usher, 1974; Rosengarten, 1984
Quercus glauca Himalayas		acorns eaten	Menninger, 1977
Quercus grisea S.W. North America	grey, evergreen, live or Mexican blue oak	tree or shrub; acorns eaten by native Americans	Hedrick, 1972
Quercus ilex subsp. *ilex* Mediterranean excluding the Iberian Peninsula	holm oak, holly oak; cultivated	evergreen tree; acorns occasionally eaten; oak timber used for furniture; galls used for tanning; also planted as an ornamental	Kuzeneva, 1936; Camus, 1936-54; Howes, 1948; Uphof, 1968; Hedrick, 1972; Camus, 1974; Menninger, 1977; Mabberley, 1987

Species and distribution	Common name	Details	References
subsp. *rotundifolia* Spain, Portugal, N. Africa		evergreen tree, cultivated in Spain and Portugal for its acorns, which are roasted and eaten, also source of oil	Howes, 1948; Menninger, 1977
Quercus kelloggii California	California black or Kellogg oak	deciduous tree; acorns used by Indians for food; browsed by game and livestock; wood used for fuel	Saunders, 1976; Menninger, 1977; USDA, 1988
Quercus libani Middle East	Lebanon oak	deciduous tree; acorns roasted and eaten	Townsend and Guest, 1980
Quercus lobata California	California or valley white oak	massive tree; ground acorns formerly a favourite food of native Americans; important timber tree	Uphof, 1968; Hedrick, 1972; Usher, 1974; Saunders, 1976; Menninger, 1977; Mabberley, 1987; USDA, 1988
Quercus macrocarpa North America	bur oak	acorns large, eaten raw or roasted by native Americans, also ground for baking	Menninger, 1977
Quercus macrolepis S. Balkan, Aegean	camata, camatina or valonia oak	evergreen tree; ripe acorns eaten boiled or raw; cups - "valonia" and unripe fruits - "carnatas" or "carnatina" used for tanning	Howes, 1948; Hedrick, 1972; Menninger, 1977
Quercus marilandica E. USA	black jack oak	acorns eaten	Howes, 1948
Quercus nigra S.E. USA	black jack or possum oak	tree; acorns formerly used by Indians for food; wood for fuel	Uphof, 1968; Usher, 1974
Quercus oblongifolia S.W. USA	evergreen or live oak	tree or shrub; acorns eaten by native Americans	Hedrick, 1972
Quercus petraea Europe	sessile oak	acorns eaten	Mabberley, 1987

Species and distribution	Common name	Details	References
Quercus phellos N.E. North America	willow oak	acorns eaten	Hedrick, 1972; Menninger, 1977
Quercus prinus S. USA	basket, chestnut, chinquapin or cow oak	deciduous tree; acorns sweet, 4 cm long, eaten raw or roasted by native Americans, also ground for baking; acorns eaten by livestock; important source of tanbark; timber	Camus, 1936-74; Hedrick, 1972; Saunders, 1976; Menninger, 1977; Mabberley, 1987
Quercus robur Europe, Mediterranean	English, French, Scandinavian, Polish, black or truffle oak	deciduous tree; acorns bitter, used as famine food, ground acorns used as coffee substitute; acorns eaten by pigs; sweet manna-like exudate used as sweetener; important timber tree; wood source of acetic acid; bark and galls source of tannin; galls source of acetic acid	Camus, 1936-54; Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Mabberley, 1987
Quercus stellata E. USA	iron or post oak	tree or shrub; acorns eaten raw or roasted by native Americans, also ground for baking; wood for charcoal	Camus, 1936-54; Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Mabberley, 1987
Quercus suber S. Europe	cork oak	evergreen tree; acorns sometimes eaten roasted; thick bark source of commercial cork	Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Quercus undulata California	Rocky Mountain scrub or wavyleaf oak	low shrub; acorns sweet, eaten by native Americans; wood used for fuel; bark used for tanning	Camus, 1936-54; Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977
Quercus virginiana E. North America	live oak	acorns eaten raw or roasted by native Americans, also ground for baking, also source of sweet cooking oil; timber formerly important for ship-building; bark used for tanning	Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Mabberley, 1987

Species and distribution	Common name	Details	References
GUTTIFERAE; fruit a drupe, berry or septicidal capsule			
Allanblackia floribunda West Africa	tallow tree; kisidwe	seeds edible, source of oils, used as a butter substitute, suitable for soap making; seedcake too bitter cattle food	Menninger, 1977; Mabberley, 1987; Peters et al., 1992
Allanblackia stuhlmannii Tanzania		evergreen tree; seeds yield an edible fat used in cooking, as an illuminant and liniment. Seeds marketed; potential plantation crop	FAO, 1983; Peters et al., 1992
Allanblackia ulugurensis Tanzania		evergreen tree; seeds yield an edible fat used in cooking and as an illuminant; sap produces a yellow dye. Seeds exported; potential plantation crop	FAO, 1983; Peters et al., 1992
Garcinia conrauana Cameroon		seeds edible	Menninger, 1977
Garcinia cowa Assam, Myanmar		aril and pericarp good flavour	Mabberley, 1977
Garcinia indica tropical Asia	cocum; kokum	fruit pulp edible, seeds source of edible fat - "kokum" or "Goa butter", pericarp used to flavour curries	Hedrick, 1972; Mabberley, 1987
Garcinia kola West Africa	bitter or false kola	pulp eaten raw, rind used in curries, seeds eaten raw, chewed with a bitter, astringent and resinous taste; root a chewstick	Menninger, 1977; Peters et al., 1992
Garcinia lateriflora Philippines		seeds edible	Menninger, 1977
Garcinia mangostana Malesia; cultivated, not known in the wild	mangosteen	evergreen tree; arils delicious, one of the best tropical fruit; seeds eaten raw or in various preparations; rind used for tanning and source of black dye; wood used for cabinet work and construction Seeds contain 45% fat	Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Purseglove, 1987; Verheij and Coronel, 1991

Species and distribution	Common name	Details	References
Garcinia planchonii Viet Nam, N. Laos		seeds edible, acidic pulp edible, sun dried for storage	Menninger, 1977; Verheij and Coronel, 1991
Mesua ferrea Indo-Malesia	ironwood	fruit with a rind like that of a chestnut, resembles a chestnut in size, shape substance and taste; timber very hard, formerly used for lances; sacred tree in India; flowers used medicinally, cosmetically and to scent the stuffing of pillows	Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Pentadesma butyracea West Africa	butter, candle or tallow tree; black mango	young seeds eaten, old seeds source of "Sierra Leone, Kanga or lamy butter", used for cooking, soap, margarine and candles	Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Peters et al., 1992
HIPPOCASTANACEAE; fruit a capsule			
Aesculus californica California	Californian buckeye	deciduous tree or shrub; seeds boiled or roasted and leached, toxic if eaten raw, formerly much eaten by Californian native Americans	Howes, 1948; Hedrick, 1972; Saunders, 1976; Krochmal, 1982; Mabberley, 1987
Aesculus hippocastanum Balkans to Himalayas	horse-chestnut	deciduous tree; seeds bitter and inedible unless leached, may be used as coffee substitute; horse medicine; leaves and husks yield a yellow dye; timber of limited use; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; Krochmal, 1982; Mabberley, 1987
Aesculus indica Himalayas	Indian horse-chestnut	deciduous tree; seeds edible, eaten by hill tribes as famine food; seed oil used externally for rheumatic complaints; fruits given to horses for colic; browse lopped for livestock; wood used to building, packing cases, troughs, etc.	Howes, 1948; Mabberley, 1987; Rathore, 1993
Aesculus octandra S.E. USA	yellow, big or sweet buckeye	starchy seeds roasted and leached for several days to remove toxic aesculin before eaten by native Americans - a nutritious food	Krochmal, 1982

Species and distribution	Common name	Details	References
Aesculus parviflora S. USA	buckeye	fruit eaten boiled or roasted	Hedrick, 1972
Aesculus pavia S.E. USA	little, red or scarlet buckeye; firecracker plant	starch extracted from seeds; ground seeds toxic to fish and possibly livestock; seeds used to relieve headache	Krochmal, 1982
IRVINGIACEAE; fruit a capsule, samara, rarely a berry or drupe, often a schizocarp of dry and sometimes samaroid or fleshy mericarps			
Irvingia gabonensis	dika nut; bread tree; wild mango	large tree; drupe 5-6 cm long; pulp eaten, seed ground cooked to make dika bread, also source of an edible oil, dika butter, formerly considered as a substitute for cocoa butter; seed oil used for making soap	Howes, 1948; Menninger, 1977; FAO, 1982; Mabberley, 1987; Peters et al., 1992
JUGLANDACEAE; fruit a nut or drupe-like			
Carya alba North America	shagbark or shellbark hickory	an important food of native Americans, also marketed and exported; timber for wagons, agricultural implements and tool handles; fuel	Hedrick, 1972
Carya aquatica S.E. USA	water or swamp hickory, bitter or wild pecan	nuts small, astringent, sometimes eaten; source of a brown dye	Howes, 1948; Menninger, 1977; Krochmal, 1982
Carya carolinae-septentrionalis S.E. USA	Caroline hickory, southern shagbark hickory	nuts sweet, edible	Krochmal, 1982

Species and distribution	Common name	Details	References
Carya cathayensis E. China	Chinese hickory; mountain walnut	nuts edible, used in sweetmeats; wood used for tool handles	Uphof, 1968; Usher, 1974; Menninger, 1977; Rosengarten, 1984
Carya cordiformis E. North America, S. Appalachians	bitternut, swamp hickory	nuts bitter, rarely eaten by native Americans; bark formerly used in making chair seats; wood used for yokes and hoops	Howes, 1948; Uphof, 1968; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987
Carya glabra E. North America	broom, hognut, oval, redheart, red or pignut hickory	nuts variable, hard and tough, kernel sometimes sweetish but usually astringent, eaten by native Americans; timber used for wagons, agricultural implements and tool handles; fuel	Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987
Carya illinoinensis S. USA; widely cultivated	pecan; Illinois nut, sof-shelled hickery	common dessert nut, especially thin-shelled ones; used like hazelnuts (*Corylus* spp.) or walnuts (*Juglans* sp.) in food; seed oil formerly used by native Americans to season food, now used in cosmetics, etc.; timber for veneer, furniture, flooring and panelling; grown as ornamental; first cultivar selected in 1846, now over 500 names	Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988;
Carya laciniosa central North America; cultivated	big, western, botton shellbark or king nut hickory	nuts thick shelled, considered to be of fine quality, marketed; nuts eaten by native Americans, source of the fermented drink "powcohiccorir"; wood used for agricultural implements and tool handles; fuel	Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987
Carya myristiciformis S.E. USA	numeg or bitter water hickory	nuts with very thick shell, sometimes eaten by native Americans	Howes, 1948; Menninger 1977; Krochmal, 1982
Carya ovalis North America	smaller loose bark hickory	nuts small, sometimes eaten by native Americans	Howes, 1948; Krochmal, 1982

Species and distribution	Common name	Details	References
Carya ovata E. North America; cultivated	shagbark, scalybark, white, red heart or upland hickory	nuts edible, marketed - commercial hickory nuts; wood used for wagons, axe handles, basketry and fuel	Howes, 1948; Uphof, 1968; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987
Carya pallida S.E. USA	sand, pale or pale leaf hickory	nuts with thick, hard shell, eaten by native Americans	Menninger, 1977; Krochmal, 1982
Carya texana var. *villosa* S-central USA	Texas, Buckley's or black hickory	small nuts often produced from young plants, sometimes eaten	Howes, 1948; Menninger, 1977
Carya tomentosa E. North America	mockernut; white hickory	nut with very hard, thick shell; kernel sweet and in some varieties as large as that of shellbark but difficult to extract. A variety with prominent angles known as "square nut"	Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987
Carya tonkinensis N.E. India, Viet Nam, S. China	may-chau	kernels source of edible oil, also used as illuminant	Howes, 1948
Juglans ailanthifolia var. *cordiformis* China, Japan; cultivated	cordate, Japanese or Siebold walnut; heatnut	nuts small, edible; husk used as piscicide; wood used for gunstocks, cabinet work; bark exocarp used in dyeing; hardy, cultivated for nuts in Canada; grown as an ornamental; rootstock for cultivars of *J. regia*	Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987
Juglans australia Argentina, S. Bolivia	Argentine walnut	nut small with thick shell, edible; wood prized, especially for making guitars	National Research Council, 1989
Juglans baccata Caribbean	walnut	nuts edible, rich in starch, source of oil	Hedrick, 1972

Species and distribution	Common name	Details	References
Juglans boliviana N. Bolivia, S. and Central Peru; mountains	Bolivian black walnut	nuts excellent, good quality; grows well in Costa Rica	Uphof, 1968; Usher, 1974; National Research Council, 1989
Juglans californica S. California	black walnut	fruit with thick husk, kernels eaten	Krochmal, 1982
Juglans cathayensis central China		kernels eaten locally; cultivated as an ornamental	Howes, 1948; Uphof, 1968; Usher, 1974
Juglans cinerea E. North America; cultivated	butternut; lemon nut; oil nut; white walnut	kernels edible, with strong oily taste, used to thicken pottage, seed oil used for seasoning, immature kernels pickled; sap source of butternut sugar; timber for furniture and interior finishing; nuts laxative, used to treat intermittent fever, tape worm and fungal infection; inner root bark mildly cathartic; green husks yield yellow to orange dye; cultivated for shade	Howes, 1948; Uphof. 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984;
Juglans duclouxiana Asian mountains; cultivated in China		nuts edible	Uphof, 1968; Usher, 1974
Juglans hindsii California	California black walnut, Hind's walnut	nuts edible, harvested from the wild; grown in California as a street tree; rootstock used for *J. regia*	Howes, 1948; Krochmal, 1982; Rosengarten, 1984
Juglans kamaonia W. Himalayas		nuts edible	Uphof, 1968; Usher, 1974
Juglans major S.W. North America	Arizona, Arizona black or little walnut; nogal sylvestro	nuts small, eaten by native Americans; leaves astringent	Howes, 1948; Uphof, 1968; Usher, 1974; Krochmal, 1982; Rosengarten, 1984
Juglans mandshurica N. China	Manchurian walnut	nuts edible; cultivated as an ornamental	Howes, 1948

Species and distribution	Common name	Details	References
Juglans microcarpa W. North America; sometimes cultivated	Texas, Texas black, little or river walnut	nuts small, sweet, edible	Howes, 1948; Hedrick, 1972; Krochmal 1982; Rosengarten, 1984
Juglans neotropica W. Venezuela, Colombia, Ecuador; highlands	Ecuador walnut	semievergreen; nuts thick-shelled, edible, marketed locally, used in sweetmeats; wood strong, used in furniture; occasionally cultivated	Uphof, 1968; Usher, 1974; Rosengarten, 1984; National Research Council, 1989
Juglans nigra E. North America; cultivated	black, American or eastern black walnut	nuts thick-shelled, kernels sweet, edible, used in confectionery; timber prized for cabinet making, furniture, gunstocks, etc.; rootstock for cultivars of *J. regia;* husk for treating intestinal worms, syphilis, ulcers, fruit juice laxative; nuts and bark yield brown, green or blue dye	Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987
Juglans regia S.E. Europe to W. Asia; cultivated	English or Persian walnut	walnuts of commerce; timber excellent cabinet wood, furniture, gunstocks, veneer; seed oil used in cooking, paints and soap; sap source of sugar; dye from husks as floor stain; cultivated as ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988;
Juglans venezuelensis N. Venezuela; coastal mountains	Venezuelan walnut	nuts edible, now rare	National Research Council, 1989
Pterocarya fraxinifolia W. Asia; cultivated	Caucasian wingnut	nut edible; wood used for matches and clogs; cultivated as ornamental	Uphof, 1968; Hedrick, 1972; Usher, 1974; Mabberley, 1987
Pterocarya rhoifolia Japan	Japanese wingnut	nut edible; wood used for chopsticks, clogs and matches	Uphof, 1968; Usher, 1974
Pterocarya stenoptera China; cultivated	wingnut	nut edible; bark medicinal	Uphof, 1968; Usher, 1974

Species and distribution	Common name	Details	References
LAURACEAE; fruit a 1-seeded berry or drupe, rarely dry and indehiscent			
Beilschmiedia bancroftii Queensland	canary ash; yellow walnut; wanga	ground kernels eaten by Aborigines; good timber	Menninger, 1977; Mabberley, 1987; Lazarides et al., 1993
Beilschmiedia mannii West Africa		seed eaten	Peters et al., 1992
Cryptocarya alba Chile	peumo	oily seed kernels cooked and eaten in times of scarcity; bark source of tannin; wood for firewood and charcoal	Howes, 1948; Menninger, 1977; Hoffman, 1978
Cryptocarya latifolia South Africa	ntonga nuts	fruit used locally for their oil; fatty kernels used by Zulus for flaying leather	Howes, 1948; Mabberley, 1987
Cryptocarya moschata Brazil	Brazilian nutmeg	tree, pungent seed used as spice; timber hard, yellowish, esteemed	Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Endiandra insignis Queensland	Boomban	roasted, pounded and leached kernel eaten by Aborigines	Menninger, 1977
Endiandra palmerstonii Queensland	Queensland walnut	pounded kernel eaten by Aborigines	Menninger, 1977; Lazarides et al., 1993
Umbellaria californica S.W. USA	California laurel bay or olive; bay tree; bay laurel; Oregon, Pacific, black, white or yellow myrtle; Cocos cinnamon bush,	aromatic evergreen, drupe with 1 nut-like seed <2cm in diameter; fruit and seed eaten raw, roasted or ground to a flour and baked by native Americans; root bark used for beverage; aromatic dried leaves as flavouring; leaves used in internal and external medicines and flea control; good timber	Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Mabberley, 1987

Species and distribution	Common name	Details	References
LECYTHIDACEAE; fruit a capsule, drupe or berry, seeds often nut-like			
Barringtonia asiatica Madagascar to Queensland; introduced Caribbean		fruits eaten as a vegetable; seeds oleaginous, toxic	Payens, 1967; Hedrick, 1972; Menninger, 1977
Barringtonia edulis Fiji; semi-cultivated	cut-nut	fruit insipid, eaten raw or cooked; seeds eaten raw, flavour of raw peanuts	Payens, 1967; Hedrick, 1972; Menninger, 1977
Barringtonia niedenzuana Melanesia; semi-cultivated	cut-nut	seeds eaten raw, flavour of raw peanuts	Payens, 1967; Menninger, 1977
Barringtonia novae-hyberniae Melanesia; semi-cultivated	cut-nut	seeds eaten raw, flavour of raw peanuts	Menninger, 1977
Barringtonia procera New Guinea, Micronesia; planted	nua nut	tree with ovoid drupes; seed eaten on Santa Cruz; young leaves eaten as a vegetable	Payens, 1967; Hedrick, 1972; Menninger, 1977; Duke, 1989
Barringtonia scortechinii Borneo		seed used to flavour food	Menninger, 1977
Bertholletia excelsa South America	Brazil, Amazon or Pará nut; butternut; creamnut;	fruit a large woody capsule, seeds with hard, woody testa and oily endosperm, takes 14 months to mature; largely harvested from the wild, fruit being split open with an axe; seeds with hard woody testa, eaten as a dessert nut and in confectionary, also a source of commercial edible oil, also used in soap	Howes, 1948; Hill, 1952; Hedrick, 1972; Menninger, 1977; FAO, 1982, 1986; Mabberley, 1987; Purseglove, 1987; Bianchini et al., 1988; ; Verheij and Coronel, 1991
Careya arborea Sri Lanka	patana oak; slow match tree	seeds edible; leaves used for silkworms	Hedrick, 1972; Menninger, 1977; Mabberley, 1987

Species and distribution	Common name	Details	References
Chydenanthus excelsus New Guinea		seeds eaten	Menninger, 1977
Eschweilera grandiflora Guyana		seeds edible	Hedrick, 1972
Eschweilera jarana South America		seeds edible; timber for sleepers	Prance and Mori, 19979
Lecythis lanceolata South America		seeds edible	Howes, 1948
Lecythis minor New Granada		seeds edible but contain toxic selenium analogue of the amino-cystathionine causing temporary loss of hair and nails and nausea when growing on soils high in selenium	Hedrick, 1972; Prance and Mori, 1979; Mabberley, 1987
Lecythis ollaria tropical America	pot nut	seeds edible but contain toxic selenium analogue of the amino-cystathionine causing temporary loss of hair and nails and nausea when growing on soils high in selenium	Howes, 1948; Hedrick, 1972; Prance and Mori, 1979; Mabberley, 1987
Lecythis usitata South America; Amazon rain forest, cultivated	paradise or sapucaia nut	tall tree; fruit woody, large, dehiscent; seeds (nuts) 30-40, irregularly oblong, resembling Brazil nuts but more rounded with thinner and softer shell, kernel white, creamy texture and superior sweet flavour, delicious; kernels eaten raw, roasted or in confectionary, highly nutritious, source of oil 62% fat, 20% protein	Howes, 1948; Hill, 1952; Prance and Mori, 1979; Rosengarten, 1984; Macrae et al., 1993
Lecythis zabucajo Brazil, Guyana; cultivated	sapucaia nut	oily seeds (sapucaia nuts) c 5 cm long, edible, with delicate flavour suitable for chocolates	Howes, 1948; Hill, 1952; Hedrick, 1972; Mabberley, 1987
Planchonia careya Australia	cocky apple	fruit large, with adherent calyx, eaten by Aborigines; source of fuel, toxins, medicines and fibre	Hedrick, 19772; Lazarides and Hince, 1993

Species and distribution	Common name	Details	References
LEGUMINOSAE subfamily CAESALPINIOIDEAE; fruit usually a dry legume (pod), usually dehiscent			
Cordeauxia edulis central Somalia, Ogaden	ye-eb, yeheb or yehib	seed eaten raw or boiled, potential as a dessert nut; source of a red dye; potential for development and commercial exploitation	Howes, 1948; Menninger, 1977; National Academy of Sciences, 1979; Mabberley, 1987; Peters et al., 1992
Lemuropisum edule S.W. Madagascar	tara nut	dehiscent legume with 6-12 sweet, starchy seeds which are eaten raw; shrub browsed by goats	Willing, 1989
Tylosema esculentum southern Africa	marama or maramba bean	pod hard, 1.5-2 cm in diameter, seeds 1-6, eaten as a dessert nut, tuber also edible. Plant difficult to cultivate	Hedrick, 1972; Menninger, 1977; National Academy of Sciences, 1979; Arnold et al., 1985; Peters et al., 1992
LEGUMINOSAE subfamily MIMOSOIDEAE; fruit usually a dry pod			
Pithecellobium bubalinum Malaysia		seed edible, although a surfeit can cause kidney damage due to presence of crystals	Whitmore, 1972
Pithecellobium dulce Central America; naturalized throughout the tropics	Madras thorn; Manila tamarind	armed shrub or tree; seed oil edible, aril edible, pulp made into a lemonade; seed oil used for making soap, seed meal fed to livestock; bark, leaves and seeds source of tannin; browsed by livestock; source of fuelwood, grown for shade and hedges	Mabberley, 1987; Verheij and Coronel, 1991
Pithecellobium jiringa Myanmar to W. Malesia	jering; ngapi nut	seed marketed locally, with powerful smell and flavour which disappears on cooking. Eaten raw, salted, boiled or cooked in coconut milk or oil, surfeit can cause kidney damage due to presence of crystals; reputed good for diabetes; pod source of dye	Howes, 1948; Whitmore, 1972; Menninger, 1977

Species and distribution	Common name	Details	References
LEGUMINOSAE subfamily PAPILIONOIDEAE; fruit usually a dry pod (legume) usually dehiscent			
Apios americana North America; occasionally cultivated	potato or wild bean, groundnut; Indian potato	climber; sweet tubers boiled or roasted, an important Indian food and potato substitute; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; National Academy of Sciences, 1979; Mabberley, 1987
Arachis hypogaea South America; cultivated throughout the tropics	peanut, groundnut	annual herb with indehiscent fruit with 1-6 seeds, gynophore lengthening, reflexing and stiffening to bury the fruit; seeds edible raw or roasted, widely used as a dessert nut and as source of groundnut oil used in margarine	Howes, 1948; Hedrick, 1972; Menninger, 1977; Verdcourt, 1979; Rosengarten, 1984; Mabberley, 1987; Purseglove, 1987
Arachis villosulicarpa South America		seeds edible, locally cultivated	Rosengarten, 1984
Castanospermum australe N.E. Australia, New Caledonia, Vanuatu; cultivated elsewhere	Australian or Morton Bay chestnut	tree of coastal forests with indehiscent, fruit turgid, 2-valved, with 2-5 chestnut-like seeds; seeds (black beans) leached, roasted and eaten by Aborigines, toxic if eaten raw; decorative timber; street tree	Howes, 1948; Hedrick, 1972; Menninger, 1977; Verdcourt, 1979; Mabberley, 1987
Glycine max E. Asia, now widely cultivated	soya bean or soybean	annual herb bearing dehiscent, *ca.* 3-seeded pods containing 30-45% protein; newly germinated seeds used as "bean sprouts" in Chinese cooking; one of the world's most important legume crops, processed beans as soynuts for dessert and food industry; soya meal and protein used industrially for plastics, adhesives, waterproofing, synthetic fibre, fire-fighting foam, etc.	Rosengarten, 1984; Menninger, 1977; Verdcourt, 1979; Mabberley, 1987; Purseglove, 1987

Species and distribution	Common name	Details	References
Inocarpus fagifer Malesia to Pacific Islands, occasionally cultivated elsewhere	Tahiti chestnut	medium sized forest tree with kidney shaped, indehiscent, 1-seeded fruit borne in terminal clusters; chestnut flavoured, fleshy seeds eaten raw, boiled or roasted when nearly ripe, moderately nutritious, palatable but sometimes hard to digest, known as aila or lala in Neo-melanesian, staple food for some islanders; wood used for mouldings and interior finishing seeds 80% carbohydrates (starch), 10% protein, 7% fat	Howes, 1948; Hedrick, 1972; Verdcourt, 1979; Rosengarten, 1984; Mabberley, 1987; Macrae et al., 1993
Macrotyloma geocarpum West Africa; cultivated	Hausa or Kersting's groundnut	annual herb with geocarpic fruit; seeds eaten; mainly cultivated in West Africa; potential for further research and development	Menninger, 1977; National Academy of Sciences, 1979; Mabberley, 1987; Purseglove, 1987; Peters et al., 1992
Vigna subterranea tropical Africa; cultivated	Bambara groundnut	annual herb with geocarpic fruit; seed eaten green and raw or mature and cooked; widely cultivated	Howes, 1948; Hedrick, 1972; Menninger, 1977; National Academy of Sciences, 1979; Mabberley, 1987; Purseglove, 1987; Peters et al. 1992
MONIMIACEAE; fruit a head of drupes or nuts			
Laurelia sempervirens Peru and Chile	Peruvian nutmeg, tepa	aromatic seeds used as a spice	Hedrick, 1972; Mabberley, 1987

Species and distribution	Common name	Details	References
MORACEAE; fruit a drupe			
Artocarpus altilis Pacific, widely cultivated	breadfruit; breadnut; pana de pepita	evergreen, monoecious tree; seeds (fruits from female trees) roasted or boiled and eaten, fruit pulp cooked and eaten; staple food in Polynesia, sliced fruit fermented under storage and baked; browsed by livestock; bark fibre and latex used for caulking; wood used for canoes, surfboards, crates, light construction; cultivated for windbreaks, shade and as ornamental	Menninger, 1977; FAO, 1982; Rosengarten, 1984; Mabberley, 1987; Purseglove, 1987; Verheij and Coronel, 1991
Artocarpus elasticus W. Malesia		ripe seeds roasted and eaten, seeds source of small quantities of a solid oil; source of bark cloth	Menninger, 1977; Mabberley, 1977; Purseglove, 1987
Artocarpus heterophyllus Western Ghats, India; widely cultivated in the tropics	jack or jak nut; jak fruit	large evergreen, monoecious tree, seeds (jak nuts) eaten raw, grilled or boiled, pulp eaten raw or variously preserved, young fruit pulp boiled as a vegetable, pickled or canned; browsed by livestock; good timber, bark source of tannin and yellow dye; grown as shade tree in coffee and areca plantations; various uses in local medicine	Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1982; Rosengarten, 1984; Mabberley, 1987; Purseglove, 1987; Verheij and Coronel, 1991
Artocarpus integer Myanmar, Malesia; cultivated	champedak	evergreen, monoecious tree; fruit pulp disgusting stench, immature fruits used in soups, pulp of ripe fruits eaten; seeds eaten roasted or boiled; young leaves eaten; wood used for building, furniture and boats; bark used for cordage; latex used in preparation of lime	Menninger, 1977; Purseglove, 1987; Verheij and Coronel, 1991
Artocarpus odoratissimus Borneo, cultivated in the Philippines	marang	evergreen tree; seeds eaten roasted or boiled, pulp eaten fresh, cooked as a vegetable or in cakes	Verheij and Coronel, 1991
Artocarpus ovatus Philippines	anubing	tree; roasted seeds eaten; timber strong and durable, used for construction	FAO, 1984; Verheij and Coronel, 1991

Species and distribution	Common name	Details	References
Brosimum alicastrum central America	breadnut; alicastrun; snakewood	evergreen tree, seeds (bread nuts) boiled eaten in times of scarcity or roasted for a beverage; latex potable; leaves and fruit for fodder; wood for crates, tool handles and fuel; browse; various local medicinal applications	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987
Treculia africana tropical Africa	African breadfruit; mozinda	numerous small seeds embedded pulp of massive fruit; roasted, fried or boiled seeds eaten as dessert nut; seed embryo ground to meal and eaten	Howes, 1948; Hedrick, 1972; Mabberley, 1987; Purseglove, 1987; Peters et al., 1992
OLACACEAE; fruit usually a 1-seeded drupe or nut			
Anacolosa frutescens India to Philippines	galo nut	tree; nut resembling a filbert, kernel eaten fresh or roasted, of good flavour and quality; pulp eaten fresh or boiled; potential for domestication; wood for house posts	Howes, 1948; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991
Coula edulis tropical West Africa; cultivated in plantations	Gabon nut, African walnut	tree; drup 3-4 cm long; seeds (Gabon nuts) eaten raw, cooked or fermented, marketed locally, seeds source of edible oil; timber a commercial mahogany substitute, used for construction and charcoal	Howes, 1948; Menninger, 1977; FAO, 1982; Mabberley, 1987; Peters et al., 1992; Macrae et al., 1993
Heisteria parvifolia West Africa		shrub; kernels eaten	Menninger, 1977; Peters et al., 1992
Ongokea gore West Africa		tree; fruit an offensive smelling drupe; ripe flesh eaten; seed kernels little eaten; seed yields a drying oil - isano oil	Menninger, 1977; Mabberley, 1987
Scorodocarpus borneensis Malesia	kulim	fruit edible; hard, onion-scented wood used for construction	Menninger, 1977; Mabberley, 1987
Strombosia grandifolia West Africa		kernels roasted and eaten	Menninger, 1977

Species and distribution	Common name	Details	References
Strombosia pustulata West Africa		evergreen tree; seed kernel eaten as famine food	Menninger, 1977; Peters et al., 1992
Strombosia scheffleri tropical Africa		kernels eaten in small quantities in times of scarcity as they can cause vomiting	Menninger, 1977
Ximenia americana pantropical	tallow nut; wild, beach, hog, tallowwood or wild plum; wild olive	densely branched, spinose shrub;, usually deciduous; drupe ovoid, juicy, 1-seeded; raw or cooked pulp eaten, kernels white, palatability varies, purgative, eaten raw or roasted, seed oil used for cooking and as cosmetic; timber substitute for white sandalwood, used for fuel	Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1983; Rosengarten, 1984; Mabberley, 1987; Verheij and Coronel, 1991; Peters et al., 1992; Macrae et al., 1993
PROTEACEAE; fruit a follicle, nut, achene or drupe			
Brabejum stellatifolium South Africa; cultivated	wild, Hottentots or bitter almond	kernels require leaching before eating, formerly used as a coffee substitute; grown as hedges, noteworthy as first indigenous tree to be cultivated in South Africa	Howes, 1948; Hedrick, 1972; Palmer and Pitman, 1972; Menninger, 1977
Finschia carrii W. Pacific		kernels eaten	Menninger, 1977
Finschia chloroxantha Papua New Guinea, Solomon Islands		tree; kernels eaten, locally important food; timber for cabinet work; potential ornamental	Menninger, 1977; Verheij and Coronel, 1991
Finschia ferruginiflora New Guinea		kernels cooked and eaten	Menninger, 1977
Finschia rufa W.Pacific		kernels eaten	Menninger, 1977

Species and distribution	Common name	Details	References
Finschia sp. W. Pacific		nuts eaten in Vanuatu	
Gevuina avellana Chile	Chilean wild nut; gevuina nut; Chile nut; avellano	evergreen tree, hazel-flavoured seeds eaten fresh or roasted; wood for furniture, picture frames, roof shingles, grown as an ornamental	Howes, 1948; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987
Grevillea annulifera W. Australia		shrub; seeds hard-shelled, kernel edible	Menninger, 1977
Grevillea elaeocarpifolia Micronesia		kernels eaten	Menninger, 1977
Helicia cochinchinensis Indo-China, China, Japan		seeds edible; wood used for fuel	Menninger, 1977; Verheij and Coronel, 1991
Helicia diversifolia Queensland		source of "helicia nuts"	Mabberley, 1987
Hicksbeachia pinnatifolia N. Australia	monkey, rose or red bopple nut	tree, seed eaten; potential as an ornamental	Howes, 1948; Menninger, 1977; Mabberley, 1987; Tow, 1989; Lazarides and Hince, 1993
Kermadecia leptophylla		nuts require lengthy washing and cooking before eating	Menninger, 1977
Macadamia integrifolia Queensland; rainforest, cultivated	macadamia (smooth, thin-shell type); Queensland nut; Australian bush nut	seeds edible - "macadamia" or "Queensland nut", taste like hazel nuts, sold either in endocarp and then cracked like almonds or shelled, roasted and salted	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Tow, 1989; Verheij and Coronel, 1991; Lazarides and Hince, 1993

Species and distribution	Common name	Details	References
Macadamia ternifolia Queensland	macadamia (thick-shell)	seeds edible	Howes, 1948; Menninger, 1977; Mabberley, 1987; Purseglove,1987; Lazarides and Hince, 1993
Macadamia tetraphylla Queensland, New South Wales	macadamia (rough-shell type)	fruit dehiscing on tree, seeds edible, roasted and eaten in Tonga	Thaman, 1976; Rosengarten, 1984; Mabberley, 1987; Lazarides and Hince, 1993
Panopsis suaveolens Costa Rica	palo de papa; palon de la montañas	nuts very hard, kernels edible	Menninger, 1977
ROSACEAE; fruit a head of follicles or achenes in swollen hypanthium or a pome, rarely a capsule			
Prinsepia utilis Himalayas		deciduous thorny shrub; kernel source of an edible oil, also used as an illuminant	Hedrick, 1972; Menninger, 1977
Prunus armeniaca N. China; widely cultivated in Eurasia and America	apricot, Chinese almond	cultivated in N. China for its edible kernels, where it has been grown since 2000 BC, kernels smaller than the almond but used in similar ways; fruit pulp the apricot of commerce	Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991
Prunus bucharica Central Asia		suffructose, exceptionally drought resistant, 98.5% bitter kernels, 1,5% sweet kernels; kernels source of edible oil; root bark yields yellow dye and tanning	Kovalev, 1941
Prunus dulcis W. Asia; cultivated	almond	kernel eaten as a dessert nut, used in confectionery and as almond butter; seed oil used medicinally; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988;

Species and distribution	Common name	Details	References
Prunus fasciculata S.W. USA	desert or wild almond; wild peach	kernels baked and eaten; browsed	Kearney and Peebles, 1951; Hedrick, 1972; Krochmal, 1982
Prunus ulmifolia Turkestan		kernels edible; attractive, early flowering tree	Kovalev, 1941
RUTACEAE; fruit schizocarp, berry or drupe			
Calodendrum capensis East Africa to Cape	Cape chestnut	nuts eaten; seeds source of an oil used in cosmetics; timber useful; cultivated as an ornamental	Mabberley, 1987; Martin et al., 1988
SANTALACEAE; fruit a nut or drupe, 1-seeded			
Santalum acuminata Australia; cultivated	quandong; native peach	root parasitic tree; fruit globose, flesh eaten raw or cooked; seed shell hard, kernel oily, nutritious, usually eaten roasted, flavour harsh; nuts as necklaces, etc.; timber for cabinet making and engraving; kernel 60% fat, 25% protein	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Macrae et al., 1993
Santalum spicatum W. Australia	sandalwood	parasitic tree; fruit pulp thin, seed shell thin, crushed by hand, kernels eaten; timber, fuelwood	Menninger, 1977
SAPINDACEAE Fruit fleshy or dry, dehiscent or indehiscent, seeds with arils or sarcotestas			
Alectryon macrococcus Hawaii	mahoe	aril and kernel eaten	Menninger, 1977

Species and distribution	Common name	Details	References
Blighia sapida West Africa; cultivated	akee	evergreen tree; ripe fruit pulp eaten fried or boiled, toxic if green or overripe, seed coat toxic but fine flavour when cooked and roasted with the fleshy aril	Hedrick, 1972; Menninger, 1977; Purseglove, 1987; Peters et al., 1972
Cubilia cubili central Malesia	kubili nut	seeds eaten boiled or roasted, leaves used as vegetable; cultivated in Java	Howes, 1948; Menninger, 1977; Mabberley, 1987
Cupania americana Mexico		seeds sweet, chestnut-like, eaten in the Caribbean, also source of fermented liquor	Hedrick, 1972; Menninger, 1977
Deinbollia grandifolia West Africa		fruit pulp edible, seeds slightly oily and eaten	Menninger, 1977
Glenniea penangensis Malesia		kernel boiled and eaten	Menninger, 1977
Lepisanthes fruticosa Malesia (not in New Guinea); cultivated	lunan nut	fruit with edible flesh and kernel, the latter roasted and chestnut flavoured; root used in traditional medicine	Howes, 1948; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991
Magonia pubescens Paraguay, Brazil	tingui	seed oil used for cooking and soap making	Menninger, 1977
Melicoccus bijugatus Caribbean	Spanish lime; honney berry; genip; mamoncillo	fruit pulp eaten, seeds usually eaten after roasting	Hedrick, 1972; Menninger, 1977
Nephelium lappaceum Malesia; widely cultivated in the humid tropics	rambutan; rampostan	evergreen tree; fruit pulp edible, seeds bitter and narcotic, sometimes roasted and eaten, source of an edible cocoa-butter; fruit and seeds source of dyes; wood used in general construction; fruit used in traditional medicine Seed contains up to 31% dry weight of fat	Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Verheij and Coronel, 1991
Nephelium ramboutan-ake Philippines; cultivated	pulasan	fruit pulp edible; seeds boiled or roasted for a cocoa-like beverage, also source of an edible cocoa-butter, also used as an illuminant	Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Purseglove, 1987

Species and distribution	Common name	Details	References
Paullinia cupana South America; cultivated	guarana	climbing shrub; whole roasted seeds source of commercial "guarana", containing 4.2% caffeine; seeds pounded for a bread, seeds with cassava and water source of alcoholic beverage; used in local medicine as stimulant and digestive	Hedrick, 1973; Menninger, 1977; Mabberley, 1978
Paullinia subrotunda Asia		aril and seeds eaten	Hedrick, 1972; Menninger, 1977
Pometia pinnata Malesia	Fijian longan; langsir; malugai	raw fruit eaten; oily seeds boiled or roasted and eaten; timber used locally for construction purposes 4.4% fat, 4.4% protein, 39.9% fibre	Hedrick, 1972; Menninger, 1977; FAO, 1984; Mabberley, 1987
Sapindus indicum Asia	soapberry	fruit latex caustic, ripe seed eaten, contain 50% oil	Menninger, 1977
Schleichera oleosa Indo-Malesia	lac tree; Ceylon oak; kussum; kosumba; gum lac	unripe fruit pickled; aril eaten; seeds commercial source of the edible "Macassar oil", used for candles, hair dressing, batik work, soap and illuminant; leaves edible; timber hard, used for mortars; bark for tanning; host of lac insects	Menninger, 1977; Mabberley, 1987; Purseglove, 1987
SAPOTACEAE; fruit fleshy, indehiscent			
Argania spinosa Morocco; cultivated	argan tree	seed oil used for cooking and illuminant; drupe eaten by livestock	Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Baillonella toxisperma Nigeria to Zaire	djave; false shea butternut; African pearwood	forest tree; fruits source of edible seed oil; good timber	Menninger, 1977; Mabberley, 1987; Falconer, 1990; Peters et al. 1992
Diploknema butyracea India	Indian butter tree; pholwara	deciduous tree; kernel source of an edible phulwara butter; seed cake edible, source of fat used in soap; durable timber used for cabinet work, construction and fuel kernel contains 60-67% fat	Menninger, 1977; FAO, 1982; Mabberley, 1987

Species and distribution	Common name	Details	References
Madhuca longifolia India	illipe nut; mahua	kernel commercial source of "illipe butter" used in margarine and soap; seed-cake, "mahua meal", used as worm-killer on lawns; flowers edible	Howes, 1948; Menninger, 1977; Mabberley, 1987; Purseglove, 1987
Madhuca motleyana Malesia		seed source of edible oil	Menninger, 1977
Palaquium amboinense S.E. Asia		seed source of fat	Menninger, 1977
Palaquium gutta Malaysia	gutta-percha	evergreen tree; seed source of fat; latex commercial source of "gutta-percha"	Menninger, 1977; Mabberley, 1987
Palaquium hexandrum Sumatra		fruit sour, edible, seed source of fat, used for food	Menninger, 1977
Palaquium philippense Philippines		seed source of fat, used for food and as an illuminant	Menninger, 1977
Palaquium rostratum		fruit green, sweet and edible, seed source of a bitter oil	Menninger, 1977
Pouteria caimito Peru; cultivated	egg fruit; abiu	evergreen tree; fruit 4-12 cm in diameter, seeds 1-5, edible, fresh mucilaginous pulp eaten	Menninger, 1977; FAO, 1986
Pouteria campechiana Central America, Caribbean	canistel; egg-fruit; yellow sapote	fruit pulp edible, dehydrated, powdered and used as food additive; seed edible	Menninger, 1977; Mabberley, 1987; Purseglove, 1987; Verheij and Coronel, 1991
Pouteria glomerata Central America		seed edible	Menninger, 1977
Pouteria obovata Peru	lucuma	seed edible; fruit pulp edible, dehydrated, powdered and used as food additive	Menninger, 1977; Verheij and Coronel, 1991

Species and distribution	Common name	Details	References
Pouteria sapota Central America; cultivated	sapote; mammee zapote; marmalade plum	fruit pulp edible, kernel large, oily, finely ground for a confection, also boiled, roasted, ground and mixed with cocoa; seed oil potential in soap, cosmetic and pharmaceutical industries; wood used in construction, for carts and furniture	Hedrick, 1972; Menninger, 1977; Verheij and Coronel, 1991
Pouteria viridis	green apote		
Tieghemella heckelii West Africa	makore; cherry mahogany; bacu, baku	fleshy fruit; kernels source of cooking oil, also used for soap and medicine; timber a mahogany substitute	Menninger, 1977; Peters et al., 1992
Vitellaria paradoxa N. tropical Africa	shea nut; shea butternut	tree; fruit source of edible seed oil, shea butter, used in food and illumination, the fractionated shea oil commercial source of cocoa butter equivalents used in chocolate formulations; melliferous.	Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Purseglove, 1987; Peters et al., 1992
SIMMONDSIACEAE; fruit a loculicidal capsule, 2 empty locules			
Simmondsia chinensis S. California, Arizona and northern Mexico	jojoba; jajoba; goat, sheep or deer nut; wild hazel	dioecious, evergreen shrub bearing 1-seeded, acorn-like capsules; seeds readily eaten by children, native Americans and caprivores, ground as a coffee substitute; seed oil substitute for spermwhale oil, widely used in cosmetics and industry	Howes, 1948; Hedrick, 1972; Saunders, 1976; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987
STAPHYLEACEAE; fruit a head of follicles, drupe or berry or inflated capsule			
Staphylea bolanderi California	California bladdernut	shrub or tree; inflated capsule with edible seeds, seed oil sweet, used for cooking	Krochmal, 1982

Species and distribution	Common name	Details	References
Staphylea pinnata Europe	European bladder nut	kernels taste of pistachio, eaten by children; cultivated as an ornamental	Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Staphylea trifolia N.E. USA	American bladdernut	shrub or tree, inflated capsule with edible seeds; seeds sometimes eaten like a dessert nut, seed oil sweet, used for cooking; cultivated as an ornamental	Hedrick, 1972; Menninger, 1977; Krochmal, 1982
STERCULIACEAE; fruit dehiscent or indehiscent, fleshy to leathery or woody, often separating into mericarps			
Brachychiton acerifolius E. Australia	bottle tree, kurrajong	deciduous tree; roasted seeds eaten; timber; Aborigine source of fibre; cultivated as an ornamental	Tow, 1989; Lazarides and Hince, 1993
Cola acuminata West Africa to Angola, introduced in America; cultivated	Abatacola, kola or bata nut	evergreen tree, fruit edible, "nut" (seed) chewed as a masticatory and stimulant to promote digestion; used in cola drink; sun-dried seeds formerly exported as a source of caffeine; used in local medicine	Dalziel, 1937; Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Purseglove, 1987; Peters et al., 1992
Cola anomala Cameroon	Bamenda cola	"nut" (seed) chewed as a masticatory to promote digestion; used in cola drink;	Mabberley, 1987; Purseglove, 1987
Cola caricaefolia West Africa	false or monkey cola	seed kernel eaten	Dalziel, 1937; Menninger, 1977; Rosengarten, 1984; Peters et al., 1992
Cola heterophylla West Africa	monkey cola	seed kernel eaten	Menninger, 1977
Cola millenii West Africa	false or monkey cola	whole seed eaten	Dalziel, 1937; Menninger, 1977

Species and distribution	Common name	Details	References
Cola nitida West Africa; cultivated	kola nut; gbanja kola	evergreen tree; fruit eaten as a masticatory and stimulant, used as an ingredient or flavouring in beverages and mineral waters	Howes, 1948; Menninger, 1977; FAO, 1982; Purseglove, 1987; Peters et al., 1992
Cola rostrata West Africa		seed eaten	Dalziel, 1937; Peters et al., 1992
Cola verticillata West Africa	Owé kola, slippery cola	kernel eaten, also chewed as a masticatory to promote digestion; used in cola drink; caffeine present	Dalziel, 1937; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Purseglove, 1987
Heritiera fomes Indo-Malesia		starchy seeds eaten as famine food after leaching tannins	Menninger, 1977
Heritiera littoralia coasts of Indian and Pacific Oceans		seeds eaten with fish; timber for dhow masts	Menninger, 1977; Mabberley, 1987
Pterygota alata India	Buddha's coconut	seeds winged eaten; reputedly used as opium substitute; grown as a street tree	Hedrick, 1972; Menninger, 1977; Mabberley, 19987
Sterculia apetala Central America	Panama tree	oily seeds eaten raw, roasted or fried	Hedrick, 1972; Menninger, 1977
Sterculia balanghas tropical E. Asia		seeds roasted, chestnut flavour	Hedrick, 1972; Menninger, 1977
Sterculia chicha N.E. South America	maranhao nut	seeds eaten; seed oil used for lubrication, etc.	Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Sterculia diversifolia Australia	bottle tree	seeds and young taproots eaten by Aborigines	Hedrick, 1972; Menninger, 1977

Species and distribution	Common name	Details	References
Sterculia foetida Old World tropics	Java olive, sterculia nuts	seeds eaten raw or roasted, taste like filberts, source of oil	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Sterculia guttata tropical India		seeds eaten	Hedrick, 1972
Sterculia oblongata Philippines	malaboho	seeds eaten raw or roasted; root edible; bark fibre for cordage, wood for light carpentry and matches	Menninger, 1977; FAO, 1984; Guzman et al., 1986; Verheij and Coronel, 1991
Sterculia quadrifida Australia	peanut tree; gorarbar	deciduous tree; roasted seeds eaten by Aborigines; also source of medicine and fibre	Menninger, 1977;Tow, 1989; Lazarides and Hince, 1993
Sterculia rupestris Australia	narrow leaved bottle tree	roasted seeds eaten	Menninger, 1977
Sterculia setigera tropical Africa		seeds eaten as famine food; source of a gum exudate	Dalziel, 1937; Hedrick, 1972; Menninger, 1977; Purseglove, 1987; Peters et al., 1993
Sterculia treubii Lesser Sunda Islands		seeds eaten, also source of oil	Menninger, 1977
Sterculia trichosiphon	broad leaved bottle tree	roasted seeds eaten	Menninger, 1977
Sterculia urceolata Lesser Sunda Islands		seeds eaten, also source of oil	Menninger, 1977

Species and distribution	Common name	Details	References
Sterculia urens India		seeds roasted and eaten, also used as coffee substitute; source of "karaya gum" or "Indian tragacanth"	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Theobroma bicolor tropical central and South America	patashte	evergreen tree; fruit 10-15 x 6-18 cm, seeds numerous, 1.6-3 x 0.8-1.3 cm; pulp eaten raw, seeds eaten cooked toasted or made into inferior chocolate; cocoa butter of good quality; pericarp used for containers	FAO, 1986
Theobroma cacao tropical South America; widely cultivated	cocoa	tree; fruit 10-30 x 5-12 cm, seeds numerous; pulp eaten raw, made into jams or jellies, or fermented for alcohol or vinegar; seeds commercial source of cocoa butter for chocolate, contains stimulant theobromine, also used in cosmetics and industry; widely cultivated in the tropics	Menninger, 1977; FAO, 1986; Mabberley, 1987; Purseglove, 1987
STYLOBASIACEAE; nut-like			
Stylobasium spathulatum Australia	nut bush	nut eaten by Australian aborigines	Brand and Cherikoff, 1985
TILIACEAE; fruit a dry or not, dehiscent or indehiscent			
Diplodiscus paniculatus Philippines	baroba nut	tree; starchy seeds boiled and eaten; bark used for cordage; wood for light construction and domestic utensils	Howes, 1948; Mabberley, 1987; Verheij and Coronel. 1991

Species and distribution	Common name	Details	References
TRAPACEAE; fruit indehiscent, persistent stony endocarp, one cotyledon retained in fruit			
Trapa bicornis S.E. Asia; cultivated	ling nut	annual aquatic herb; fruit eaten boiled, preserved, candied or ground into flour for baking; fruits make a bitter medicine for treating stomach complaints, spleen and ulcers; widely cultivated in China, Japan and Korea	Howes, 1948; Rosengarten, 1984; Anderson, 1986; Mabberley, 1987
Trapa cochinchinensis S.E. Asia		annual aquatic herb; fruit eaten	Hedrick, 1972
Trapa incisa Japan, cultivated		annual aquatic herb; fruit eaten	Hedrick, 1972
Trapa natans			
var. *natans* Eurasia, Africa, naturalized North America; cultivated	European water chestnut, horn nut; Jesuit's nut, saligot, water calthrops	annual aquatic herb; fruit eaten, ground to flour or boiled, staple food in Neolithic	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987
var. *bispinosa* tropical Asia; cultivated	singhara nut	annual aquatic herb; fruit eaten raw, boiled, roasted, fried or ground into flour for baking, staple food for Hindus	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Peters et al., 1992
var. *africana* Lake Victoria		annual aquatic herb; fruit eaten by the Waganda	Menninger, 1977
UMBELLIFERAE; fruit a schizocarp of 2 mericarps facially united			

Species and distribution	Common name	Details	References
Conopodium majus W.Europe	earth or pig nut; arnut; jurnut; earth chestnut	annual herb; globose root tubers eaten boiled or roasted	Hedrick, 1972; Mabberley, 1977
VOCHYSIACEAE; fruit a loculicidal capsule or winged samara with accrescent calyx			
Erisma japura Amazonia	japurá; quaruba branca	evergreen tree; indehiscent fruit 12-13 x 4 cm, seeds 1, 3-4 cm long; seeds a famine food, eaten raw, roasted or boiled, source of a vile-smelling edible oil, also used for candles, etc.	Hedrick, 1972; FAO, 1986; Mabberley, 1987

Species and distribution	Common name	Details	References
		MONOCOTYLEDONS	
CYPERACEAE; fruit an achene			
Cyperus esculentus Africa and W. Asia; cultivated	tiger, chufa, bush, rush or Zulu nut; earth almond	perennial, stoloniferous herb, stolons terminating in a tuber; tuber rich in starch, sugar and fat, eaten raw or roasted, in confectionary, made into flour or juice served as a beverage - "horchata de chufas" in Spain, source of the edible "chufa oil", also used in soap-making; cultivated in warm climates for its edible tubers and for feeding pigs.	Howes, 1948; Hedrick, 1972; Saunders, 1976; Menninger, 1977; Purseglove, 1985; Mabberley, 1987
Cyperus rotundus pantropical weed	nut grass	perennial stoloniferous herb bearing root tubers; root tuber eaten raw	Hedrick, 1972; Saunders, 1976
Eleocharis dulcis Old World tropics	Chinese water chestnut	perennial, stoloniferous herb; cultivated in China, etc. in flooded fields which are drained for harvesting the tubers or corms which constitute the chief crunchy white vegetable in chop suey, etc., exported fresh and canned	Rosengarten, 1984; Mabberley, 1987
IRIDACEAE; fruit a loculicidal capsule			
Gynandriris sisyrinchium Mediterranean to Afghanistan	Spanish nut	iris-like with spring-flowering corms, corms eaten; grazed by sheep	Hedrick, 1972; Townsend and Guest, 1985

Species and distribution	Common name	Details	References
NYMPHAEACEAE; fruit berry-like			
Euryale ferox N. India to China	fox or gorgon nut; prickly water lily	aquatic herb, pulpy fruit with 8-15 black, globose seeds; cultivated by Chinese for 3000 years; seeds eaten raw before fully ripe, nutty flavour, roasted or boiled when mature; fruit pulp, stems and rhizome also edible	Hedrick, 1977; Menninger, 1977; Mabberley, 1987
Nelumbo lutea North America, Caribbean	American lotus; water chinquapin	aquatic rhizomatous herb; seeds and rhizome edible	Hedrick, 1972; Mabberley, 1987
Nelumbo nucifera warm Asia to Australia; cultivated	sacred lotus; water cinquapin; water or rattle nut; Egyptian bean	aquatic rhizomatous herb with white, 1-seeded carpels embedded in flat-topped, fleshy receptacle which at maturity dries and ripe seeds rattle within; revered by Buddhists; unripe seed eaten raw (lotus nut or seed), ripe seed roasted or boiled after removal of bitter, green embryo; rhizome source of Chinese arrowroot; cultivated as an ornamental seed contains 68% carbohydrates (starch), 17% protein, 2.5% fat, rich in vitamin C	Howes, 1948; Hedrick, 1977; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Macrae et al., 1993
PALMAE; fruit usually a fleshy or fibrous drupe, rarely more or less dehiscent			
Acrocomia aculeata Martinique, Dominica	mucujá; macaúba; gru gru nut	solitary, spiny, pleonanthic, monoecious, feather palm; kernel edible, source of an edible oil; pulp oily, sweet, edible, used in cooking and soap; nuts fed to pigs; palm cabbage eaten; leaves used for browse, thatch and basketry; trunks for posts	Howes, 1948; Hedrick, 1972; FAO, 1986; Menninger, 1977; Johnson, 1983; Uhl and Dransfield, 1987
Acrocomia lasiospatha Caribbean, Brazil	macaw; mucuja	pleonanthic, monoecious, feather palm; fruit with thin, edible pulp; nut oily and bitter, esteemed locally	Hedrick, 1972; Uhl and Dransfield, 1987

Species and distribution	Common name	Details	References
Acrocomia totai N.E. Argentina, Paraguay	gru gru; mbocarya; Paraguay palm	pleonanthic, monoecious, feather palm; kernels an important source of oil, used locally for cooking, soap and as an illuminant	Menninger, 1977; Mabberley, 1987; Uhl and Dransfield, 1987
Aiphanes minima Central America	coyor	solitatry, spiny, pleonanthic, monoecious, feather palm; kernel thick, white, edible, similar to that of coconut; thin, sweet pulp edible	Menninger, 1977; Uhl and Dransfield, 1987
Areca catechu tropical cultigen; cultivated in S. and S.E. Asia	betel or areca palm; bungaa; jamba; pinang	solitary, unarmed, pleonanthic, monoecious, feather palm; masticatory, sliced endospern of ripe or unripe seeds (nuts) chewed in a wad of betel pepper (*Piper betle,* Piperaceae) with lime, a mild narcotic containing arecaine, causing salivation, dulling of appetite and reddening of saliva; palm cabbage eaten; leaves for thatch; leaf sheaths for hats and containers; seed used as a vermifuge and in veterinary medicine; fruit source of tannin and dye; cultivated as ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1977; Johnson, 1983; Rosengarten, 1984; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987
Areca laxa Andaman Islands		pleonanthic, monoecious, feather palm; used as substitute for betel nut	Hedrick, 1972
Arenga pinnata Malesia from W. India to Hainan, Philippines and Papua New Guinea; widely cultivated in the tropics	black sugar palm; sugar plum; toddy palm; areng palm; ejow; gomuti; kaong	solitary, unarmed, pleonanthic, monoecious feather palm; immature kernels cooked and eaten in Philippines, boiled and marketed as a sweetmeat; male spadix tapped for palm sugar, jaggery, palm wine or toddy, distilled for arrak; palm cabbage eaten raw or cooked; stem pith source of sago; leaf sheath source of good fibre; leaves for thatching; split petioles for basketry	Miller, 1964; Hedrick, 1972; Menninger, 1977; FAO, 1984; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987
Astrocaryum aculeatum Amazonia	star nut palm; tucumá	solitary, spiny, pleonanthic, monoecious, feather palm; mesocarp thin, edible, contains 15-75% oil; kernels hard and inedible, contain 37% edible oil, used commercially, residue used as cattle feed; leaf fibres marketed commecially, used for hammocks. Potential oil crop	Hedrick, 1972; Menninger, 1977; FAO, 1986; Mabberley, 1987; Uhl and Dransfield, 1987

Species and distribution	Common name	Details	References
Astrocaryon jauari South America	jauari; awarra	solitary, spiny, pleonanthic, monoecious, feather palm; kernel source of edible oil; leaves used for thatch	Johnson, 1983
Astrocaryum murumuru Amazonia	muru-muru or murumuru	spiny, pleonanthic, monoecious, feather palm; kernel chief source of edible oil in Pará, Brazil, used commercially; leaf fibres used for hammocks	Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Uhl and Dransfield, 1987
Astrocaryon tucumoides N.E. South America	awarra	spiny, pleonanthic monoecious, feather palm; kernel source of edible oil used commercially; leaves used for matting	Menninger, 1977; Mabberley, 1987
Astrocaryon vulgare tropical America	tucuma	spiny, pleonanthic, monoecious, feather palm; mesocarp edible, rich in vitamin A; kernels source of edible oil, excellent for cooking and soap-making, used commercially; leaf fibres used for fishing lines and nets, hammocks, strongest fibre in Amazonia, possibly commercially viable. Plant often of disturbed areas therefore probably easily domesticated	Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987; Prance, 1994
Attalea oleifera Brazil		solitary, unarmed, pleonanthic, monoecious, feather palm; extremely hard nut; kernels source of a cooking oil	Menninger, 1977; Uhl and Dransfield, 1987
Bactris gasipaes Amazonian Peru; unknown in the wild, widely cultivated in South America, especially for palm hearts, introduced in S. E.Asia	peach palm; palm chestnut; pejibay(e); pejivalle; pupuha	suckering, spiny, pleonanthic, monoecious, feather palm; starchy fruit pulp dry and mealy, edible; boiled kernels edible; kernels a commercial oilseed; fruit regarded as the most nutritionally balanced of tropical foods; palm hearts an important export; fruit residues fed to livestock; leaves for thatching; wood for long bows and floor slabs, source of cellulose for cellophane paper and rayon. Potential for improvement as an oil crop.	Howes, 1948; Hedrick, 1972; National Academy of Sciences, 1975; Menninger, 1977; Johnson, 1983; Purseglove, 1985; FAO, 1986; Mabberley, 1987; Uhl and Dransfield, 1987; Verheij and Coronel, 1991; Clay and Clement, 1993; Clement and Villachica, 1994

Species and distribution	Common name	Details	References
Bactris major Caribbean	prickly plum; black roseau	spiny, pleonanthic, monoecious, feather palm; nut marketed as "cocorotes", cultivated as an ornamental	Hedrick, 1972; Mabberly, 1987; Uhl and Dransfield, 1987
Borassus aethiopum Tropical Africa	African fan palm; deleib palm	solitary, unarmed, pleonanthic, dioecious, fan palm; fibrous pulp eaten raw of cooked; germinating radicle of buried nut cooked as famine food; palm cabbage eaten; sap source of toddy; leaves used for thatch and basketry	Menninger, 1977; Johnson, 1983; Purseglove, 1985; Uhl and Dransfield, 1987
Borassus flabellifer India to Myanmar; cultivated	palmyra, toddy or wine palm; siwalan	solitary, unarmed, pleonanthic, dioecious, fan palm; fruit pulp roasted and eaten, seedlings edible; inflorescence sap source of sugar and toddy; timber for rafters, leaves for thatch, basketry, writing paper, etc.; fibre exported	Hedrick, 1972; Menninger, 1877; Johnson, 1983; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987
Caryota cumingii Philippines	pugahan	hapaxanthic, monoecious, feather palm, leaves bipinnate with fish-tail leaflets; seeds used as substitute chewing gum; sap source of palm wine and alcohol, stem source of sago; palm cabbage eaten; soft petiole fibre used for tinder, cauking and stuffing pillows; petioles for basketry; leaves used for thatch; timber slats used for flooring; cultivated as an ornamental	FAO, 1986; Uhl and Dransfield, 1987
Caryota mitis Indo-Malesia	fishtail palm	hapaxanthic, monoecious, feather palm, leaves bipinnate with fish-tail leaflets; mesocarp toxic with numerous oxalate crystals, immature kernel edible; fruits used as a masticatory after leaching macerated fruit; palm cabbage eaten, sap source of wine, stem source of sago; leaves used for thatching, leaf sheath source of fibre; cultivated as an ornamental	Menninger, 1977; Johnson, 1987; Mabberley, 1987; Uhl and Dransfield, 1987
Caryota obtusa var. *aequatorialis* Malaysia	giant mountain fishtail palm	solitary, hapaxanthic, monoecious, feather palm, leaves bipinnate with fish-tail leaflets; mesocarp toxic with numerous oxalate crystals, kernel edible; fruits used as a masticatory after leaching macerated fruit	Whitmore, 1972; Menninger, 1977; Uhl and Dransfield, 1987

Species and distribution	Common name	Details	References
Cocos nucifera western Pacific, now pantropical coasts; cultivated	coconut	solitary, unarmed, pleonanthic, monoecious, feather palm; fruit 1-seeded drupe; fibrous mesocarp (husk) yields fibre coir for doormats, matting, cordage, coir-dust a peat substitute in horticulture; endocarp hard, woody, 3-pored with adherent seed; endosperm hollow, edible, containing *ca.* 500 ml of refreshing coconut milk which is also used in plant physiology experiments, dried endosperm (copra) used in confectionery (desiccated coconut), also important source of oil for margarine, soap, etc., residue used in stockfeed; apical buds of over mature trees used for tinned palm hearts; axis tapped for toddy which, when evaporated yields jaggery (palm sugar), when fermented, produces arrak and may be further fermented to vinegar; leaves for basketry, thatch, etc.; timber (porcupine wood) for building.	Howes, 1948; Hedrick, 1972; Menninger, 1977; Johnson, 1983; Rosengarten, 1984; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987
Copernica prunifera N.E. Brazil	wax or carnauba wax palm	solitary, unarmed, pleonanthic, hermaphrodite, fan palm; immature kernels edible; leaf wax used commercially in shoe polish, gramaphone records, candles, etc.; leaves for basketry, etc.; trunk for wood	Menninger, 1977; Johnson, 1983; Mabberley, 1987; Uhl and Dransfield, 1987
Elaeis guineensis tropical Africa; cultivated	African oil palm	solitary, unarmed, pleonanthic, monoecious, feather palm; pericarp and kernel processed commercially for edible oil, pulp and kernel eaten, an important source of vitamin A; sap used to make wine and alcohol; shell used for fuel and road surfacing; palm heart eaten; leaves for thatch, weaving; petiole for fencing	Howes, 1948; Kedrick, 1972; Menninger, 1977; Johnson, 1983; Mabberley, 1987; Uhl and Dransfield, 1987; Hartley, 1988; Falconer, 1990; Peters et al., 1992
Elaeis oleifera Central and South America	American oil palm	solitary, unarmed, pleonanthic, feather palm; nuts source of edible and industrial oil; germplasm source for hybrids with *E. guineensis* for disease restistance etc.	Johnson, 1983; Uhl and Dransfield, 1987; Hartley, 1988

Species and distribution	Common name	Details	References
Eugeissona utilis S.E. Asia; locally cultivated	bertam palm	suckering, dioecious, feather palm; fruit edible; starch from trunk a staple food of some natives; leaves for thatch	Johnson, 1983; Mabberley, 1987
Gastrococcus crispa Cuba	corojo; belly palm	solitary, heavily armed, pleonanthic, monoecious, feather palm; fruit with hard shell; kernel edible, appreciable quantities of oil; leaf fibres for cordage; cultivated as an ornamental	Menninger, 1977; Uhl and Dransfield, 1987
Hyphaene compressa East Africa		solitary, spiny, pleonanthic, dioecious, fan palm; fibrous flesh of fruit eaten, seed kernel of unripe fruit eaten, also the part of germinating seedling just below ground; endocarp a substitute vegetable ivory used for buttons; palm heart eaten; leaves used for thatch, matting, baskets, cordage, paper and fuel	Uhl and Dransfield, 1987; Peters al., 1992
Hyphaene coriacea East and South Africa, Madagascar		clustered or solitary, spiny, pleonanthic, dioecious, fan palm; fibrous flesh of fruit eaten, seed kernel of unripe fruit eaten, also the part of germinating seedling just below ground; endocarp a substitute vegetable ivory used for buttons; palm heart eaten; leaves used for thatch, matting, baskets, cordage, paper and fuel	Uhl and Dransfield, 1987; Peters et al., 1992
Hyphaene petersiana tropical Africa	gingerbread palm	solitary or rarely clustered, dioecious fan palm; pulp and seeds eaten raw, germinating seeds eaten; seed kernel of unripe fruit eaten, also the part of germinating seedling just below ground; endocarp formerly a substitute source of vegetrable ivory for buttons; palm heart eaten; leaves used for thatch, matting, baskets, cordage, paper and fuel	Menninger, 1977; Uhl and Dransfield, 1987; Peters et al., 1992
Hyphaene thebaica Sudan and Egypt	doum or dum palm	solitary, armed, pleonanthic, dioecious, fan palm; fibrous mealy mesocarp (husk), which tastes of gingerbread and seed kernel of unripe fruit eaten, also the part of germinating seedling just below ground; endocarp a substitute vegetable ivory used for buttons; palm heart eaten; leaves used for thatch, matting, baskets, cordage, paper and fuel	Howes, 1948; Hedrick, 1972; Menninger, 1977; Johnson, 1983; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987; Peters et al., 1992

Species and distribution	Common name	Details	References
Jessenia bataua tropical South America	batawa; chapil; jagua; mille pesos; palma de leche; palma patavona; patauá; serje; ungurauy; yagua	solitary, unarmed (except for short fibres on upper parts of leaf sheath) pleonanthic, monoecious, feather palm; kernels eaten mainly by the poor; thin, oily pulp edible, made into a wine, mesocarp oil used for food, soap and cosmetics, residue fed to pigs; leaves used for thatching; leaf sheath and petiole source of soft and stiff fibres. Managed in the wild	Menninger, 1977; FAO, 1986; Mabberley, 1987; Uhl and Dransfield, 1987 Clay and Clement, 1993; Clement and Villachica, 1994
Jubaea chilensis coastal Chile	Chilean wine-palm; coquito; honey-palm; little, pigmy or monkey coconut	massive, solitary, unarmed, pleonanthic, monoecious, feather palm; nuts - "little cokernuts" or "coquitos" used in Chilean confectionery, occasionally marketed, source of an edible oil; massive bole formerly felled and tapped for sap (up to 300 litres) which is reduced by boiling for treacle (palm honey) and palm wine; leaves used for basketry; cultivated as ornamental; occasionally exported	Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Mabberley, 1987; Uhl and Dransfield, 1987
Livistonia cochinchinensis S.E. Asia		solitary, pleonanthic, hermaphrodite, fan palm; ripe fruits eaten in N. Vietnam; cultivated as an ornamental	Uphof, 1968; Menninger, 1977; Uhl and Dransfield, 1987; Braun, 1984
Livistonia saribus Indo-Malesia		solitary, pleonanthic, hermaphrodite fan palm of swamp forests; endosperm macerated in vinegar or salt solution and eaten in S.E. Asia	Uphof, 1968; Menninger, 1977
Lodoicea maldivica Seychelles	double coconut coco de mer	robust, solitary, unarmed, pleonanthic, dioecious fan palm; fruit large, requires six years to ripen; immature fruit at 10-12 months with sweet, translucent, jelly-like, edible kernel; mature endocarp a vegetable ivory, hard and inedible, used for bowls, etc.; leaves used for thatch and plaiting, down from young leaves for stuffing pillows; wood used for pallisades, troughs; cultivated as ornamental	Hedrick, 1972; Menninger, 1977; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987

Species and distribution	Common name	Details	References
Manicaria saccifera tropical America	busso, monkey cap or sleeve palm	solitary, unarmed, pleonanthic, monoecious, feather palm of fresh water swamps; seeds a source of oil - "ubusou"; palm source of sago in Venezuela; leaves used for thatch and sails; spathe used for a hat	Menninger, 1977; Mabberley, 1987; Uhl and Dransfield, 1987
Mauritia flexuosa N. South America, Trinidad	tree of life; buriti; guagara muriti; ta or temiche palm	massive, solitary, unarmed, pleonanthic, dioecious, fan palm; farinaceous kernel eaten; mesocarp used to make ice cream, refreshing drink and oil; pith source of sago, sap source of palm wine; leaves for thatching and fibre for cordage, petiole source of cork; trunk for rafts and dug-out canoes; roots medicinal. Palm of local importance as "tree of life"	Hedrick, 1972; Menninger, 1977; Johnson, 1983; FAO, 1986; Mabberley, 1987; Uhl and Dransfield, 1987; Clay and Clement, 1993
Maximiliana maripa N.E. South America, Trinidad	cucurite; huacava; inaja; incham; kokerite	masive, solitary, unarmed, pleonanthic, monoecious, feather palm; outer husk provides a saline flour used for seasoning food; pulp edible, yellow and sweet, made into drinks; kernel toasted and eaten, source of an edible oil; palm cabbage eaten; leaves used for thatch, basketry and matting, peduncle bract as a container; cultivated for landscaping kernels 4.7% moisture, 59.3% oil, 19.3% protein	Hedrick, 1972; Menninger, 1977; FAO, 1986; Mabberley, 1987; Uhl and Dransfield, 1987
Medemia argun N. Sudan, S. Egypt	argun	robust, solitary, unarmed, pleonanthic, dioecious, fan palm; germinating fruit eaten; an endangered species	Mabberley, 1987; Uhl and Dransfield, 1987
Nypa fruticosa India to Australia; mangove swamps; cultivated locally	nipa palm	suckering fan palm; immature seeds edible, too hard when mature, pulpy immature kernels eaten raw, mature kenerls pounded and eaten; inflorescences tapped for sugar; leaves used for thatch, cigarette papers, basketry, matting	Hedrick, 1972; Menninger, 1977; Johnson, 1983; Mabberley, 1987; Uhl and Dransfield, 1987
Orbignya cohune Central America	cohune nut; corozo	solitary, unarmed, pleonanthic, monoecious, feather palm; egg-sized, hard-shelled fruit with kernel tasting like coconut but more oleaginous and the oil superior, unripe kernel used as cooking "milk"; young leaves edible; endocarp used as fuel; subsistence oil crop; leaves used for thatch, rachis for light construction	Howes, 1948; Hedrick, 1972; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987; Clay and Clement, 1993; McSweeney, 1995

Species and distribution	Common name	Details	References
Orbignya cuatrecasana Colombia	táparos	solitary, unarmed, pleonanthic, monoecious,feather palm; seeds edible	Mabberley, 1987; Uhl and Dransfield, 1987
Orbignya martiana Amazonian Brazil	babassu or babacu palm	solitary, unarmed, pleonanthic, monoecious, feather palm; fruit formerly exported now processed locally for oil	Purseglove, 1985; Uhl and Dransfield, 1987
Orbignya oleifera South America	babassu or babacu palm	solitary, unarmed, pleonanthic, monoecious, feather palm; fruit source of an edible oil, oil exported; leaves used for thatch	Uhl and Dransfield, 1987; Clay and Clement, 1993
Orbignya phalerata Amazonia from the Guianas to Bolivia	babassu or babacu palm; coco de macaco; palmaguassú;	solitary, unarmed, pleonanthic, monoecious, feather palm; hard-shelled fruit; kernels important source of palm kernel oil; source of shade, fibre, timber, fuel and medicine	Menninger, 1977; FAO, 1986; Mabberley, 1987; Uhl and Dransfield, 1987; Pinheiro and Frazão, 1995
Orbignya speciosa South America	babassu or babacu palm	solitary, unarmed, pleonanthic, monoecious, feather palm; fruit source of an edible oil, oil exported; leaves used for thatch	Johnson, 1983; Uhl and Dransfield, 1987
Orbignya spectabilis Central Brazil	babassu or babacu palm	solitary, unarmed, pleonanthic, monoecious, feather palm; fruit formerly exported now processed locally for oil	Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987
Parajubaea cocoides Ecuador, S. Colombia; mountains	Quito palm	solitary, unarmed, pleonanthic, monoecious, feather palm; mesocarp sweet, fleshy, eaten raw; kernels source of oil; cultivated as an ornamental; potential for development	Mabberley, 1987; Uhl and Dransfield, 1987; National Research Council, 1989
Parajubaea torallyi S. and central Bolivia	janchicoco	solitary, unarmed, pleonanthic, monoecious palm; mesocarp sweet, fleshy, eaten raw; kernels source of oil; fruit as animal feed; palm hearts eaten; leaf fibre for cordage and basketry; leaf midrib for fuel, petiole for local construction; cultivated as an ornamental; potential for development	Mabberley, 1987; Uhl and Dransfield, 1987; National Research Council, 1989

Species and distribution	Common name	Details	References
Phytelephas aequatorialis Panama to Peru and W. Brazil; riverine	vegetable ivory; coroso; corozo; tagua	solitary, unarmed, pleonanthic, dioecious, feather palm; immature pericarp and endosperm provides refreshing drink and at a later stage eaten; very hard; mature cellulose endosperm used as vegetable ivory for buttons, carvings, ornaments, etc.	FAO, 1986; Uhl and Dransfield, 1987
Phytelephas macrocarpa Panama to Peru; riverine	ivory nut; tagua	solitary, unarmed, pleonanthic, dioecious, feather palm; young seed provides refreshing drink and at a later stage eaten; very hard, cellulose endosperm used as vegetable ivory for billiard balls, chessmen, buttons, etc.	Hedrick, 1972; Menninger, 1977; Johnson, 1983; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987
Raphia farinifera S. tropical Africa, Madagascar; cultivated	raphia palm	suckering, armed, hapaxanthic, monoecious, feather palm; boiled kernels eaten, yellow, oily pulp edible and source of raphia butter, oil used in cooking, also as illuminant, lubricant and pomade; young leaves formerly important source of raffia, older leaves source of raffia wax	Hedrick, 1972; Menninger, 1977; Purseglove, 1985; Mabberley, 1987; Uhl and Dransfield, 1987
Raphia vinifera West Africa	bamboo or wine palm	armed, hapaxanthic, monoecious, feather palm; pulp and seed eaten; sap source of palm wine; palm cabbage eaten; leaves for thatch, matting, etc.	Hedrick, 1972; Purseglove, 1985; Uhl and Dransfield, 1987; Peters et al., 1992
Salacca zalacca S.W. Java, S. Sumatra; widely cultivated in S. E. Asia and Queensland	salak palm; snake fruit	creeping and tillering, armed, dioecious, feather palm; pulp sour-sweet, eaten raw, candied or pickled, canned; kernels sweet, edible, sometimes pickled; leaves for thatch and matting; petiole bark for matting; grown for hedges	Hedrick, 1972; Menninger, 1977; Johnson, 1977; Purseglove, 1985; Mabberley, 1987; Verheij and Coronel, 1991
Scheelea butyracea tropical America	oil or wine palm	solitary, unarmed, pleonanthic, monoecious, feather palm; oil seed; sap source of palm wine; cultivated as an ornamental	Hedrick, 1972; Mabberley, 1987; Uhl and Dransfield, 1987
Scheelea macrocarpa tropical America	yagua palm	solitary, unarmed, pleonanthic, monoecious, feather palm; fruit edible but kernels hard and rarely eaten, source of oil; cultivated as an ornamental	Menninger, 1977; Uhl and Dransfield, 1987

Species and distribution	Common name	Details	References
Scheelea magdalenica tropical America	mamarron	solitary, unarmed, pleonanthic, monoecious, feather palm; fruit edible but kernels hard and rarely eaten	Menninger, 1977; Uhl and Dransfield, 1987
Scheelea martiana tropical South America	chopaja; maripá; uricuri; urucuri; urucurizeiro	solitary, unarmed, pleonanthic, monoecious, feather palm; starchy/oily mesocarp cooked and eaten; seeds ground to a flour; pericarp used for smoking rubber latex	FAO, 1986; Uhl and Dransfield, 1987
Serenoa repens E. USA	saw palmetto	suckering, rhizomatous, more or less stemless, hermaphrodite, fan palm; kernels formerly an important food of native Americans; palm cabbage edible	Saunders, 1976; Menninger, 1977
Syagrus cocoides tropical America		pleonanthic, monoecious, feather palm with leaves appearing 3-ranked; kernel source of pururima oil	Menninger, 1977; Uhl and Dransfield, 1987
Syagrus coronata arid Brazil; limited cultivation	nicuri plum; ouricuri or licuri palm	solitary, pleonanthic, monoecious, feather palm; kernel sometimes eaten; palm kernel oil - "urucury wax" edible, also used in soap and as substitute for carnauba wax	Howes, 1948; Johnson, 1983; Mabberley, 1987; Uhl and Dransfield, 1987
Syagrus edulis N.E. Brazil		pleonanthic, monoecious, feather palm; nuts delicious	Menninger, 1977; Uhl and Dransfield, 1987
Veitchia joannis Fiji; introduced South America		solitary feather palm; kernels slightly astringent, readily eaten, especially by children; cultivated as an ornamental	Menninger, 1977; Braun, 1984
Washingtonia filifera Colorado Desert, California	Californian fan palm	robust, tall, solitary, pleonanthic, hermaphrodite, fan palm, fruit a 1-seeded berry; pulp thin and sweet, seed large, eaten fresh, dry or ground into a meal by native Americans; leaf fibre used for basketry; source of building materials; palm grown as a street tree	Hedrick, 1972; Saunders, 1976; Menninger, 1977; Mabberley, 1987; Uhl and Dransfield, 1987
Washingtonia robusta Mexico	Mexican fan palm	robust, tall, solitary, pleonanthic, hermaphrodite, fan palm, fruit a 1-seeded berry; fruit edible	Hedrick, 1972; Saunders, 1976; Mabberley, 1987; Uhl and Dransfield, 1987

Species and distribution	Common name	Details	References
PANDANACEAE; fruit berry or drupe			
Pandanus brosimos New Guinea; highlands	screw pine	cultivated for its edible, oil-rich seeds	Purseglove, 1985; Verheij and Coronel, 1991
Pandanus conoideus New Guinea	karuka	screwpine; oily seeds edible	Verheij and Coronel, 1991
Pandanus dubius		screwpine; seeds edible; leaf fibres used for basketry	Verheij and Coronel, 1991
Pandanus julianettii New Guinea; highlands	screw pine	dioecious screwpine; multiple fruit large, dense, up to 16 kg, individual fruits readily separated, up to 10 x 1.5 cm; pulp sweet coconut flavour, eaten raw or smoked, kernel eaten raw or normally roasted, source of oil	Menninger, 1977; Purseglove, 1985; Verheij and Coronel, 1991; Macrae et al., 1993
Pandanus luzoniensis Philippines	alas-as	arborescent screwpine, multiple fruit, subglobose, 9.1 cm in diameter, individual fruits 3-4 x 2-2.6 cm, seeds (nuts) 1-10; seeds eaten boiled or roasted; decoction of prop root medicinal; grown as ornamental 5.89% fat, 12.1% protein, 36.9% fibre	FAO, 1984
ZOSTERACEAE: fruit a small drupe or irregularly dehiscing			
Zostera marina Atlantic and Pacific coasts of North America and Eurasia	water nut; eel or sea grass; grass wrack; alva or ulva marina	submerged marine grass-like herb, ripe, seed-bearing portion floats to surface and is harvested; threshed grain eaten by Seri Indians of Baja California, grain with economic potential for development; dried leaves used for packing glass, pillows, etc.; plant use for compost	Hedrick, 1972; Menninger, 1977; Felger and Moser, 1985; Mabberley, 1987; Irving et al., 1988

Species and distribution	Common name	Details	References
		GYMNOSPERMS	
ARAUCARIACEAE; female cones large, more or less globose, disintegrating when seeds mature			
Araucaria angustifolia S. Brazil, N. Argentina	Brazilian or Paraná pine	seeds large, edible, marketed in Rio de Janeiro; important timber tree	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987
Araucaria araucana Chile; introduced and cultivated	Chilean pine; monkey puzzle	evergreen tree, seeds - "Chile nut" eaten fresh, boiled or roasted, also distilled for spirit. Eighteen good-sized trees will provide a year's sustenance; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1877; Mabberley, 1987
Araucaria bidwillii Queensland	bunya-bunya pine	large tree, cones large, seeds starchy, up to 6 x 2 cm; seeds edible, sold in supermarkets, eaten roasted or boiled by Aborigines, flavour of chestnuts, also stored until germinating and then eaten; good timber and cultivated as an ornamental and street tree	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Tow, 1989; Lazarides and Hince, 1993
CUPRESSACEAE; cones woody, leathery or berry-like			
Juniperus californica Californian desert	Californian juniper	evergreen tree or shrub; fruit eaten by Indians	Saunders, 1976; Mabberley, 1977
Juniperus communis north temperate region	juniper	evergreen shrub with sweet, aromatic fruit; edible, used to flavour gin, liqueurs and meat dishes; cultivated as an ornamental	Kedrick, 1972; Mabberley, 1987
Juniperus deppeana var. *pachyphlaea* S.W. USA	check-barked or alligator juniper	evergreen tree; fruit eaten by native Americans	Kedrick, 1972; Saunders, 1976; Menninger, 1977
Juniperus occidentalis California	western juniper	fruit eaten by native Americans	Menninger, 1977

Species and distribution	Common name	Details	References
Juniperus osteosperma arid S.W. USA	Utah juniper	evergreen tree or shrub; fruit eaten by native Americans	Kedrick, 1972; Saunders, 1976
CYCADACEAE; female cones leafy, toothed to deeply lobed with large, naked seeds terminally			
Cycas media Australia	Australian nut palm	seeds first leached to remove toxic substances before cooking and eating; boiled seeds a staple diet of the Aborigines	Menninger, 1977; Mabberley, 1977
Cycas pectinata E. Himalyas		dioecious, palm-like tree; seeds first leached to remove toxic substances before cooking and eating; stem pith source of sago; young leaves as vegetable; ornamental	Verheij and Coronel, 1991
Cycas revoluta Japan		seeds first leached to remove toxic substances before cooking and eating; sago from pith used for flour and bread	Hedrick, 1972; Menninger, 1977; Mabberley, 1977
Cycas rumphii Malesia to Pacific	sago palm	dioecious, palm-like tree; seeds first leached to remove toxic substances before cooking and eating; stem pith source of sago; young leaves as vegetable; ornamental	Hedrick, 1977; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991
Cycas siamensis Myanmar, Thailand, Indo-China, Malaysia		dioecious, palm-like tree; seeds first leached to remove toxic substances before cooking and eating; stem pith source of sago; young leaves as vegetable; ornamental	Verheij and Coronel, 1991
Dioon edule Mexico		seeds foul smelling, yield a starch used as arrowroot, cooked and eaten	Hedrick, 1972; Menninger, 1977; Mabberley, 1987

Species and distribution	Common name	Details	References
GINKGOACEAE; female gametophyte pedunculate in leaf axil, 2 ovules, seed 1 by abortion			
Ginkgo biloba E. China, cultivated elsewhere	ginkgo; maidenhair; Kew tree	dioecious tree, widely cultivated as an ornamental and street tree though female trees are objectionable because the fallen seeds stink of rancid butter. Ginkgo nuts eaten after first removing nauceous outer layer to leave female gametophyte, canned and marketed in USA, eaten roasted or in birds nest soup; also source of an edible oil which is also used fuel and can cause dermatitis in sensitive people. Peel source of insecticide	Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988; Li Penglai and Song Zexia, 1990
GNETACEAE; female stroboli bearing drupe-like fruit			
Gnetum costatum Papua New Guinea		Dioecious tree; bitter fruits boiled and eaten;kernels nutritious; bast fibre for cordage kernels 40-45% starch, 8-10% protein	Verheij and Coronel, 1991
Gnetum gnemon incl. var. *brunonianum* Indo-Malesia; cultivated	gnetum; bago; melindjo	dioecious, evergreen tree, fruit *ca.* 2 cm long;; seeds eaten in Ambon roasted, boiled or fried, marketed locally; young leaves and inflorescences used as a vegetable; fibre from inner bark	Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1984; Mabberley, 1987; Verheij and Coronel, 1991
Gnetum indicum Philippines	kuliat	woody vine, fruit ovoid, 3.1 cm long, seeds 1; fruit eaten boiled or roasted; seeds boiled with sugar and eaten; bast fibre for cordage and baskets; cut stem source of water	FAO, 1984
Gnetum latifolium incl. var. *funiculare* Malaysia to Philippines		woody vine; fruit eaten boiled or roasted; seeds boiled with sugar or fried and eaten after removal of the inner, hairy seed-coat;	FAO, 1984; Menninger, 1977; Verheij and Coronel, 1991

Species and distribution	Common name	Details	References
Gnetum nodiflorum Amazonia	curucuda; itua	woody vine; fruit ellipsoid, 4-5 x 2.5 cm; roasted seeds chestnut-flavour, also ground to a flour; stem fibres for cordage, also used as a cellulose base for some paper	FAO, 1986
Gnetum tenuifolium Malaysia	dagum	slender liana; boiled seeds eaten; decoction of the roots drunk after childbirth	Menninger, 1977; Verheij and Coronel, 1991
PINACEAE; female cones usually 2 seeds per scale			
Pinus albicaulis Rocky Mountains	whitebark, nut, scrub or alpine pine	seeds and inner bark eaten by native Americans	Menninger, 1977; Krochmal, 1982
Pinus armandii W. China	Armand or Chinese white palm	seeds commonly sold in markets and eaten	Howes, 1948
P. bungeana N.W. China; cultivated	lace-bark pine	seeds small, eaten in China; hardly in USA	Menninger, 1977
Pinus cembra Alps and Carpathians; cultivated	Swiss stone pine; Siberian ceder	seed wingless, edible, sole winter food of peasants in Siberia; leaves source of turpentine; timber tree	Howes, 1948; Hedrick, 1972; Mabberley, 1987
Pinus cembroides S.W. North America; cultivated	single leaved or big cone pine; Mexican piñon nut	evergreen tree; seeds eaten fresh or lightly roasted by native Americans	Howes, 1948; Kearney and Peebles, 1951; Hedrick, 1972; Saunders, 1976; Menninger, 1977; Rosengarten, 1984
Pinus coulteri California	Coulter, Californa, nut or big cone pine	enormous cones, seeds large, edible	Howes, 1948; Hedrick, 1972; Krochmal, 1982

Species and distribution	Common name	Details	References
Pinus edulis S.W. North America	Nevada two-leaved, two-leaved, Rocky Mountain, Colorado or piñon pine	evergreen tree; seeds - "piñon nuts" important food of native Americans and Mexicans, eaten raw or roasted, marketed commercially; resin chewed for sore throats, also used for treating boils, sores and insect bites, hot resin for poulticing muscular pains, boiled needles with sugar for syphilis	Howes, 1948; Kearney and Peebles, 1951; Hedrick, 1972; Saunders, 1976; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984
Pinus flexilis W. USA; cultivated	limber, Arizona or Rocky Mountain pine	seeds large, eaten by native Americans	Howes, 1948; Hedrick, 1972; Krochmal, 1982
Pinus gerardiana Himalayas, 300-400 m; cultivated	Nepal nut pine; chilgoza, chilghoza or noosa pine	seeds large, *ca.* 2.5 cm long; high protein "neoza nuts" marketed locally in India, stored for winter use, potential for export; grown for social forestry but has not adapted to European or North American climates	Howes, 1948; Hedrick, 1972; Menninger, 1977; Anthony et al., 1993; Rosengarten, 1984
Pinus koraiensis China, Korea, Japan; cultivated	Korean nut or cedar pine	seeds edible, exported from mainland China; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984
Pinus lambertiana S.W. USA	California sugar, sugar, big or giant pine	evergreen tree bearing cones *ca.* 50 cm long; seeds eaten by native Americans; resin cathartic	Howes, 1948; Menninger, 1977; Krochmal, 1982
Pinus monophylla Great Basin to Baja California; cultivated	single-leaf piñon, nut, one-leaf or stone pine	evergreen tree; seeds edible, eaten roasted or made into cakes by native Americans, resin used to sweeten food	Kearney and Peebles, 1951; Hedrick, 1972; Saunders, 1976; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984
Pinus monticola S.W. USA	western white, silver or Idaho pine	seeds edible	Merringer, 1977

Species and distribution	Common name	Details	References
Pinus nelsonii Mexico	Nelson pinyon pine	seeds edible	Howes, 1948; Menninger, 1977
Pinus pinea N. Mediterranean and Portugal; cultivated	pignolia; stone, parasol or umbrella pine	evergreen tree; seeds with wings small or absent; seeds, pignolias, eaten as dessert nut and in confectionery, cultivated and marketed commercially; broken kernels source of an oil; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988;
Pinus ponderosa Pacific North America	western yellow, bull or ponderosa pine	seeds small, edible	Howes, 1948; Kearney and Peebles, 1951; Meninger, 1977
Pinus pumila E. Asia; cultivated	Japanese dwarf stone pine	seeds eaten locally	Rosengarten, 1984
Pinus quadrifolia Baja California	Parry's or four-leaved nut pine	evergreen tree; seeds eaten by native Americans	Howes, 1948; Hedrick, 1972; Saunders, 1976; Menninger, 1977
Pinus roxburgii Himalayas	chir or emodi pine	seeds eaten in times of scarcity; source of terpentine, charcoal for Chinese fireworks	Howes, 1948; Hedrick, 1972; Mabberley, 1987
Pinus sabiniana California (Great Valley and Coast Ranges)	digger, bull or gray pine	evergreen tree up to 25 m tall, cones up to 20 cm long, containing up to 180 seeds, cones require only 2 years to develop and produce seed compared to 3 years for the Italian stone pine, *P. pinea*; seeds eaten by native Americans; timber source of fuelwood, pit props and oleoresin; pitch for treating burns and sores, bark infusion for consumption	Howes, 1948; Hedrick 1972; Saunders, 1976; Menninger, 1977; Krochmal, 1982; Farris, 1983; Mabberley, 1987
Pinus sibirica N.E. Russia eastwards to 57°E	Siberian stone pine	seeds eaten locally	Rosengarten, 1984

Species and distribution	Common name	Details	References
Pinus torreyana California	Torrey, del mar, lone or soledad pine	seeds *ca.* 2.5 cm long, edible	Howes, 1948; Hedrick 1972; Menninger, 1977; Krochmal, 1982; Mabberley, 1987
TAXACEAE; fruit usually a 10-numerous seeds			
Torreya grandis China		seeds eaten and used medicinally	Howes, 1948; Menninger, 1977
Torreya nucifera China and Japan	Japanese torreya; kaya nut	evergreen tree; seeds eaten, also source of seed oil used for cooking in Japan; regarded mildly laxative and anthelmintic; cultivated as an ornamental	Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987
ZAMIACEAE; female cones determinate, scales more or less peltate bearing 2(-3) ovules on adaxial margins			
Encephalartos hildebrandtii		husks of ripe seed dried and ground to a flour, broken kernels dried, ground to a flour and leached, then dried and stored; stem pith source of sago	Menninger, 1977; Peters et al., 1992
Lepidozamia hopei Queensland	arumba	treated nuts used for flour by Aborigines	Menninger, 1977; Lazarides and Hince, 1993
Macrozamia riedlii West Australia	zamia	nut with volatile toxin removed by roasting	Menninger, 1987; Lazarides and Hince, 1993
Macrozamia spiralis New South Wales	Queensland nut	seeds eaten if soaked and pounded or baked, source of good quality arrowroot	Mabberley, 1987
Zamia chigua New Granada		seeds boiled and mashed before eating	Menninger, 1977

Species and distribution	Common name	Details	References
Zamia floridiana Central America	seminole bread; coontie; comptie	seeds edible	Menninger, 1977

COMPOSITION OF NUTS PER 100 g EDIBLE PORTION (Raw unless otherwise indicated)

(Farris, 1983; Rosengarten, 1984; Arnold et al., 1985; Brand and Cherikoff, 1985; Booth and Wickens, 1988; Willing, 1989)

Species	Plant part	Energy	Water	Protein	Fat	Carbohydrate	Fibre	Ash	Ca	P	K	Na	Mg	Fe	Zn	Cu	Vitamin A	Nicotinic acid	Thiamine	Riboflavine	Vitamin C
		kJ/100g-	----------/100g----------						----------mg/100g----------												
Average daily requirements		**1300**	**55**						**800**	**800**	**4000**	**2200**	**350**	**15**	**15**	**800**		**1.4**	**1.1**	**1.3**	**60**
ANACARDIACEAE																					
Pistacia vera		594	5.3	19.3	53.7	17.1	1.9	2.7	131	500	972	-		7.3			230	1.4	0.67	-	0
Sclerocarya birrea subsp. *caffra*	nut	2703	4.0	28.3	57.3	3.7	2.9	3.8	118	808	601	3.81	462	4.87	5.19	2.81		0.72	0.42	0.12	
BOMBACACEAE																					
Adansonia digitata	fruit	1292	8.7	2.7	0.2	73.7	8.9	5.8	335	76.2	2409	11.2	167	2.65	1.0	0.37		2.73	0.62	0.14	
	kernel	1803	8.1	33.7	30.6	4.8	16.9	5.9	273	5.12	1275	2.48	640	6.55	6.68	2.78		1.0	0.25	0.14	209
BURSERACEAE																					
Canarium ovatum		669	6.3	11.4	71.1	5.7	2.7	2.8	140	554	489	3		3.4			40	0.5	0.88	0.09	Tr
CARYOCARACEAE																					
Caryocar sp.	kernel	629	3.8	23.7	61.2	8.4	-	2.9													
COMPOSITAE																					
Helianthus annuus	dry kernels	560	4.8	24.0	47.3	16.1	3.8	4.0	120	837	920	30		7.1			50	5.4	1.96	0.23	
CORYLACEAE																					
Corylus avellana	kernel	634	5.8	12.6	62.4	13.7	3.0	2.5	209	337	704	2		3.4				0.9	0.46	-	Tr
CUCURBITACEAE																					
Cucurbita spp.	dry kernels	553	4.4	29.0	46.7	13.1	1.9	4.9	51	1144				11.2			70	2.4	0.24	190.	

Species	Plant part	Energy	Water	Protein	Fat	Carbohydrate	Fibre	Ash	Ca	P	K	Na	Mg	Fe	Zn	Cu	Vitamin A	Nicotinic acid	Thiamine	Riboflavine	Vitamin C
EUPHORBIACEAE																					
Schinziophyton rautanenii	flesh	1410	8.6	7.8	0.5	75.0	2.9	5.2	85.0	74.3	2145	2.39	214	2.54	1.68	1.30					
	kernel	2715	4.2	26.3	58.1	4.6	2.7	4.1	223	869	674	3.35	493	3.42	3.54	2.52					
FAGACEAE																					
Castanea dentata			33.4	10.2	10.2	42.3	1.9	1.9													
Castanea mollissima			57.6	4.4	0.9	34.6	1.4	1.1													
Castanea sativa	fresh	194	52.5	2.9	1.5	41.0	1.1	1.0	27	88	454	6		1.7				0.6	0.22	0.22	
	dry	377	8.4	6.7	4.1	76.1	2.5	2.2	52	162	875	12		3.3				1.2	0.32	0.38	
Fagus sp.		568	6.6	19.4	50	16.6	3.7	3.7													
JUGLANDACEAE																					
Carya alba		673	3.3	13.2	68.7	10.9	1.9	2.0	Tr	380				2.4							
Carya illinoensis		687	3.4	9.2	71.2	12.3	2.3	1.6	73	289	603	Tr		2.4			130	0.9	0.86	0.13	2
Juglans nigra		628	3.1	20.5	59.3	13.1	1.7	2.3	Tr	570	460	3		6.0			300	0.7	0.22	0.11	
Juglans regia		651	3.5	14.8	64.0	13.7	2.1	1.9	99	380	450	2		3.1			30	0.9	0.33	0.13	2
LECYTHIDACEAE																					
Bertholletia excelsa		654	4.6	14.3	66.9	7.8	3.1	3.3	186	693	715	1		3.4			Tr	1.6	0.96	0.12	
LEGUMINOSAE-CAES.																					
Cordeauxia edulis	seed	446	7.8-16.9	10.8-15.9	9.9-13.4	31.4-41.5	2.1	2.2-3.8	31-33	221-232	625-633	452-493	79-82 163	2.3							
Guibourtia coleosperma	seed	1589	9.1	14.3	4.4	62.3	4.4	1.9	323	198	390	20.3	295	4.69	2.7	0.87					
Tylosema esculentum	seed	2253	3.7	32.9	2.1	20.5	2.1	3.0	183	463	780	22.6		3.87	3.33	1.38		1.89	0.62	0.52	
Lemuropisum edulen	seed			14-26	6-9	38-43	26-32														

Species	Plant part	Energy	Water	Protein	Fat	Carbohydrate	Fibre	Ash	Ca	P	K	Na	Mg	Fe	Zn	Cu	Vitamin A	Nicotinic acid	Thiamine	Riboflavine	Vitamin C
LEGUMINOSAE-PAP, *Arachis hypogaea*	raw with skins	564	5.6	26.0	47.5	16.2	2.4	2.3	69	401	674	5		2.1				17.2	1.14	0.13	0
	raw less skins	568	5.4	26.3	48.4	15.7	1.9	2.3	59	409	674	5		2.0			0	15.8	0.99	0.13	0
	boiled	376	36.4	15.5	31.5	12.7	1.8	2.1	43	181	462	4		1.3				10.0	0.48	0.08	0
	roasted with skins	582	1.8	26.2	48.7	17.9	2.7	2.7	72	407	701	5		2.2				17.1	0.32	0.13	0
	roasted and salted	585	1.6	26.0	49.8	16.4	2.4	3.8	74	401	674	418		2.1				17.2	0.32	0.13	0
Vigna subterranea	seed			14--24		c.60															
PROTEACEAE *Macadamia*		691	3.0	7.8	71.6	13.4	2.5	1.7	48	161	264			2.0			0	1.3	0.34	0.11	0
ROSACEAE *Prunus dukcis*	kernel, dried	598	4.7	18.6	54.2	16.9	2.6	3.0	234	505	773	4		4.7			0	3.5	0.24	0.92	Tr
	roasted and salted	627	0.7	18.6	57.7	16.9	2.6	3.5	235	504	773	198		4.7			0	3.5	0.05	0.92	0
SANTALACEAE *Santalum acuminata*	kernel	3000	1.6	15.5	67.6	3.1	20.8	1.3													
SAPOTACEAE *Vitellaria paradoxa*	kernel				45-60																
SIMMONDSIACEAE *Simmondsia chinensis*	nut			c. 30	c. 50																
STYLOBASIACEAE *Stylobasium spathulatum*	kernel	1988	1.3	11.6	0.9														0		3
TRAPACEAE *Trapa natans*	fruit	79	78.3	1.4	0.2	18.2	0.8	1.1	4	65	500	20		0.6			0	1.0	0.14	0.20	4
			70.0	4.7	0.3		0.6		20	150				0.8							

Species	Plant part	Energy	Water	Protein	Fat	Carbohdrate	Fibre	Ash	Ca	P	K	Na	Mg	Fe	Zn	Cu	Vitamin A	Nicotinic acid	Thiamine	Riboflavine	Vitamin C
PINACEAE																					
Pinus edulis	seed	635	3.1	13.0	60.5	19.4	1.1	2.9	51	1144				11.2			70		0.24	0.19	
Pinus pinea	seed	552	5.6	31.1	47.4	10.7	0.9	4.3	12	604				5.2			30	Tr	1.28	0.23	Tr
Pinus sabiniana	seed	571	3.6	25.0	49.4	17.5		4.5	5.1				53.87	8.39	13.04	1.69					

APPENDIX C

BOTANICAL NAMES (bold) CITED IN THE TEXT AND THEIR SYNONYMS (*italics*) USED IN THE CITED LITERATURE

Acanthosicyos horrida Welw. ex Benth. & Hook.f. CUCURBITACEAE
Acioa edulis Prance = **Couepia edulis** CHRYSOBALANACEAE
Acrocomia aculeata (Jacq.) Mart. PALMAE
A. lasiospatha Mart.
A. sclerocarpa Mart. = **A. aculeata**
A. totai Mart. PALMAE
Adansonia digitata L. BOMBACACEAE
A. gregorii F.Muell.
Aesculus californica (Spach) Nutt. HIPPOCASTANACEAE
A. hippocastanum L,
A. indica (Wall. ex Cambess.) Hook.
A. octandra Marsh.
A. parviflora Walt.
A. pavia L.
Aiphanes minima (Gaertn.) Burret PALMAE
Alectryon macrococcus Radlk. SAPINDACEAE
Aleurites moluccana (L) Willd. EUPHORBIACEAE
A. triloba J.R. & G. Forst. = **A. moluccana**
Allanblackia floribunda Oliv. GUTTIFERAE
Allantoma cylindrica Miers = **A. lineata** LECYTHIDACEAE
A. lineata (Mart. ex Berg.) Miers
A. stuhlmannii (Engl.) Engl.
A. ulugorensis Engl.
Amygdalus bucharica Korsh. = **Prunus bucharica** ROSACEAE
A. communis L. = **P. dulcis**
A. ulmifolia (Franch.) Popov. = **P. ulmifolia**
Anacardium giganteum Hanc. ex Engl. ANACARDIACEAE
A. humile St. Hil.
A. nanum St. Hil.
A. occidentale L.
A. rhinocarpus DC.
Anacolosia frutescens (Blume) Blume OLACACEAE
A. luzoniensis Merr. = **A. frutescens**
Anisoptera thurifera (Blanco) Blume DIPTEROCARPACEAE
Antrocaryon micraster A.Chev. & Guill. ANACARDIACEAE
Apios americana Medik. LEGUMINOSAE subfamily PAPILIONOIDEAE
A. tuberosa Moench = **A. americana**
Arachis hypogaea L. LEGUMINOSAE subfamily PAPILIONOIDEAE
A. villosulicarpa Hoehne
Aralia trifolia Decne & Planch. = **Panax trifolius** L. ARALIACEAE
Araucaria angustifolia (Bertol.) Kuntze ARAUCARIACEAE
A. araucana (Molina) K.Koch
A. bidwellia Hook.
A. brasiliana R.Rich. = **A. angustifolia**
A. imbricata Pav. = **A. araucana**
Areca catechu L. PALMAE
A. laxa Buch.-Ham.

Arenga pinnata (Wurmb) Merr. PALMAE
A. saccarifera Labill. = **A. pinnata**
Argania sideroxylon Roem. & Schultes = **A. spinosa** SAPOTACEAE
A. spinosa (L.) Skeels
Artocarpus altilis (L.) Fosb. MORACEAE
A. champeden (Lour.) Spreng.
A. communis J.R. & G.Forst. = **A. altilis**
A. elasticus Reinw. ex Blume
A. heterophyllus Lam.
A. integer (Thunb.) Merr.
A. integra (Thurb.) Merr. = **A. heterophyllus**
A. integrifolia L.f. = **A. heterophyllus**
A. ovatus Blanco
Astrocaryum aculeatum G.Mey. PALMAE
A. jauari C.Mart.
A. murumuru C.Mart.
A. tucuma C.Mart.
A. tucumoides Drude
A. vulgare C.Mart.
Attalea cohune Mart. = **Orbignya cohune** PALMAE
A. oleifera Barb.Rodr.
Azadirachta indica A.Juss. MELIACEAE
Bactris gasipaes Kunth PALMAE
B. major Jacq.
B. maraja Mart.
B. minor Jacq.
Baillonella toxisperma Pierre SAPOTACEAE
Barringtonia asiatica (L.) Kurz LECYTHIDACEAE
B. butonica J.R. & G.Forst. = **B. asiatica**
B. careya F.Muell. = **Planchonia careya**
B. edulis Seem.
B. excelsa auct. non Bl. = **B. procera**
B. magnifera Laut. = **B. procera**
B. niedenzuana (K.Schum.) Knuth
B. novae-hyberniae Laut. **B. procera** (Miers) Kunth
B. scortechinii King
Bauhinia esculenta Burch. = **Tylosema esculentum** (Burch.) A.Schreib.
LEGUMINOSAE subfamily. CAESALPINIOIDEAE
Beilschmiedia bancroftii C.White LAURACEAE
B. mannii (Meisn.) Benth. & Hook.f.
Bertholletia excelsa Humb. & Bonpl. LECYTHIDACEAE
Blighia sapida König SAPINDACEAE
Borassus aethiopum Mart. PALMAE
B. flabellifer L.
Boscia angustifolia A.Rich. CAPPARACEAE
B. senegalensis (Pers.) Lam. ex Poir.
Boswellia serrata Roxb. ex Colebr. BURSERACEAE
Brabejum stellatifolium L. PROTEACEAE
Brachychiton acerifolius (G.Don) F.Muell. STERCULIACEAE
Brosimum alicastrum Sw. MORACEAE
Buchanania lanzan Spreng. = **B. latifolia** ANACARDIACEAE
B. latifolia Roxb.
Buchholzia coriacea Engl. CAPPARACEAE
Butyrospermum parkii (G.Don) Kotschy = **Vitellaria paradoxa** SAPOTACEAE

Calodendrum capensis Thunb. RUTACEAE
Canarium album (Lour.) Rauesch BURSERACEAE
C. amboinense Hochr. = **C. indicum**
C. commune L. = **C. indicum** *pro major parte*, **C. vulgare** *pro minor parte*
C. harveyi Seem.
C. indicum L.
C. littorale L.
C. luzonicum (Blume) A.Gray
C. mehenbethe Gaertn. = **C. indicum**
C. moluccanum Bl. = **C. indicum**
C. muelleri Bailey
C. nungi Guill. = **C. indicum**
C. ovatum Engl.
C. pachyphyllum Park. = **C. ovatum**
C. patentinervium Miq.
C. pilosum Bennett
C. pimela Leenh.
C. rufum Benn. = **C. litorale**
C. salomonense B.L.Burtt
C. schweinfurthii Engl.
C. sylvestre Gaertn.
C. vrieseanum Engl.
C. vulgare Leenh.
Careya arborea Roxb. LECYTHIDACEAE
Carya alba Nutt. JUGLANDACEAE
C. aquatica (Michx.) Laud.
C. carolinae-septentrionalis (Ashe) Engl. & Graebn.
C. cathayensis Sarg.
C. cordiformis (Wangenh.) K.Koch
C. glabra (Mill.) Sweet
C. illinoinensis (Wangenh.) K.Koch
C. laciniosa (F.Michx.) Loudon
C. microcarpa Nutt. = **C. ovalis**
C. myristiciformis Nutt.
C. olivaeformis Nutt. = **C. illinoinensis**
C. ovalis (Wangenh.) Sarg.
C. ovata (Mill.) K.Koch
C. pallida (Ashe) Engl. & Graebn.
C. pecan (Marsh.) Engl. & Graebn. = **C. illinoinensis**
C. porcina Nutt. = **C. glabra**
C. sulcata Nutt. = **C. laciniosa**
C. texana Buckl. var. **villosa** (Sarg.) Little
C. tomentosa (Poir.) Nutt.
C. tonkinensis Lecomte
C. villosa Sarg. = **C. texana** var. **villosa**
Caryocar amygdaliferum Mutis CARYOCARACEAE
C. amygdaliforme G.Don **C. brasiliense** Cambess.
C. brasiliense Cambess.
C. butyrospermum Willd. = **C. villosum**
C. butyrosum Willd. = **C. villosum**
C. coccineum Pilger = **C. glabrum**
C. coriaceum Wittm.
C. glabrum (Aubl.) Pers.
C. nuciferum L.

C. tomentosum L. = **C. nuciferum**
C. villosum (Aubl.) Pers.
Caryodendron amazonicum Ducke EUPHORBIACEAE
C. orinocense Karst.
Caryota aequatorialis (Becc.) Ridl. = **C. obtusa** var. **aequatorialis** PALMAE
C. cumingii Lodd.
C. mitis Lour.
C. obtusa Griff. var. **aequatorialis** Becc.
Castanea crenata Sieb. & Zucc. FAGACEAE
C. dentata (Marsh.)) Borkh.
C. henryi Rehder & Wilson
C. mollisima Blume
C. ozakensis Ashe
C. pumila (L.) Mill.
C. sativa L.
C. seguinii Dode
Castanopsis accuminatissima (Bl.) A.DC. FAGACEAE
C. argentea (Blume) A.DC.
C. argyrophylla King
C. boisii Hickel & A.Camus
C. chinensis Hance
C. chrysophylla (Dougl.) A.DC.
C. costata (Bl.) A.DC.
C. cuspidata (Thunb.) Schottky
C. hullettii King
C. hystrix Miq.
C. indica (Roxb.) Miq.
C. inermis (Lindl. ex Wall.) Benth. & Hook.
C. javanica (Bl.) A.DC.
C. lucida (Nees ex Wall.) Soepadmo
C. malaccensis Gamble
C. megacarpa Gamble
C. philippensis (Blanco) Vidal
C. rufescens Hook.f. & Thonn. = **C. hystrix**
C. sclerophylla Schott & Kotschy
C. sempervirens (Kellogg) Dudley
C. sumatrana A.DC. = **C. inermis**
C. tibestana Hance
C. tribuloides A.DC.
C. wallichii King ex Hook.f.
Castanospermum australe A.Cunn. & Fraser ex Hook. LEGUMINOSAE subfamily PAPILIONOIDEAE
Ceiba pentandra (L.) Gaertn. BOMBACACEAE
Chrysobalanus icaco L. CHRYSOBALANACEAE
Chydenanthus excelsus Miers LECYTHIDACEAE
Citrullus lanatus (Thunb.) Matsum & Nakai CUCURBITACEAE
C. vulgaris Eckl. & Zeyh. = **C. lanatus**
Cnidiscolus oligandrus (Muell. Arg.) Pax EUPHORBIACEAE
Cocos aculeata Jacq. = **Acrocomia aculeata** PALMAE
C. butyracea (Mutis) L.f. = **Scheelea butyracea** PALMAE
C. coronata Mart. = **Syagrus coronata**
C. nucifera L.
C. ventricosa Arruda = **Acrocomia aculeata**

Cola acuminata (Beauv.) Schott & Endl. STERCULIACEAE
C. anomala Schumann
C. caricaefolia (G.Don) K.Schum.
C. heterophylla (P.Beauv.) Schott & Endl.
C. millenii K.Schum.
C. nitida (Vent.) Schott & Endl.
C. rostrata K.Schum.
C. togoensis Engl. & K.Krause = **C. millenii**
C. vera K.Schum. = **C. nitida**
C. verticillata (Thonn.) A.Chev.
Conopodium denudatum Koch UMBELLIFERAE
C. majus (Gouan) Loret UMBELLIFERAE
Copernicia prunifera (Mill.) H.Moore PALMAE
Cordeauxia edulis Hemsl. LEGUMINOSAE subfamily CAESALPINIOIDEAE
Corylus americana Marshall CORYLACEAE
C. avellana L.
C. chinensis Franch.
C. colurna L.
C. cornuta Marsh.
C. ferox Wall.
C. heterophylla Trautv.
C. mandshurica Maxim. & Rupr. = **C. sieboldiana** var. **mandshurica** - **C. maxima** Mill.
C. rostrata Ait. = **C. cornuta**
C. sieboldiana Blume
var. **sieboldiana**
var. **mandshurica** (Maxim. & Rupr.) Schneid.
C. tibetica Batalin
C. tubulosa Willd. = **C. maxima**
Corynocarpus laevigata Forster & Forster CORYNOCARPACEAE
Couepia edulis (Prance) Prance CHRYSOBALANACEAE
C. longipendula Pilger
Coula edulis Baill. OLACACEAE
Crescentia alata Kunth **BIGNONIACEAE**
C. cujete L.
Crossonephelis penangensis (Ridl.) Leenh. = **Glenniea penangensis** SAPINDACEAE
Cryptocarya alba (Mol.) Looser LAURACEAE
C. latifolia Sond.
C. moschata Nees & Mart.
C. peumus Nees = **C. alba**
Cubilia blancoi Blume = **Cubilia cubili** SAPINDACEAE
Cubilia cubili (Blanco) Adelb.
Cucurbita maxima Duchesne ex Lam. CUCURBITACEAE
C. mixta Pang.
C. moschata (Duchesne ex Lam.) Duchesne ex Poir.
C. pepo L.
Cupania americana L. SAPINDACEAE
Cycas circinalis L. = **C. rumphii** CYCADACEAE
C. media R.Br.
C. pectinata Griff.
C. revoluta Thunb.
C. rumphii Miq.
C. siamensis Miq.

Cyperus esculentus L. CYPERACEAE
C. rotundus L.
Deinbollia grandifolia Hook.f. SAPINDACEAE
Derris spp. LEGUMINOSAE subfamily PAPILIONOIDEAE
Dioon edule Lindley ZAMIACEAE
Diplodiscus paniculatus Turcz. TILIACEAE
Diploknema butyracea (Roxb.) H.J.Lam SAPOTACEAE
Durio zibethinus Murray BOMBACACEAE
Elaeis guineensis Jacq. PALMAE
E. oleifera (Kunth) Cortés
Elaeocarpus bancroftii F. Muell. ELAEOCARPACEAE
Elateriospermum tapos Blume EUPHORBIACEAE
Eleocharis dulcis (Burm.f.) Henschel CYPERACEAE
E. tuberosa Schultes = **E. dulcis**
Encephalartos hildebrandtii A.Braun & Bouché ZAMIACEAE
Endiandra insignis F.M.Bailley LAURACEAE
E. palmerstonii (Bailey) C.White & Francis
Erisma japura Spruce VOCHYSIACEAE
Eschweilera grandiflora (Aubl.) Sandwith LECYTHIDACEAE
E. jaranum (Huber) Ducke
E. subglandulosa Miers = **E. jarana**
Eucarya acuminata (R.Br.) Sprague = **Santalum acuminata** SANTALACEAE
Eugeissona utilis Becc. PALMAE
Euryale ferox Salisb. NYMPHAEACEAE
Fagus ferruginea Ait. = **F. grandifolia** FAGACEAE
F. grandifolia Ehrh.
F. sylvatica L.
Finschia carrii (Sleumer) White PROTEACEAE
F. chloroxantha Diels
F. ferruginiflora White
F. rufa Warb.
Fusanus acuminatus R.Br. = **Santalum acuminata** SANTALACEAE
Ganua motleyana (de Vriese) Pierre ex Dubard = **Madhuca motleyana** SAPOTACEAE
Garcinia barrettiana conrauana Engl. GUTTIFERAE
G. cowa Roxb. ex DC.
G. indicum (Lour.) Merr.
G. kola Heckel
G. lateriflora Bl.
G. mangostana L.
G. planchonii Pierre
Gastrococos crispa (Kunth) H.Moore PALMAE
Gevuina avellana Molina PROTEACEAE
Ginkgo biloba L. GINKGOACEAE
Glenniea penengensis Ridl. SAPINDACEAE
Gluta elegans (Wall.) Hook.f. ANACARDIACEAE
G. renghas L.
G. velutina Bl.
Glycine max (L.) Merr. LEGUMINOSAE subfamily PAPILIONOIDEAE
Gnetum brunonianum Griff. = **G. gnemon** var. **brunonianum** GNETACEAE
G. costatum K.Schum.
G. edule Bl. = **G. latifolium** var. **funiculare**
G. gnemon L.
var. **bruninianum** (Griff.) Markgr.
G. indicum (Lour.) Merr.

G. latifolium Bl.
var. **funiculare** (Bl.) Markgr.
G. nodiflorum Brogn.
G. scandens nomen.
G. tenuifolium Ridl.
Grevillea annulifera F.Muell. PROTEACEAE
G. elaeocarpifolia Guill. = **Finschia chloroxantha**
Guilielma utilis (Kunth) Bailey = **Bactris gasipaes**
Gynandriris sisyrinchium (L.) Parl. IRIDACEAE
Heisteria parvifolia Sm. OLACACEAE
Helianthus annuus L. COMPOSITAE
var. **macrocarpus** (DC.) Cockerell
Helicia cochinchinensis Lour. PROTEACEAE
H. diversifolia C.White
Heritiera fomes Buch.-Ham. STERCULIACEAE
H. littoralis Ait.
H. minor Roxb. = **H. fomes**
Hicksbeachia pinnatifolia F.Muell. PROTEACEAE
Holopyxidium jaranum (Huber) Ducke = **Eschweilera jaranum** LECYTHIDACEAE
Hyphaene compressa H.Wendl.PALMAE
H. coriacea Gaertn.
H. petersiana Mart.
H. thebaica Mart.
H. ventricosa J.Kirk = **H. petersiana**
Inocarpus edulis J.R. & G.Forst. = **I. fagifer** LEGUMINOSAE subfamily PAPILIONOIDEAE
I. fagifer (Parkinson) Fosb.
Iris sisyrinchium L. = **Gynandriris sisyrinchium** IRIDACEAE
Irvingia gabonensis (O'Rorke) Baill. IRVINGIACEAE
var. **excelsa** Okafor
var. **gabonensis**
Jessenia batua (Mart.) Burret PALMAE
J. polycarpa Karst = **J. batua**
Jubaea chilensis (Molina) Baill. PALMAE
J. spectabilis Kunth = **J. chilensis**
Juglans ailanthifolia Carrière JUGLANDACEAE
var. **cordiformis** (Makino) Rehder
J. australis Griseb.
J. baccata L.
J. boliviana (C.DC.) Dode
J. californica S.Wats.
J. cathayensis Maxim.
J. californica S.Wats.
J. cinerea L.
J. duclouxiana Dode
J. hindsii (Jeps.) R.E.Sm.
J. honorei Dode = **J. neotropica**
J. kamaonia Dode
J. major (Torr. ex Sitsgr.) Heller
J. mandshurica Maxim.
J. microcarpa Berland.
J. neotropica Diels
J. nigra L.
J. regia L.

J. rupestris Engelm. = **J. microcarpa**
var. *major* Torr. ex Sitsgr. = **J. major**
J. sieboldiana Maxim.
var. *cordiformis* Makino = **J. ailanthifolia** var. **cordiformis**
var. *sieboldiana* = **J. ailanthifolia** var. **ailanthifolia**
J. venezuelensis Manning
Juniperus californica Carrière CUPRESSACEAE
J. communis L.
J. deppeana Steud. var. **pachyphlaea** (Torr,) Martinez
J. occidentalis Hook.f.
J. osteosperma (Torr.) Little
J. pachyphlaea Torr. = **J. deppeana** var. **pachyphlaea**
J. utahensis (Engelm.) Lemmon = **J. osteosperma**
Kermadecia leptophylla Guill. PROTEACEAE
Kerstingiella geocarpa Harms = **Macrotyloma geocarpum** LEGUMINOSAE subfamily PAPILIONOIDEAE
Kigelia africana (Lam.) Benth. BIGNONIACEAE
K. pinnata (Jacq.) DC. = **K. africana**
Lannea schweinfurthii (Engl.) Engl. ANACARDIACEAE
var. **stuhlmannii** (Engl.) Kokwaro
L. stuhlmannii Engl. = **L. schweinfurthii** var. **stuhlmannii**
Laurelia aromatica Juss. ex Poir. = **L. sempervirens** MONIMIACEAE
L. sempervirens (Ruíz & Pavón) Tul.
L. serrata Bert. = **L. sempervirens**
Lecythis davisii Sandw. LECYTHIDACEAE
L. grandiflora Aubl. = **Eschweilera grandiflora**
L. lanceolata Poir.
L. minor Jacq.
L. ollaria Loefl.
L. pisonis Cambess.
L. urnigera Mart. ex Berg. = **L. pisonis**
L. usitata Miers
L. validissima Miers = **L. zambucajo**
L. zabucajo Aublet
Lemuropisum edule H.Perrier LEGUMINOSAE subfamily CAESALPINIOIDEAE
Lepisanthes fruticosa (Roxb.) Leenh. SAPINDACEAE
Leptozamia hopei Regel ZAMIACEAE
Litchi chinensis Sonn. SAPINDACEAE
Lithocarpus cornea (Lour.) Rehder FAGACEAE
L. cuspidatus (Thunb.) Nakai = **Castanopsis cuspidata**
L. densiflorus Rehder
L. philippienis (A.DC) Rehder
Livistonia cochinchinensis Blume PALMAE
L. saribus (Lour.) Chev.
Lodoicea callipyge Comm. = **L. maldivica** PALMAE
L. maldivica (J.Gmel.) Pers.
Lucuma caimito (Ruíz & Pav.) Roem. & Schult. = **Pouteria caimito** SAPOTACEAE
Macadamia integrifolia Maiden & Betche PROTEACEAE
M. ternifolia F.Muell.
M. ternifolia F.Muell. var. *integrifolia* (Maiden & Betche) Maiden & Betche = **M. integrifolia**
M. tetraphylla L. Johnson
Macrotyloma geocarpum (Harms) Maréch & Baudet LEGUMINOSAE subfamily PAPILIONOIDEAE

Macrozamia riedlii (Gaudich.) C.Gardner ZAMIACEAE
M. spiralis (Salisb.) Miq.
Madhuca butyracea (Roxb.) Pierre ex Dubard = **Diploknema butyracea** SAPOTACEAE
M. latifolia (Roxb.) Macbr. = **M. longifolia**
M. longifolia (Koenig.) Macbr.
M. motleyana (de Vriese) Baehni SAPOTACEAE
Magonia pubescens A.St.-Hil. SAPINDACEAE
Mangifera altissima Blanco ANACARDIACEAE
M. caesia Jack
M. indica L.
M. kempanga Blume
M. odorata Griff.
Manicaria saccifera Gaertn. PALMAE
Manniophyton africanum Muell. Arg. = **M. fulvum** EUPHORBIACEAE
M. fulvum Muel. Arg.
Mauritia flexuosa L.f PALMAE
Maximiliana maripa (Correa) Drude PALMAE
M. regia C.Mart. = **M. maripa**
Medemia argun Würtetemb. PALMAE
Melicoccus bijugatus Jacq. SAPINDACEAE
Mesua ferrea L. GUTTIFERAE
Mimusops djdjave Engl. = **Baillonella toxisperma** SAPOTACEAE
M. heckelii (Pierre ex Chev.) Hutch. & Dalz. = **Tieghemella heckelii**
Nelumbium nelumbo Druce = **Nelumbo nucifera** NYMPHAEACEAE
Nelumbo lutea (Willd.) Pers. NYMPHAEACEAE
N. nucifera Gaertn.
N. speciosa Willd. = **N. nucifera**
Nephelium lappaceum L. SAPINDACEAE
N. litchi Camb. = **Litchi chinensis**
N. mutabile Bl. = **N. ramboutan-ake**
N. ramboutan-ake (Labill.) Leenh.
Nothofagus alpina (Poepp. & Endl.) Oest. = **N. procera** FAGACEAE
N. procera (Poepp. & Endl.) Oest.
Nypa fruticans Wurmb PALMAE
Omphalea diandra L. EUPHORBIACEAE
O. megacarpa Hemsl.
O. triandra L.
Ongokea gore (Hua) Pierre OLACACEAE
Orbignya barbosiana Burret = *O. phalerata* PALMAE
O. cohune (C.Mart.) Dahlgren
O. cuatrecasana Dugand
O. martiana Barb.-Rodr. = **O. phalaris**
O. oleifera Burret
O. phalerata Mart.
O. speciosa (C.Mart.) Barb.Rodg. = **O. phalerata**
O. spectabilis (C.Mart.) Burret
Oroxylum indicum (L.) Kurz BIGNONIACEAE
Otophora fruticosa Roxb. = **Lepisanthes fruticosa** SAPINDACEAE
Owenia cerasifera F.Muell. = **Pleiogynium timoriense** ANACARDIACEAE
Pachira aquatica Aubl. BOMBACEAE
P. grandiflora Tussac = **P. aquatica**
P. insignis (Sw.) Savigny

Palaquium amboinense Burck SAPOTACEAE
P. gutta (Hook.f.) Baill.
P. hexandrum (Griff.) Baill.
P. javense Burck = **P. amboinense**
P. philippense (Perrott.) Rob.
P. rostratum (Miq.) Burck
Panax trifolius L. ARALIACEAE
Pandanus brosimos Merr. & Perry PANDANACEAE
P. conoideus Lam.
P. dubius Spreng.
P. julianettii Martelli
P. luzoniensis Merrr.
Panopsis suaveolens Pittier PROTEACEAE
Parajubaea cocoides Burret PALMAE
P. torallyi (Mart.) Burret
Parinari campestris Aubl. CHRYSOBALANACEAE
P. curatellifolia Planch. ex Benth.
P. excelsa Sabine
P. mobola Oliv. = **P. curatellifolian**
P. montana Aubl.
Parinarium campestre Aubl. = **Parinari campestris** CHRYSOBALANACEAE
P. montanum Aubl. = **Parinari montana**
Parmentiera cereifera Seem. BIGNONIACEAE
Pasania cuspidata Oerst. = **Castanopsis cuspidatus** FAGACEAE
Paullinia cupana Kunth SAPINDACEAE
P. subrotunda (Ruíz & Pav.) Pers.
Pentadesma butyracea Sabine GUTTIFERAE
Phyllanthus emblica L. EUPHORBIACEAE
Phytelephas aequatorialis Spruce PALMAE
P. macrocarpa Ruiz & Pavón
Pimelodendron amboinicum Hassk. EUPHORBIACEAE
Pinus albicaulis Engelm. PINACEAE
P. armandii Franch.
P. bungeana Zucc. ex Endl.
P. cembra L.
P. cembroides Zucc.
var. *edulis* (Engelm.) Jones = **P. edulis**
var. *monophylla* (Torr. & Frém.) Voss = **P. monophylla**
var. *parryana* (Engelm.) Voss = **P. quadrifolia**
P. cembroides Zucc.
var. *quadrifolia* (Parl. ex Sudw.) De Laub.
P. coulteri D.Don
P. edulis Engelm.
P. flexilis James
P. gerardiana Wall. ex D.Don
P. koraiensis Sieb. & Zucc.
P. lambertiana Douglas
P. longifolia Roxb. = **P. roxburghii**
P. monophylla Torr. & Frém.
P. monticola Douglas ex D.Don
P. nelsonii Shaw
P. parryana Engelm. = **P. quadrifolia**
P. pinea L.
P. ponderosa Douglas ex Lawson

P. pumila (Pallas) Regel
P. quadrifolia Parl. ex Sudw.
P. roxburghii Sarg.
P. sabiniana Douglas ex D.Don
P. sibirica Du Tour
P. torreyana Parry ex Carrière
Pistacia mexicana Kunth ANACARDIACEAE
P. terebinthus L.
P. texana Swingle
P. vera L.
Pithecellobium bubalinum (Jack) Benth. LEGUMINOSAE subfamily MIMOSOIDEAE
P. dulce (Roxb.) Benth.
P. jiringa (Jack) Prain
P. lobatum Benth. = **P. jiringa**
Planchonia careya (F.Muell.) Kunth LECYTHIDACEAE
Pleiogynium cersiferum (F.Muell.) Parker = **P. timoriense** ANACARDIACEAE
P. timoriense (DC.) Leenh.
Plukenetia conophora Muell. Arg. EUPHORBIACEAE
Poga oleosa Pierre ANISOPHYLLEACEAE
Pometia pinnata Forst. & Forst.f. SAPINDACEAE
Pouteria caimito (Ruíz & Pav.) Radlk. SAPOTACEAE
P. campechiana (Kunth) Baehni
P. glomerata (Miq.) Radlk.
P. hypoglauca Standl. = **P. glomerata**
P. obovata (R.Br.) Baehni
P. sapota (Jaq.) H.E.Moore & Stearn
P. viridis (Pittier) Cronquist
Prinsepia utilis Royle ROSACEAE
Pritchardia filifera Linden = **Washingtonia filifera** PALMAE
Prunus amygdalus Batsch = **P. dulcis** ROSACEAE
P. armeniaca L.
P. bucharica (Korsk.) Hand.-Mazz.
P. domestica L.
P. dulcis (Mill.) D.A.Webb
P. fasciculata (Torr.) A.Gray
P. ulmifolia Franch.
Pterocarya caucasica C.A.Mey. = **P. fraxinifolia** JUGLANDIACEAE
P. fraxinifolia (lam. ex Poir.) Spach
P. rhoifolia Sieb. & Zucc.
P. stenoptera C.DC.
Pterygota alata (Roxb.) R.Br. STERCULIACEAE
Pyrularia pubera Michx. SANTALACEAE
Quercus aegilops L. FAGACEAE
subsp. **persica** (Jaub. & Spach.) Blakelock
Q. aegilops sensu auct. = **Q. macrolepis**
Q. **agrifolia** Née
Q. alba L.
Q. ballota Desf. = **Q. ilex** subsp. **rotundifolia**
Q. bicolor Willd. = **Q. prinus**
Q. californica (Torr.) Cooper = **Q. kelloggii**
Q. calliprinos Webb = **Q. coccifera**
Q. coccifera L.
Q. cornea Lour. =**Lithocarpus cornea**
Q. cuspidata Thunb. = **Castanopsis cuspidata**

Q. emoryi Torr.
Q. frainetto Tenn.
Q. gambelii Nutt.
Q. garryana Douglas
Q. glabre Thunb.
Q. glauca Thunb.
Q. grisea Liebm.
Q. ilex L.
subsp. **ilex**
subsp. **rotundifolia** (Lam.) T.Marais
var. *ballota* Desf. = **Q. ilex** subsp. **rotundifolia**
Q. kelloggii Newb.
Q. libani Oliv.
Q. lobata Née
Q. marilandica
Q. macrocarpa Michx.
Q. macrolepis Kotschy
Q. michauxii Nutt. = **Q. prinus**
Q. nigra L,
Q. oblongifolia Torr. = **Q. grisea**
Q. obtusiloba Michx. = **Q. stellata**
Q. persica Jaub. & Spach. = **Q. aegilops** subsp. **persica**
Q. petraea (Matt.) Liebl.
Q. phellos L.
Q. prinoides Willd. = **Q. prinus**
Q. prinus L.
Q. robur L.
Q. sessilis Ehrh. =**Q. petraea**
Q. stellata Wangenh.
Q. suber L.
Q. undulata Torr.
Q. virginiana Mill.
Raphia farinifera (Gaertn.) Hyl. PALMAE
R. vinifera P.Beauv.
Ravensara aromatica Sonn. LAURACEAE
Ricinodendron heudelottii (Baill.) Heckel EUPHORBIOACEAE
R. rautanenii Schinz = **Schinziophyton rautanenii** EUPHORBIACEAE
Rhodognaphalon schumannianum A.Robyns BOMBACACEAE
Salacca edulis Reinw. = **S. zalacca** PALMAE
S. zalacca (Gaertn.) Voss
Santalum acuminata (R.Br.) DC. SANTALACEAE
S. spicatum (R.Br.) DC.
Santiria trimera (Oliv.) Aubrév. BURSERACEAE
Sapindus indicum Poir. (status uncertain) SAPINDACEAE
Scheelea butyracea (Mutis ex L.f.) Karst. ex H.A.Wendl. PALMAE
S. macrocarpa Karst.
S. magdalenica
S. martiana Burret
Schinziophyton rautanenii (Baill.) Radcl.-Sm. EUPHORBIACEAE
Schleichera oleosa (Lour.) Oken SAPINDACEAE
S. trijuga Willd. = **S. oleosa**
Sclerocary birrea (A.Rich.) Hochst. ANACARDIACEAE
subsp. **birrea**
subsp. **caffra** (Sond.) Kokwaro

Scorodoarpus borneensis (Baill.) Becc. OLACACEAE
Semecarpus anacardium L.f. ANACARDIACEAE
S. atra Viell. = **S. vitiensis**
S. vitiensis (A.Gray) Engl.
Serenoa repens (Bartram) Small PALMAE
Shorea amplexicaulis Ashton DIPTEROCARPACEAE
S. beccariana Burck
S. fallax Meijer
S. gysbertsiana Burck = **S. macrophylla**
S. hemsleyana (King) King ex Foxw.
S. lepidota (Korth) Bl.
S. macrantha Brandis
S. macrophylla (de Vriese) Ashton
S. mecistopteryx Ridl.
S. palembanica Miq.
S. parvistipulata Heim
S. pilosa Ashton
S. pinanga Scheff.
S. scaberrima Burok
S. seminis (de Vriese) Slooten
S. smithiana Sym.
S. splendida (de Vriese) Ashton
S. stenoptera Burck
S. sumatrana (Slecten ex Thor.) Sym.
Simmondsia californica Nutt. = **S. chinensis** SIMMONDSIACEAE
S. chinensis (Link) C.Schneider
Sorindeia longifolia (Hook.f.) Oliv. = **Trichoscypha longifolia** ANACARDIACEAE
Spondias lutea L. = **S. mombin** ANACARDIACEAE
S. mombin L.
Staphylea bolanderi STAPHYLEACEAE
S. pinnata L.
S. trifolia L.
Sterculia alata Roxb. = **Pterygota alata** STERCULIACEAE
S. apetala (Jacq.) Karst.
S. balanghas L.
S. carthaginensis Cav. = **S. apetala**
S. chicha A.St.Hil.
S. diversifolia G.Don
S. foetida L.
S. guttata Roxb.
S. oblongata R.Br.
S. quadrifida R.Br.
S. rupestris (Lindl.) Benth.
S. setigera Del.
S. tomentosa Guill. & Perr. = **S. setigera**
S. treubii Hochst.
S. trichosiphon Benth.
S. urceolata Sm.
S. urens Roxb.
Strombosia grandifolia Benth. OLACACEAE
S. pustulata Oliv.
S. scheffleri Engl.
Stylobasium spathulatum Desf. STYLOBASIACEAE

Syagrus cocoides Mart. PALMAE
S. coronata (C.Mart.) Becc.
S. edulis (Barb.-Rodr.) Flambach
Telfairia pedata (Sims) Hook. CUCURBITACEAE
Terminalia bellerica (Gaertn.) Roxb. COMBRETACEAE
T. bentzoë (L.) L.
T. catappa L.
T. chebula Retz.
T. copelandii Elmer
T. glabrata Forst.f.
T. impediens Coode
T. kaernbachii Warb.
T. latifolia Sw.
T. litoralis Seem.
T. mauritiana Lam. = **T. bentzoë**
T. microcarpa Blume
T. nitens Presl
T. okari C.White = **T. kaernbachii**
T. pamea DC.
T. platyphylla F.Muell.
Tetracarpidium conophorum (Muell.-Arg.) Hutch. & Dalz. EUPHORBIACEAE
Theobroma bicolor Humb. & Bonpl. STERCULIACEAE
T. cacao L.
T. leiocarpa Bern. = **T. cacao**
Tieghemella heckelii (Pierre ex Chev.) SAPOTACEAE
Torreya grandis Fortune ex Lindl. TAXACEAE
T. nucifera (L.) Sieb. & Zucc.
Trapa bicornis Osbeck TRAPACEAE
T. bispinosa Roxb. = **T. natans** var. *bispinosa*
T. cochinchinensis lour.
T. incisa Sieb, & Zucc.
T. natans L.
var. **africana** Brenan
var. **natans**
var. **bispinosa** (Roxb.) Makino
Treculia africana Decne. ex Trécul MORACEAE
Trichoscypha longifolia (Hook.f.) Engl. ANACARDIACEAE
Tylosema esculentum (Burch.) A.Schreib. LEGUMINOSAE subfamily CAESALPINIOIDEAE
Umbellularia californica (Hook. & Arn.) Nutt. LAURACEAE
Vateria indica L. DIPTEROCARPACEAE
Veitchia joannis Wendl. PALMAE
Vigna subterranea (L.) Verdc. LEGUMINOSAE subsp. PAPILIONOIDEAE
Vitellaria paradoxa Gaertn. f. SAPOTACEAE
Voandzeia subterranea (L.) Thouars = **Vigna subterranea** LEGUMINOSAE subfamily PAPILIONOIDEAE
Washingronia filifera (Linden) H.Wendl. PALMAE
W. robusta H.Wendl.
Ximenia americana L. OLACACEAE
Zamia chigua Seem. ZAMIACEAE
Z. floridiana A.DC.
Zostera marina L. ZOSTERACEAE

Most edible nuts contain concentrated food reserves and are a valuable source of energy, protein, oils, minerals and vitamins suitable for human consumption. Apart from direct consumption in the raw form as well as coated and salted, edible nuts find use in confectionery, ice creams and sweets, beverages, oils, etc. This document examines the importance of edible nuts as a non-wood forest product. It deals with the distribution, ecology, harvesting, processing, storage, marketing and economic benefits of several major, minor and potential edible nut-producing plants and their products.

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