# Edible Nuts

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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.

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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

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, sclerchymatous 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

foliaceous  
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

gecoarpic  
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  
the 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  
the male and female organs present in the same flower

herbaceous  
soft, not hard or woody

hull  
the layer term for skin of kernel

husk  
the layer 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
sepultum (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 kilograms), 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
1. INTRODUCTION

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 guineensis. 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 habit 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 on ly 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 hopper 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

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<tbody>
<tr>
<td>Almonds</td>
<td>1 006 457</td>
<td>1 232 222</td>
<td>1 281 355</td>
<td>1 194 497</td>
</tr>
<tr>
<td>Cashew nuts</td>
<td>446 004</td>
<td>707 583</td>
<td>726 418</td>
<td>479 804</td>
</tr>
<tr>
<td>Chestnuts</td>
<td>484 595</td>
<td>470 979</td>
<td>492 805</td>
<td>437 403</td>
</tr>
<tr>
<td>Filberts/Hazel nuts</td>
<td>477 662</td>
<td>520 428</td>
<td>721 622</td>
<td>565 157</td>
</tr>
<tr>
<td>Pistachios</td>
<td>109 379</td>
<td>329 804</td>
<td>313 256</td>
<td>345 305</td>
</tr>
<tr>
<td>Walnuts</td>
<td>788 097</td>
<td>938 998</td>
<td>931 697</td>
<td>1 006 547</td>
</tr>
<tr>
<td>BrazilnutA</td>
<td>53 333</td>
<td>32 000</td>
<td>4 924 000</td>
<td>4 579 000</td>
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</tbody>
</table>
These include Brazil nuts, macadamia nuts, pili nuts and sapucaia nuts.

Table 2: Disposable World Production of Oil Nuts and their Products

('000 tonnes)

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<tbody>
<tr>
<td>Coconuts</td>
<td>35 062</td>
<td>42 668</td>
<td>43 768</td>
<td>43 385</td>
</tr>
<tr>
<td>in shell</td>
<td>4 439</td>
<td>4 829</td>
<td>4 642</td>
<td>4 569</td>
</tr>
<tr>
<td>copra</td>
<td>18 491</td>
<td>23 531</td>
<td>24 601</td>
<td>25 005</td>
</tr>
<tr>
<td>Groundnuts (in shell)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm kernels</td>
<td>1 740</td>
<td>3 574</td>
<td>3 800</td>
<td>4 532</td>
</tr>
<tr>
<td>kernels</td>
<td>5 025</td>
<td>11 883</td>
<td>12 775</td>
<td>14 317</td>
</tr>
<tr>
<td>oila</td>
<td>14</td>
<td>70</td>
<td>62</td>
<td>68</td>
</tr>
<tr>
<td>babassu oil</td>
<td>14 413</td>
<td>22 947</td>
<td>21 979</td>
<td>20 489</td>
</tr>
<tr>
<td>Sunflower seeds</td>
<td></td>
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</tbody>
</table>

Source: FAO, 1994

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 reforestation 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 *Cryptonectria 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).
2. MAJOR EDIBLE NUTS

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
dry 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).

**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).

**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 pickers 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.

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).
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).

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 1000 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, windrows, 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

<table>
<thead>
<tr>
<th></th>
<th>Raw</th>
<th>Roasted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>710.0</td>
<td>740.0</td>
</tr>
<tr>
<td>Calories from fat (kJ)</td>
<td>630.0</td>
<td>673.0</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>10.0</td>
<td>9.3</td>
</tr>
<tr>
<td>Total fat (g)</td>
<td>70.0</td>
<td>74.7</td>
</tr>
<tr>
<td>Saturated fat (g)</td>
<td>6.7</td>
<td>9.3</td>
</tr>
<tr>
<td>Cholesterol (mg)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>13.3</td>
<td>13.7</td>
</tr>
<tr>
<td>Sugars (g)</td>
<td>3.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Dietary fibre (g)</td>
<td>6.7</td>
<td>5.7</td>
</tr>
<tr>
<td>Ca (mg)</td>
<td>73.0</td>
<td>73.0</td>
</tr>
<tr>
<td>P (mg)</td>
<td>603.0</td>
<td>603.0</td>
</tr>
<tr>
<td>Fe (mg)</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>K (mg)</td>
<td>603.0</td>
<td>603.0</td>
</tr>
<tr>
<td>Na (mg)</td>
<td>0.0</td>
<td>128.0</td>
</tr>
<tr>
<td>Mg (mg)</td>
<td>142.0</td>
<td>142.0</td>
</tr>
<tr>
<td>Vitamin A (IU)</td>
<td>130.0</td>
<td>120.0</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>2.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th>Thiamin (mg)</th>
<th>Riboflavin (mg)</th>
<th>Niacin (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.9</td>
<td>0.1</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>0.1</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: Young Pecan Company, undated.
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).

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 "charkasiya" (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 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 steam 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

<table>
<thead>
<tr>
<th></th>
<th>C14:0</th>
<th>C16:0</th>
<th>C16:1</th>
<th>C18:0</th>
<th>C18:1</th>
<th>C18:2</th>
<th>C18:3</th>
<th>%IS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil Nuts Kernel Fat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C14:0 = myristic;
C16:0 = palmitic acid;
C16:1 = palmitoleic;
C18:0 = stearic;
C18:1 = oleic;
C18:2 = linoleic;
C18:3 = linolenic;
%IS = insaturation = C16:1 + C18:1 + C18:2 + C18:3

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>
<thead>
<tr>
<th>Year</th>
<th>Brazil ('000 tons)</th>
<th>Bolivia ('000 tons)</th>
<th>Peru ('000 tons)</th>
<th>Total ('000 tons)</th>
<th>Approximate price FOB (£/ton or US$/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>50</td>
<td></td>
<td>50</td>
<td>50</td>
<td>£378/ton</td>
</tr>
<tr>
<td>1971</td>
<td>30</td>
<td></td>
<td>30</td>
<td>30</td>
<td>£487/ton</td>
</tr>
<tr>
<td>1972</td>
<td>65</td>
<td></td>
<td>65</td>
<td>65</td>
<td>£466/ton</td>
</tr>
<tr>
<td>1973</td>
<td>65</td>
<td></td>
<td>65</td>
<td>65</td>
<td>US$ 0.63/lb</td>
</tr>
<tr>
<td>1974</td>
<td>33</td>
<td></td>
<td>33</td>
<td>33</td>
<td>US$ 0.77/lb</td>
</tr>
<tr>
<td>1975</td>
<td>50</td>
<td></td>
<td>50</td>
<td>50</td>
<td>US$ 0.59/lb</td>
</tr>
<tr>
<td>1976</td>
<td>32</td>
<td></td>
<td>32</td>
<td>32</td>
<td>US$ 0.76/lb</td>
</tr>
<tr>
<td>1977</td>
<td>38</td>
<td></td>
<td>38</td>
<td>38</td>
<td>US$ 1.28/lb</td>
</tr>
<tr>
<td>1978</td>
<td>32</td>
<td>8</td>
<td>2</td>
<td>42</td>
<td>US$ 1.33/lb</td>
</tr>
<tr>
<td>1979</td>
<td>50</td>
<td>7</td>
<td>3</td>
<td>60</td>
<td>US$ 1.04/lb</td>
</tr>
<tr>
<td>1980</td>
<td>60</td>
<td></td>
<td>60</td>
<td>60</td>
<td>US$ 0.98/lb</td>
</tr>
<tr>
<td>1981</td>
<td>40</td>
<td></td>
<td>40</td>
<td>40</td>
<td>US$ 1.07/lb</td>
</tr>
<tr>
<td>1982</td>
<td>28</td>
<td></td>
<td>28</td>
<td>28</td>
<td>US$ 1.63/lb</td>
</tr>
</tbody>
</table>
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 favour 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 (Rosen garten, 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).

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

<table>
<thead>
<tr>
<th></th>
<th>Macadamia</th>
<th>Pistachio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (%)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Food energy (kJ)</td>
<td>3 064</td>
<td>2 465</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>7.1</td>
<td>21.4</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>78.6</td>
<td>50</td>
</tr>
<tr>
<td>Fatty acids, saturated (g)</td>
<td>11.4</td>
<td>6.1</td>
</tr>
</tbody>
</table>
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).

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).

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).

**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, 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 (C₅H₄O₂), 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.
3. MINOR EDIBLE NUTS

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).

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

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).

**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).
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).
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 porridge; 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).

**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: Pinuspinea, 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).

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.
4. POTENTIAL EDIBLE NUTS

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 silviculturists. 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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Scientific Name</th>
<th>Family</th>
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<tbody>
<tr>
<td>marula or maroela</td>
<td><em>Sclerocarya birrea subsp. caffra</em></td>
<td>Anacardiaceae</td>
</tr>
<tr>
<td>Guyana or Malabar chestnuts or saba nuts</td>
<td><em>Pachira aquatica</em></td>
<td>Bombacaceae</td>
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<tr>
<td>Java almond, kanari or galip nut</td>
<td><em>Canarium indicum</em></td>
<td>Burseraceae</td>
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<tr>
<td>pequi; piquí or piquia-oil plant</td>
<td><em>Caryocar brasiilense</em></td>
<td>Caryocaraceae</td>
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<td>castanha de galinha</td>
<td><em>Couepia longipedula</em></td>
<td>Chrysobalanaceae</td>
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<td>Indian or tropical almond</td>
<td><em>Terminalia catappa</em></td>
<td>Combretaceae</td>
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<td>okari nut</td>
<td><em>Terminalia kaernbachii</em></td>
<td>Combretaceae</td>
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<td><em>Caryocar brasiliense</em></td>
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<tr>
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<td><em>Terminalia catappa</em></td>
<td>Combretaceae</td>
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<td><em>Caryodendron orinocense</em></td>
<td>Euphorbiaceae</td>
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<td>tara</td>
<td><em>Lecythis pisonis</em></td>
<td>Lecythidaceae</td>
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<td><em>Gevuina avellana</em></td>
<td>Proteaceae:</td>
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<td><em>Santalum acuminata</em></td>
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<td><em>Argania spinosa</em></td>
<td>Sapotaceae:</td>
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<td><em>Vitellaria paradoxa</em></td>
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<td><em>Cola nitida</em></td>
<td>Sterculiaceae</td>
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<td>tucumá</td>
<td><em>Arenga pinnata</em></td>
<td>Palmae</td>
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<td><em>Astro Caryum vulgare</em></td>
<td>Palmae</td>
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<td>babassu, babacu palm or aguassú</td>
<td><em>Bactris gasipaes</em></td>
<td>Palmae</td>
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**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).

**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.

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 caulkng 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).

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; Leenhouts, 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; Leenhouts, 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).

**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, *licor 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).

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).

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).

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
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 Coronel, 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).

**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).

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.

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: *Lemnopisum 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, subcylindrical, 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
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


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


Post-harvest treatments

No information.

Production and consumption/utilization


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


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 l, 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**


**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).

**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).
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).

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).

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**

Follciles 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).

**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.

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**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).

**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).

**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 km² 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).

**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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Young Pecan Company (undated) Brochure pack. Young Pecan Company, Florence, South Carolina.

## APPENDIX A

### SPECIES WITH EDIBLE "NUTS" LISTED BY FAMILIES

#### ANGIOSPERMS

#### DICOTYLEDONS

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

<table>
<thead>
<tr>
<th>Species and distribution</th>
<th>Common name</th>
<th>Details</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anacardium giganteum</td>
<td>cajui; cajuçu; caju-da-mata; oloi</td>
<td>forest tree; drupe with enlarged, edible peduncle and kernel, former fresh or for juice, latter roasted</td>
<td>FAO, 1986</td>
</tr>
<tr>
<td>Amazonia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anacardium humile</td>
<td>monkey-nut</td>
<td>nut edible, conserves made of the fruit</td>
<td>Hedrick, 1972</td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anacardium nanum</td>
<td></td>
<td>nut edible, conserves made of the fruit</td>
<td>Hedrick, 1972</td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anacardium occidentale</td>
<td>cashew nut</td>
<td>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.</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1982; Rosengarten, 1984; FAO, 1986; Mabberley, 1987; Purseglove, 1987; Bianchini et al., 1988; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td>South America</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buchanania latifolia</td>
<td>wild cashew</td>
<td>edible fruit, eaten like cashew</td>
<td>Hedrick, 1972</td>
</tr>
<tr>
<td>Antrocaryon micraster</td>
<td></td>
<td>fruit pulp edible, may be made into a fermented beverage; seeds difficult to extract, kernel edible, rich in oil; timber for planks and furniture</td>
<td>Menninger, 1977; Mabberley, 1987; Peters et al., 1992</td>
</tr>
<tr>
<td>West Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India, Myanmar, Laos, Thailand, Vietnam, Yunnan</td>
<td>almonddie; cheronjere; Cuddapah almond; Hamilton mombin</td>
<td>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 &quot;almonddettes&quot; 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</td>
<td>Howes, 1948; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Verheij</td>
</tr>
<tr>
<td>Species</td>
<td>Origin</td>
<td>Uses</td>
<td>References</td>
</tr>
<tr>
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</tr>
<tr>
<td>Gluta elegans</td>
<td>Malaysia</td>
<td>seeds edible; sap can cause dermatitis</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td>Gluta renghas</td>
<td>Malaysia</td>
<td>roasted seeds eaten; timber useful but sap can cause dermatitis</td>
<td>Menninger, 1977; Mabberley, 1987; Purseglove, 1987</td>
</tr>
<tr>
<td>Lannea schweinfurthii var. stuhlmannii</td>
<td>East Africa</td>
<td>raw fruit eaten, seeds crushed, boiled with salt and eaten as a relish, bark made into a tisane</td>
<td>Menninger, 1977; Peters et al., 1992</td>
</tr>
<tr>
<td>Mangifera altissima</td>
<td>Solomon Islands to Philippines; cultivated</td>
<td>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</td>
<td>Verheij and Coronel, 1991</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>Indo-Malesia; widely cultivated in the tropics and subtropics</td>
<td>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</td>
<td>Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Purseglove, 1987; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td>Mangifera kemanga</td>
<td>Peninsular Malaysia, Sumatra, Borneo; commercially cultivated</td>
<td>tree; ripe fruit eaten fresh, pickled or made into a juice; fresh, grated seeds sometimes eaten; young leaves eaten</td>
<td>Verheij and Coronel, 1991</td>
</tr>
<tr>
<td>Mangifera odorata</td>
<td>not known in wild; cultivated in Sumatra, Borneo and Java</td>
<td>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 <em>M. indica</em></td>
<td>Verheij and Coronel, 1991</td>
</tr>
<tr>
<td>Pistacia</td>
<td></td>
<td>seeds edible</td>
<td>Hedrick, 1972;</td>
</tr>
</tbody>
</table>
mexicana

S. Mexico to Guatemala

Pistacia terebinthus terebinth; kernel sweet, edible; source of tan galls; formerly source of turpentine

Mediterranean

Pistacia texana Texas pistacio dioecious shrub or tree; with small, nut-like drupe <1 cm long

Texas to central Mexico

Pistacia vera pistacio seed eaten as dessert nut, the pistachio nut of commerce, used in ice-cream and confectionery

Iran to central Asia; widely cultivated in Mediterranean and USA

Pleiogynium timoriense Burdekin or sweet plum fruit used in jams and jellies; timber good; ornamental street tree

Queensland

Sclerocarya birrea dioecious tree

subsp. birrea fruit flesh used to make alcoholic beverage; kernel oily, eaten

N. tropical Africa marula dioecious tree; fruit eaten, flesh rich in vitamin C, stone contains 2-3 highly nutritious embryos

subsp. caffra

E. and southern Africa

Semecarpus anacardium marking nut; varnish tree; Australian cork screw; 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

India; cultivated in tropical Asia, Australia and Africa

Semecarpus vitiensis New Caledonia, Fiji kernel eaten, care required to avoid fruit blistering latex,

Spondias mombin 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

tropical America; occasionally

Hedrick, 1972; Menninger, 1977; Mabberley, 1987

Menninger, 1977

Hedrick, 1972; Menninger, 1977; Mabberley, 1987

Krochmal, 1982

Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988

Hedrick, 1972; Menninger, 1977

Hedrick, 1972; Menninger, 1977; Arnold et al. 1985; Peters et al. 1992

Hedrick, 1972; Menninger, 1977; Tow, 1989; Verheij and Coronel, 1992

Hedrick, 1972; Menninger, 1977

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, 1977; Mabberley, 1987; Peters et al., 1992

ARALIACEAE; fruit usually a drupe or berry

*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*  
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;
<table>
<thead>
<tr>
<th><strong>Philippines</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parmentiera cereifera</strong></td>
<td>candle tree; cuachilote</td>
</tr>
<tr>
<td><strong>Panama; cultivated</strong></td>
<td></td>
</tr>
</tbody>
</table>

**BOMBACACEAE; fruit a locucidal capsule, rarely fleshy and indehiscent**

| **Adansonia digitata** | 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 |
| tropical Africa; occasionally cultivated |  |
| **Adansonia gregorii** | baobab | seeds eaten by Aborigines; source of fibre | Menninger, 1977; Lazarides and Hince, 1993 |
| **West Australia** |  |
| **Ceiba pentandra** | kapok silk cotton tree | young fruit edible; seeds eaten 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 |
| tropical South America; widely cultivated |  |
| **Durio zibethinus** | 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 |
| **W. Malesia; widely cultivated in Malaysia** |  |
| **Pachira aquatica** | 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 |
| tropical America, estuaries; cultivated |  |
| **Pachira insignis** | maranhao nut | seeds eaten; young leaves and flowers also eaten | Hedrick, 1977; Menninger, 1977 |
| **Central America** |  |
| **Rhodognaphalon schumannianum** |  | seeds cooked and eaten | Peters et al., 1992 |
| tropical Africa |  |  |  |
BURSERACEAE; fruit a drupe with 1-5 1-seeded stones or 1 stones with all seeds, rarely a capsule

<table>
<thead>
<tr>
<th>Species</th>
<th>Origin/Location</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Boswellia serrata</em></td>
<td>India; cultivated</td>
<td>tree; flowers and seeds eaten; wood used to make paper and tea chests, fuel; cultivated for its fragrant gum-resin</td>
<td>Menninger, 1977; Mabberley, 1987</td>
</tr>
<tr>
<td><em>Canarium album</em></td>
<td>S. China, Vietnam; cultivated</td>
<td>tree; fruit pulp and seeds edible, sold on the world market; wood and resin sometimes used; grown as an ornamental</td>
<td>Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Canarium harveyi</em></td>
<td>Solomon Islands</td>
<td>Santa Cruz Ngallinut; oily nut edible; oil used locally for cosmetics; potential for development</td>
<td>Pelomo, 1993</td>
</tr>
<tr>
<td><em>Canarium indicum</em></td>
<td>Malaysia to Melanesia; cultivated</td>
<td>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 &quot;pili&quot; 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</td>
<td>Hawes, 1948; Leenhouts, 1956; Hedrick, 1972; Menninger, 1977; Verheij and Coronel, 1991; Macrae et al., 1993; Pelomo, 1993</td>
</tr>
<tr>
<td><em>Canarium littorale</em></td>
<td>Malaysia</td>
<td>nuts small, hard-shelled, kernel edible</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td><em>Canarium luzonicum</em></td>
<td>S.E. Asia</td>
<td>Java almond, pili nut, elemi; &quot;oily pili&quot; nuts edible; seed oil source of &quot;Manila elmi&quot; for varnishes, etc.</td>
<td>Howes, 1948; Menninger, 1977; Mabberley, 1987</td>
</tr>
<tr>
<td><em>Canarium muelleri</em></td>
<td>Queensland</td>
<td>deciduous tree; nuts very small, eaten by Aborigines</td>
<td>Menninger, 1977; Lazarides et al., 1993</td>
</tr>
<tr>
<td><em>Canarium ovatum</em></td>
<td>Philippines; cultivated</td>
<td>pili or Philippine nut; evergreen tree; oily &quot;pili&quot; 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 &quot;Manila elmi&quot; for varnishes, etc., also used as an illuminant; young shoots edible; shell used for fuel and carving; grown as an avenue tree and windbreak</td>
<td>Howes, 1948; Leenhouts, 1956; Menninger, 1977; Rosengarten, 1984; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Canarium pateninervium</em></td>
<td>Thailand, Peninsular Malaysia;</td>
<td>kedondong tree; seeds eaten; soft, light wood used for fuel</td>
<td>Verheij and Coronel, 1991</td>
</tr>
</tbody>
</table>
Sumatra, Borneo

Canarium pilosum  
damar lilin  
tree; seeds sweet, eaten; wood durable used for houses; resin used to close wounds  
Verheij and Coronel, 1991

Indonesia, Malaysia, Brunei

Canarium pimela  
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  

Canarium salomonense  
adoa  
oily nut edible; oil used locally for cosmetics; potential for development  
Pelomo, 1993

Solomon Islands, New Guinea

Canarium schweinfurthii  
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  
oily “pili” nuts edible  
Hedrick, 1972

Ambon

Canarium vrieseanum  
solo  
tree; seeds edible; resin burnt as an illuminant; tough wood used in construction  
Verheij and Coronel, 1991

Indonesia, Philippines

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  
fruits smelling of turpentine, edible, marketed locally; oily seeds edible  
Menninger, 1977; Burkill, 1985

West Africa

CAPARACEAE; fruit often a berry, rarely a nut or drupe

Boscia angustifolia  
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  
evergreen shrub; berries marketed locally, fruit pulp, seeds and leaves eaten after leaching for 3-4 days and

Hedrick, 1972; Menninger,
<table>
<thead>
<tr>
<th><strong>CARYOCARACEAE</strong>; fruit a drupe, stone separating into 4 1-seeded pyrenes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Caryocar amygdaliforme</strong></td>
</tr>
<tr>
<td><strong>Caryocar amygdaliferum</strong></td>
</tr>
<tr>
<td><strong>Caryocar brasiliense</strong></td>
</tr>
<tr>
<td><strong>Caryocar coriaceum</strong></td>
</tr>
<tr>
<td><strong>Caryocar glabrum</strong></td>
</tr>
<tr>
<td><strong>Caryocar nuciferum</strong></td>
</tr>
</tbody>
</table>

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*Notes on sources:*
- Uphof, 1968;
- Hedrick, 1972;
- Prance and Freitas, 1973;
- Menninger, 1977;
- FAO, 1982; Prance and Freitas, 1973; Mabberley, 1987; Rosangarten, 1984; Mabberley, 1987; Verheij...
**CHRYSOBALANACEAE; fruit a 1-seeded drupe**

**Chrysobalanus icaco**  
*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; heavy construction and shipbuilding; introduced into Malaysia but plantations low yielding. Potential for development of fruit and oil  

**Couepia edulis**  
*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  

**Couepia longipendula**  
*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

**Parinari campestris**  
*Parinari curatellifolia*  
Trinidad, Guyana to N. Brazil  
small, kernel edible  
Hedrick, 1972

**Parinari curatellifolia**  
*Parinari campestris*  
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; Burkhill, 1985; Mabberley, 1987; Peters et
**Parinari excelsa**  
**tropical Africa**  
fruit usually indehiscent, 1-seeded, drupaceous  
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

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**Combretaceae**; fruit usually indehiscent, 1-seeded, drupaceous

| **Terminalia bellerica** | myrobalan | kernels eaten, possibly toxic or narcotic; seed source of tannin and black dye; timber good, source of firewood and charcoal; fruit source of commercial myrobalan, used for tanning, source of a black dye  
| Indo-Malesia; cultivated  
| Terminalia bentzoé | false benzoin | kernels eaten  
| Mascarine Islands  
| Terminalia catappa | 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  
| Peninsular Malaysia; widely planted in tropics  
| Terminalia chebula | myrobalan | fruit difficult to open, kernel edible; dried fruit for tanning  
| India, Sri Lanka, Myanmar  
| Terminalia copelandii | kernels edible; source of timber  
| East Indies, Philippines  
| Terminalia glabrata | kernels eaten, almond flavoured  
| Pacific Islands  
| Terminalia impediens | kernels edible  
| Coode, 1969

Exell, 1954;  
Hedrick, 1972;  
Menninger, 1977;  
Mabberley, 1987

Howes, 1948;  
Coode, 1969;  
Hedrick, 1972;  
Thaman, 1976;  
Menninger, 1977;  
FAO, 1982;  
Rosengarten, 1984;  
Morton, 1985;  
Mabberley, 1987;  
Tow, 1989

Mabberley, 1987

Menninger, 1977;  
Mabberley, 1987

Menninger, 1977;  
Mabberley, 1987

Exell, 1954
New Guinea

**Terminalia kaempbachii**

*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**

*kernels eaten, almond flavoured*

Hedrick, 1972

Caribbean

**Terminalia litoralis**

*kernels edible, sometimes eaten by children; useful timber*

Smith, 1971; Hedrick, 1972; Menninger, 1977

Fiji, Tonga

**Terminalia microcarpa**

*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

Philippines

**Terminalia nitens**

*sakat fruit oval, 3 cm long; raw kernel eaten; timber for construction and ship planking*

FAO, 1984

**Terminalia pamea**

*kernels eaten, almond flavoured*

Hedrick, 1972;

Menninger, 1977

Guyana; cultivated

**Terminalia platyphylla**

*wild plum kernels eaten*

Smith, 1971;

Hedrick, 1972

N. Australia

**Helianthus annuus**

*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

**COMPOSITAE; fruit usually a cypsela, usually with persistent pappus, rarely a drupe**

**Helianthus annuus**

*North America; widely cultivated*

**CORYLACEAE; fruit a nut**
<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
<th>Characteristics</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Corylus americana</em></td>
<td>E. North America; cultivated</td>
<td>American filbert or hazelnut; nuts with edible seeds, well flavoured but smaller and thicker shelled than <em>C. avellana</em>; cultivated as an ornamental</td>
<td>Howes, 1948; Hedrick, 1972; Krochmal, 1982; Mabberley, 1987</td>
</tr>
<tr>
<td><em>Corylus avellana</em></td>
<td>Eurasia, cultivated</td>
<td>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 <em>A. maxima</em></td>
<td>Bobiov, 1936; Howes, 1948; Hedrick, 1972; Mabberley, 1987; Rao, 2012</td>
</tr>
<tr>
<td><em>Corylus chinensis</em></td>
<td>China</td>
<td>Chinese hazelnut, Chinese filbert; Nuts with edible seeds</td>
<td>Howes, 1948</td>
</tr>
<tr>
<td><em>Corylus colurna</em></td>
<td>S.E. Europe, S.W. Asia; cultivated</td>
<td>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</td>
<td>Bobiov, 1936; Howes, 1948; Hedrick, 1972; Mabberley, 1987; Rathore, 1993</td>
</tr>
<tr>
<td><em>Corylus cornuta</em></td>
<td>N.E. North America</td>
<td>Beaked filbert; beaked hazel; nuts with well-flavoured, edible seeds; more cold hardy than <em>C. americana</em></td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982</td>
</tr>
<tr>
<td><em>Corylus ferox</em></td>
<td>Himalayan region</td>
<td>Himalayan hazelnut, curri; nuts small, thick shelled with edible seeds but bristly involucre limits its commercial exploitation for food</td>
<td>Howes, 1948; Hedrick, 1972</td>
</tr>
<tr>
<td><em>Corylus heterophylla</em></td>
<td>E. Mongolia, Manchuria, N. China; cultivated Japan</td>
<td>Siberian hazelnut; nuts with edible seeds, marketed commercially</td>
<td>Bobiov, 1936</td>
</tr>
<tr>
<td><em>Corylus maxima</em></td>
<td>S.E. Europe; cultivated</td>
<td>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 <em>A. avellana</em></td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Bianchini et al., 1988</td>
</tr>
<tr>
<td><em>Corylus sieboldiana</em></td>
<td>China, Japan</td>
<td>Japanese hazelnut; nuts edible but bristly involucre limits its commercial exploitation for food</td>
<td>Bobiov, 1936</td>
</tr>
<tr>
<td><em>Corylus tibetica</em></td>
<td>China</td>
<td>Tibetan hazelnut, Tibetan filbert; nuts with edible seeds but bristly involucre limits its commercial exploitation for food</td>
<td>Howes, 1948; Roecklein and Ping Sun Leun, 1987</td>
</tr>
</tbody>
</table>
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; naram; 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 |

| 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, |
**DIPTEROCARPACEAE; fruits, dry, indehiscent, 1-seeded with woody pericarp**

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Description</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Anisoptera thurifera</em></td>
<td>Palosapis</td>
<td>Deciduous forest tree; fruit 2-15 mm in diameter; seeds eaten raw or roasted</td>
<td>FAO, 1984</td>
</tr>
<tr>
<td><em>Shorea sp.</em></td>
<td>Borneo illipe nut</td>
<td>Emergent rainforest tree; kernels commercial source of specialty fats (cocoa butter equivalents) used as cocoa butter substitute in chocolate formulations also in cosmetics, formerly important for soap and candles; valuable timber tree</td>
<td>Blicher-Mathiesen, 1994; Howes, 1948; Menninger, 1977; Mabberley, 1987;</td>
</tr>
<tr>
<td><em>Vateria indica</em></td>
<td>Dammar</td>
<td>Seeds used for making a bread; seed fat - &quot;Malabar fat&quot; or &quot;dhupa fat&quot; used for candles, etc.; resin - &quot;white dammar&quot; or &quot;piney varnish&quot; formerly important</td>
<td>Hedrick, 1972; Menninger, 1977; Mabberley, 1987;</td>
</tr>
</tbody>
</table>

**ELAEOCARPACEAE; fruit a capsule or drupe**

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Description</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Elaeocarpus bancroftii</em></td>
<td>Karanda nut</td>
<td>Nut edible, excellent flavour, equalling that of <em>Macadamia</em>; virtually unknown in cultivation, CSIRO interested in developing; timber</td>
<td>Mabberley, 1987; Tow, 1989; Lazarides and Hince, 1993</td>
</tr>
</tbody>
</table>

**EUPHORBIACEAE; fruit a 3-lobed capsule**

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Description</th>
<th>Reference(s)</th>
</tr>
</thead>
</table>

1987

Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Peters et al., 1992; Macrae et al., 1993
<table>
<thead>
<tr>
<th>Species</th>
<th>Name</th>
<th>Origin</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aleurites moluccana</td>
<td>candle-nut; candleberry; balucanat; Indian or Otaheite walnut</td>
<td>S.E. Asia; widely cultivated in the tropics</td>
<td>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 &quot;China wood oil&quot;, &quot;candle-nut oil&quot;, &quot;lumbang oil&quot;, &quot;walnut-oil&quot; or &quot;artist's oil&quot;, 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</td>
<td>Howes, 1948; Hedrick, 1972; Rosengarten, 1984; Mabberley, 1987; Tow, 1989; Lazarides and Hince, 1993; Macrae et al., 1993; Burkill, 1994</td>
</tr>
<tr>
<td>Caryodendron amazonicum</td>
<td>Possibly cospecific with C. orinocense; uses as for C. orinocense</td>
<td>NW Brazil, Colombia, Peru</td>
<td></td>
<td>Reckin, 1983; Clement and Villachica, 1994</td>
</tr>
<tr>
<td>Caryodendron orinocense</td>
<td>inchi; tacay or taccy nut; orinoco nut</td>
<td>Colombia, Ecuador, Venezuela; small plantations in Colombia and Ecuador</td>
<td>Kernel surrounded by thin shell, easily broken with fingers; roasted seeds eaten, flavour like Corylus avellana (hazel); source of edible oil.</td>
<td>Howes, 1948; Menninger, 1977; Reckin, 1983; Mabberley, 1987; Clement and Villachica, 1994</td>
</tr>
<tr>
<td>Cnidoscolus oligandrus</td>
<td>seeds with 40-50% oil, eaten in times of drought</td>
<td>Brazil</td>
<td></td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td>Elateriospermum tapos</td>
<td>tapos</td>
<td>S. Thailand, Peninsular Malaysia</td>
<td>Seeds large, oily, eaten after boiling to remove HCN</td>
<td>Menninger, 1977; Mabberley, 1987</td>
</tr>
<tr>
<td>Manniophytom fulvum</td>
<td>gasso nut</td>
<td>Tropical Africa</td>
<td>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</td>
<td>Howes, 1948; Menninger, 1977; Mabberley, 1987; Peters et al., 1992</td>
</tr>
<tr>
<td>Omphalea diandra</td>
<td>cobnut</td>
<td>Caribbean</td>
<td>Seeds edible, embryo deleterious and requires removal</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977</td>
</tr>
<tr>
<td>Omphalea megacarpa</td>
<td>Russell river nut</td>
<td>Caribbean</td>
<td>Large nuts eaten raw</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td>Omphalea triandra</td>
<td>Jamaican cob nut</td>
<td>Caribbean</td>
<td>Seeds eaten raw or roasted after removal of deleterious embryo, source of a sweet, fine-flavoured oil</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Mabberley, 1987</td>
</tr>
<tr>
<td>Phyllanthus emblica</td>
<td>emblic; ambal</td>
<td>tropical America</td>
<td>Seeds edible, made into sweetmeats; dried fruit provides &quot;emblic myrobalan&quot;, used in local medicine</td>
<td>Hedrick, 1972; Menninger, 1977</td>
</tr>
</tbody>
</table>
FAGACEAE; fruit a nut

**Castanea crenata**  
Japanese chestnut  
Japan; cultivated  
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**  
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 sativa**  
Japanese chestnut  
Japan; cultivated  
nuts variable in size, some 5 cm in diameter, edible but bitter due to tannin content; grown as an ornamental  
Camus, 1929; Howes, 1948; Uphof, 1968; Usher, 1974; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987

**Pimelodendron amboinicum**  
Moluccas  
seeds edible; bark purgative; milky latex used as a varnish  
Mabberley, 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; Mabberley, 1987

**Ricinodendron heudelotii**  
tropical Africa  
erimado  
edible nuts and oilseeds; trade timber  
Menninger, 1977; Mabberley, 1987

**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

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**tropical Asia; cultivated**  
and source of tanbark and dyes  
1977; Mabberley, 1987

**Pimelodendron amboinicum**  
tropical Asia; cultivated  
and source of tanbark and dyes  
1977; Mabberley, 1987

**Moluccas**

**Plukenetia conophora**  
Sierra Leone to Zaire  
owusa nut liane cultivated for its oilseeds for use in cooking; kernels eaten raw  
Howes, 1948; Menninger, 1977; Mabberley, 1987

**Ricinodendron heudelotii**  
tropical Africa  
erimado  
edible nuts and oilseeds; trade timber  
Menninger, 1977; Mabberley, 1987

**Schinziophyton rautanenii**  
S. Angola and N. Namibia eastwards to Tanzania and N. Mozambique  
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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

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Japanese chestnut  
Japan; cultivated  
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**  
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
<table>
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<tr>
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<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Castanea henryi</em></td>
<td>Nuts excellent, small, edible; timber for building</td>
<td>Camus, 1929; Howes, 1948; Uphof, 1968; Usher, 1974</td>
</tr>
<tr>
<td><em>Castanea mollisima</em></td>
<td>Chinese chestnut; nuts edible, sweeter than <em>C. sativa</em> but less sweet than <em>C. dentata</em>, resistant to chestnut blight; cultivated and sold in local markets; source of timber and fuel</td>
<td>Camus, 1929; Howes, 1948; Uphof, 1968; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984</td>
</tr>
<tr>
<td><em>Castanea mollisima</em></td>
<td>N.W. China; cultivated China, introduced North America</td>
<td>Camus, 1929; Howes, 1948; Uphof, 1968; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984</td>
</tr>
<tr>
<td><em>Castanea ozarkensis</em></td>
<td>Ozak chinquapin; nuts small, edible</td>
<td>Krochmal, 19982</td>
</tr>
<tr>
<td><em>Castanea pumila</em></td>
<td>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</td>
<td>Camus, 1929; Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Mabberley, 1987</td>
</tr>
<tr>
<td><em>Castanea sativa</em></td>
<td>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</td>
<td>Camus, 1929; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Mabberley, 1987; Bianchini et al., 1988; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Castanea seguinii</em></td>
<td>Nuts small, edible, used for flour</td>
<td>Camus, 1929; Uphof, 1968; Usher, 1974</td>
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<tr>
<td><em>Castanopsis acuminatissima</em></td>
<td>Gon; nuts eaten raw or cooked</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td><em>Castanopsis argentea</em></td>
<td>Seeds edible; bark source of dye; timber</td>
<td>Mabberley, 1987; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Castanopsis argyrophylla</em></td>
<td>Nuts edible</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td><em>Castanopsis argyrophylla</em></td>
<td>Indo-Malesia</td>
<td>Usher, 1974</td>
</tr>
</tbody>
</table>

**References:**
- Camus, 1929
- Howes, 1948
- Uphof, 1968
- Usher, 1974
- Menninger, 1977
- Krochmal, 1982
- Rosengarten, 1984
- Mabberley, 1987
- Bianchini et al., 1988
- Verheij and Coronel, 1991
<table>
<thead>
<tr>
<th>Country</th>
<th>Species</th>
<th>Characteristics</th>
<th>References</th>
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</thead>
<tbody>
<tr>
<td><strong>India</strong></td>
<td>Castanopsis boisii</td>
<td>nuts edible, marketed locally</td>
<td>Uphof, 1968; Usher, 1974</td>
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<tr>
<td><strong>N. Vietnam</strong></td>
<td>Castanopsis chinensis</td>
<td>nuts edible</td>
<td>Menninger, 1977</td>
</tr>
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<td><strong>China</strong></td>
<td>Castanopsis chrysophylla</td>
<td>golden-leaved chestnut; tree evergreen; nuts ripen in second year, 8-12 mm long, sweet, eaten by native Americans; wood used for agricultural implements</td>
<td>Howes, 1948; Uphof, 1968; Usher, 1974; Krochmal, 1982; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>S.W. USA</strong></td>
<td>Castanopsis costata</td>
<td>berangan duri tree; nuts eaten parched, roasted or boiled, used in confectionery; wood hard, difficult to work; bark tannin source</td>
<td>Howes, 1948; Soepadmo, 1972; Menninger, 1977; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><strong>Thailand, Peninsular Malaysia, Borneo, Sumatra; lowland to submontane forest</strong></td>
<td>Castanopsis cuspidatus</td>
<td>acorns small, sweet, eaten boiled or roasted; planted in Japan as an ornamental; leaves formerly used as rice bowls</td>
<td>Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987</td>
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<tr>
<td><strong>Korea, S. China</strong></td>
<td>Castanopsis hysteris</td>
<td>nuts eaten; timber for construction, sleepers, cheap furniture, tools, etc. tannin potential; coppices well</td>
<td>Howes, 1948; CSIR, 1992</td>
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<tr>
<td><strong>E. Himalayas</strong></td>
<td>Castanopsis indica</td>
<td>nuts eaten; timber for construction, panelling, tools, fuel; browsed</td>
<td>Howes, 1948; CSIR, 1992</td>
</tr>
<tr>
<td><strong>tropical Himalayas</strong></td>
<td>Castanopsis inermis</td>
<td>nut eaten boiled, parched or roasted, used in confectionery, marketed in Sumatra; wood hard, difficult to work; bark tannin source</td>
<td>Camus, 1929; Uphof, 1968; Usher, 1974; Menninger, 1977; Verheij and Coronel, 1991</td>
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<tr>
<td><strong>Malesia; forests</strong></td>
<td>Castanopsis javanica</td>
<td>cultivated in Java for its edible nuts; post timber; bark used for rice baskets</td>
<td>Howes, 1948; Soepadmo, 1972; Menninger, 1977; Verheij and Coronel, 1991</td>
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<tr>
<td>Castanopsis lucida</td>
<td>berangan papan</td>
<td>nuts eaten raw, boiled or roasted, used in confectionery; wood hard, difficult to work; bark tannin source</td>
<td>Menninger, 1977; Verheij and Coronel, 1991</td>
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<td>-------------------</td>
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<tr>
<td>Castanopsis malaccensis</td>
<td>berangan gajah</td>
<td>nuts eaten raw, boiled or roasted, used in confectionery, causes diarrhoea if eaten to excess; wood hard, difficult to work; bark tannin source</td>
<td>Menninger, 1977; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td>Castanopsis megacarpa</td>
<td></td>
<td>nuts bitter, eaten</td>
<td>Menninger, 1977; Verheij and Coronel, 1991</td>
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<tr>
<td>Castanopsis philipensis</td>
<td></td>
<td>nuts eaten; timber</td>
<td>Uphof, 1968; Usher, 1974; Verheij and Coronel, 1991</td>
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<td>Castanopsis sclerophylla</td>
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<td>nuts eaten locally</td>
<td>Uphof, 1968; Usher, 1974</td>
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<tr>
<td>Castanopsis sempervirens</td>
<td>bush or Dudley sierra chinquapin</td>
<td>nuts eaten by native Americans, good roasted and served with butter and salt</td>
<td>Krochmal, 1982</td>
</tr>
<tr>
<td>Castanopsis tibetana</td>
<td></td>
<td>nuts eaten locally</td>
<td>Camus, 1929; Uphof, 1968; Usher, 1974</td>
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<tr>
<td>Castanopsis tribuloides</td>
<td></td>
<td>evergreen tree; nuts roasted and eaten; timber durable, used for planks, shingles and fuel</td>
<td>Howes, 1948; Menninger, 1977; CSIR, 1992</td>
</tr>
<tr>
<td>Castanopsis wallichii</td>
<td>berangan duri</td>
<td>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</td>
<td>Howes, 1948; Soepadma, 1972; Menninger, 1977; Verheij and Coronel, 1991</td>
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<tr>
<td>Fagus grandifolia</td>
<td>American, Carolina, red, grey or white beech</td>
<td>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</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td>Common Name</td>
<td>Scientific Name</td>
<td>Habitat</td>
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<tr>
<td>European beech</td>
<td><em>Fagus sylvatica</em></td>
<td>Europe; cultivated</td>
<td>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</td>
</tr>
<tr>
<td>S. China</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tanoak; tanbark oak</td>
<td><em>Lithocarpus densiflorus</em></td>
<td>Asia, introduced W. USA</td>
<td>acorns mature end of second season; acorns leached in hot water to remove tannins, dried, ground and eaten by native Americans</td>
</tr>
<tr>
<td>Ulayan tree; acorns eaten roasted or boiled, also used in candies</td>
<td><em>Lithocarpus philippinensis</em></td>
<td>Philippines</td>
<td></td>
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<tr>
<td>Rauli roble; deciduous tree; acorns edible; timber used for furniture</td>
<td><em>Nothofagus procera</em></td>
<td>Chile</td>
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</tr>
<tr>
<td>Manna oak; deciduous tree; acorns used for making bread</td>
<td><em>Quercus aegilops</em> subsp. persica*</td>
<td>Iran, Iraq</td>
<td></td>
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<tr>
<td>Coast live or Californian field oak</td>
<td><em>Quercus agrifolia</em></td>
<td>S.W. North America</td>
<td>evergreen tree; acorns eaten raw or roasted by native Americans, also ground for baking</td>
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<tr>
<td>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</td>
<td><em>Quercus alba</em></td>
<td>E. North America</td>
<td></td>
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<tr>
<td>Kermes oak; evergreen shrub, acorns ripening in second year</td>
<td><em>Quercus coccifera</em></td>
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<tr>
<td>Species</td>
<td>Distribution</td>
<td>Uses</td>
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<tr>
<td>Mediterranean</td>
<td>Formerly eaten</td>
<td></td>
<td>Hedrick, 1972; Menninger, 1977;</td>
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<tr>
<td><em>Quercus emoryi</em></td>
<td>Emory or blackjack oak; bellota</td>
<td>Evergreen tree; acorns sweet and palatable, eaten by native Americans and Mexicans; timber source; good watershed protection; browsed</td>
<td>Howes, 1948; Kearney and Peebles, 1951;</td>
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<tr>
<td>S. Arizona, New Mexico</td>
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<td></td>
<td>HDRick, 1972; Menninger, 1977; USDA, 1988;</td>
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<tr>
<td><em>Quercus garryana</em></td>
<td>Tree; ground acorns used as a coffee substitute; cultivated as an ornamental</td>
<td>Davison, 1994</td>
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<tr>
<td>Balkans</td>
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<tr>
<td><em>Quercus gambeli</em></td>
<td>Gambel or shin oak</td>
<td>Deciduous tree; ground acorns edible, used as flour; browsed by game and livestock</td>
<td>Howes, 1948; Uphof, 1968; Usher, 1974; Mabberley, 1987; USDA, 1988;</td>
</tr>
<tr>
<td>W. North America</td>
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<tr>
<td><em>Quercus grisea</em></td>
<td>Grey, evergreen, live or Mexican blue oak</td>
<td>Tree; acorns highly palatable, eaten by native Americans; important timber tree; browsed by cattle and sheep</td>
<td>Howes, 1948; Hedrick, 1972; Usher, 1974; Menninger, 1977; Mabberley, 1987; USDA, 1988</td>
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<tr>
<td><em>Quercus glabra</em></td>
<td>Acorns eaten locally</td>
<td>Camus, 1936-74; Uphof, 1968; Usher, 1974; Menninger, 1977; Rosengarten, 1984;</td>
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<tr>
<td>Japan</td>
<td>Acorns eaten</td>
<td>Menninger, 1977</td>
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<td><em>Quercus glauca</em></td>
<td>Acorns eaten</td>
<td>Menninger, 1977</td>
<td></td>
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<td>Himalayas</td>
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<tr>
<td><em>Quercus grisea</em></td>
<td>Grey, evergreen, live or Mexican blue oak</td>
<td>Tree or shrub; acorns eaten by native Americans</td>
<td>Hedrick, 1972;</td>
</tr>
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<td>S.W. North America</td>
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<tr>
<td><em>Quercus ilex</em></td>
<td>Holm oak, holly oak; cultivated</td>
<td>Evergreen tree; acorns occasionally eaten; oak timber used for furniture; galls used for tanning; also planted as an ornamental</td>
<td>Kuzeneva, 1936; Camus, 1936-54; Howes, 1948; Uphof, 1968; Hedrick, 1972; Camus, 1974; Menninger, 1977; Mabberley, 1987</td>
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<tr>
<td>subsp. <em>ilex</em></td>
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<tr>
<td>Mediterranean excluding the Iberian Peninsula</td>
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<tr>
<td>subsp. <em>rotundifolia</em></td>
<td>Evergreen tree, cultivated in Spain and Portugal for its acorns, which are roasted and eaten, also source of oil</td>
<td>Howes, 1948; Menninger, 1977;</td>
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<tr>
<td>Spain, Portugal,</td>
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<tr>
<td>Continent</td>
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<tr>
<td>N. Africa</td>
<td><em>Quercus kelloggii</em> California</td>
<td>black or Kellogg oak</td>
<td>deciduous tree; acorns used by Indians for food; browsed by game and livestock; wood used for fuel</td>
</tr>
<tr>
<td>California</td>
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<tr>
<td>Middle East</td>
<td><em>Quercus libani</em> Lebanon oak</td>
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<td>deciduous tree; acorns roasted and eaten</td>
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<tr>
<td>California</td>
<td><em>Quercus lobata</em> California or valley white oak</td>
<td>massive tree; ground acorns formerly a favourite food of native Americans; important timber tree</td>
<td>Uphof, 1968; Hedrick, 1972; Usher, 1974; Saunders, 1976; Menninger, 1977; Mabberley, 1987; USDA, 1988</td>
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<tr>
<td>North America</td>
<td><em>Quercus macrocarpa</em> bur oak</td>
<td></td>
<td>acorns large, eaten raw or roasted by native Americans, also ground for baking</td>
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<tr>
<td>E. USA</td>
<td><em>Quercus nigra</em> black jack or possum oak</td>
<td>tree; acorns formerly used by Indians for food; wood for fuel</td>
<td>Uphof, 1968; Usher, 1974</td>
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<td>S.E. USA</td>
<td></td>
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<tr>
<td></td>
<td><em>Quercus oblongifolia</em> evergreen or live oak</td>
<td>tree or shrub; acorns eaten by native Americans</td>
<td>Hedrick, 1972</td>
</tr>
<tr>
<td>S.W. USA</td>
<td><em>Quercus petraea</em> sessile oak</td>
<td></td>
<td>acorns eaten</td>
</tr>
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<td>Europe</td>
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<td></td>
<td><em>Quercus phellos</em> willow oak</td>
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<td>acorns eaten</td>
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<td>N.E. North America</td>
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<td></td>
<td><em>Quercus prinus</em> basket, chestnut, chinquapin or cow oak</td>
<td>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</td>
<td>Camus, 1936-74; Hedrick, 1972; Saunders, 1976; Menninger, 1977;</td>
</tr>
<tr>
<td>Common Name</td>
<td>Scientific Name</td>
<td>Origin</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------</td>
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<tr>
<td><strong>Quercus robur</strong></td>
<td></td>
<td></td>
<td>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</td>
</tr>
<tr>
<td><strong>Europe, Mediterranean</strong></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Quercus stellata</strong></td>
<td></td>
<td>E. USA</td>
<td>iron or post oak; acorns eaten raw or roasted by native Americans, also ground for baking; wood for charcoal</td>
</tr>
<tr>
<td><strong>Quercus suber</strong></td>
<td></td>
<td>S. Europe</td>
<td>cork oak; evergreen tree; acorns sometimes eaten roasted; thick bark source of commercial cork</td>
</tr>
<tr>
<td><strong>Quercus undulata</strong></td>
<td></td>
<td>California</td>
<td>Rocky Mountain scrub or wavyleaf oak; low shrub; acorns sweet, eaten by native Americans; wood used for fuel; bark used for tanning</td>
</tr>
<tr>
<td><strong>Quercus virginiana</strong></td>
<td></td>
<td>E. North America</td>
<td>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</td>
</tr>
</tbody>
</table>

**GUTTIFERAEE; fruit a drupe, berry or septicidal capsule**

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Origin</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allanblackia floribunda</strong></td>
<td></td>
<td>West Africa</td>
<td>tallow tree; kisidwe; seeds edible, source of oils, used as a butter substitute, suitable for soap making; seedcake too bitter cattle food</td>
<td>Menninger, 1977; Mabberley, 1987; Peters et al., 1992</td>
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<tr>
<td><strong>Allanblackia stuhlmannii</strong></td>
<td></td>
<td></td>
<td>evergreen tree; seeds yield an edible fat used in cooking, as an illuminant and liniment. Seeds marketed; potential plantation crop</td>
<td>FAO, 1983; Peters et al., 1992</td>
</tr>
<tr>
<td><strong>Tanzania</strong></td>
<td><strong>Allanblackia ulugurensis</strong></td>
<td>evergreen tree; seeds yield an edible fat used in cooking and as an illuminant; sap produces a yellow dye. Seeds exported; potential plantation crop</td>
<td>FAO, 1983; Peters et al., 1992</td>
<td></td>
</tr>
<tr>
<td><strong>Tanzania</strong></td>
<td><strong>Garcinia conrauana</strong></td>
<td>seeds edible</td>
<td>Menninger, 1977</td>
<td></td>
</tr>
<tr>
<td><strong>Cameroon</strong></td>
<td><strong>Garcinia cowa</strong></td>
<td>aril and pericarp good flavour</td>
<td>Mabberley, 1977</td>
<td></td>
</tr>
<tr>
<td><strong>Assam, Myanmar</strong></td>
<td><strong>Garcinia indica</strong></td>
<td>cocum;kokum</td>
<td>fruit pulp edible, seeds source of edible fat - &quot;kokum&quot; or &quot;Goa butter&quot;, pericarp used to flavour curries</td>
<td>Hedrick, 1972; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>tropical Asia</strong></td>
<td><strong>Garcinia kola</strong></td>
<td>bitter or false kola</td>
<td>pulp eaten raw, rind used in curries, seeds eaten raw, chewed with a bitter, astringent and resinous taste; root a chewstick</td>
<td>Menninger, 1977; Peters et al., 1992</td>
</tr>
<tr>
<td><strong>West Africa</strong></td>
<td><strong>Garcinia lateriflora</strong></td>
<td>seeds edible</td>
<td>Menninger, 1977</td>
<td></td>
</tr>
<tr>
<td><strong>Philippines</strong></td>
<td><strong>Garcinia mangostana</strong></td>
<td>mangosteen</td>
<td>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</td>
<td>Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Purseglove, 1987; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><strong>Malesia; cultivated, not known in the wild</strong></td>
<td><strong>Garcinia planchonii</strong></td>
<td>seeds edible, acidic pulp edible, sun dried for storage</td>
<td>Menninger, 1977; Verheij and Coronel, 1991</td>
<td></td>
</tr>
<tr>
<td><strong>Viet Nam, N. Laos</strong></td>
<td><strong>Mesua ferrea</strong></td>
<td>ironwood</td>
<td>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</td>
<td>Hedrick, 1972; Menninger, 1977; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>Indo-Malesia</strong></td>
<td><strong>Pentadesma butyracea</strong></td>
<td>butter, candle or tallow tree; black mango</td>
<td>young seeds eaten, old seeds source of &quot;Sierra Leone, Kanga or lamy butter&quot;, used for cooking, soap, margarine and candles</td>
<td>Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Peters et al., 1992</td>
</tr>
</tbody>
</table>

**HIPPOCASTANACEAE; fruit a capsule**

| **Aesculus** | **Californian** | deciduous tree or shrub; seeds boiled or roasted and | Howes, 1948; |
**IRVINGIACEAE**; fruit a capsule, samara, rarely a berry or drupe, often a schizocarp of dry and sometimes samaroid or fleshy mericarps

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Irvingia gabonensis</strong></td>
<td>dika nut; bread</td>
<td>large tree; drupe 5-6 cm long; pulp eaten, seed ground cooked to make dika</td>
<td>Howes, 1948; Menninger, 1977;</td>
</tr>
<tr>
<td></td>
<td>tree; wild mango</td>
<td>bread; also source of an edible oil, dika butter, formerly considered as a</td>
<td>FAO, 1982;</td>
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<td></td>
<td></td>
<td>substitute for cocoa butter; seed oil used for making soap</td>
<td>Mabberley, 1987; Peters et</td>
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<td>al., 1992</td>
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</tbody>
</table>

**JUGLANDACEAE**; fruit a nut or drupe-like

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<tr>
<th>Species</th>
<th>Common Name</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carya alba</strong></td>
<td>shagbark or</td>
<td>an important food of native Americans, also marketed and exported; timber</td>
<td>Hedrick, 1972</td>
</tr>
<tr>
<td></td>
<td>shellbark hickory</td>
<td>for wagons, agricultural implements and tool handles; fuel</td>
<td></td>
</tr>
<tr>
<td><strong>Carya aquatica</strong></td>
<td>water or swamp</td>
<td>nuts small, astringent, sometimes eaten; source of a brown dye</td>
<td>Howes, 1948; Menninger, 1977;</td>
</tr>
<tr>
<td></td>
<td>hickory, bitter</td>
<td></td>
<td>Krochmal, 1982</td>
</tr>
<tr>
<td></td>
<td>or wild pecan</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Carya carolinae-septentrionalis</strong></td>
<td>Caroline hickory, southern shagbark hickory</td>
<td>nuts sweet, edible</td>
<td>Krochmal, 1982</td>
</tr>
<tr>
<td><strong>Carya cathayensis</strong></td>
<td>Chinese hickory; mountain walnut</td>
<td>nuts edible, used in sweetmeats; wood used for tool handles</td>
<td>Uphof, 1968; Usher, 1974; Menninger, 1977; Rosengarten, 1984</td>
</tr>
<tr>
<td><strong>E. China</strong></td>
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<tr>
<td><strong>Carya cordiformis</strong></td>
<td>bitternut, swamp hickory</td>
<td>nuts bitter, rarely eaten by native Americans; bark formerly used in making chair seats; wood used for yokes and hoops</td>
<td>Howes, 1948; Uphof, 1968; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>E. North America, S. Appalachians</strong></td>
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<tr>
<td><strong>Carya glabra</strong></td>
<td>broom, hognut, oval, redheart, red or pignut hickory</td>
<td>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</td>
<td>Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>E. North America</strong></td>
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<tr>
<td><strong>Carya illinoinensis</strong></td>
<td>pecan; Illinois nut, sof-shelled hickory</td>
<td>common dessert nut, especially thin-shelled ones; used like hazelnuts (<em>Corylus</em> spp.) or walnuts (<em>Juglans</em> 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</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988</td>
</tr>
<tr>
<td><strong>S. USA; widely cultivated</strong></td>
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<tr>
<td><strong>Carya laciniosa</strong></td>
<td>big, western, bottom shellbark or king nut hickory</td>
<td>nuts thick shelled, considered to be of fine quality, marketed; nuts eaten by native Americans, source of the fermented drink &quot;powcohiccorir&quot;; wood used for agricultural implements and tool handles; fuel</td>
<td>Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>central North America; cultivated</strong></td>
<td></td>
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<tr>
<td><strong>Carya myristiciformis</strong></td>
<td>numeg or bitter water hickory</td>
<td>nuts with very thick shell, sometimes eaten by native Americans</td>
<td>Howes, 1948; Menninger 1977; Krochmal, 1982</td>
</tr>
<tr>
<td><strong>S.E. USA</strong></td>
<td></td>
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<tr>
<td><strong>Carya ovalis</strong></td>
<td>smaller loose bark hickory</td>
<td>nuts small, sometimes eaten by native Americans</td>
<td>Howes, 1948; Krochmal, 1982</td>
</tr>
<tr>
<td><strong>Carya ovata</strong></td>
<td>shagbark, scalybark, white, red heart or upland hickory</td>
<td>nuts edible, marketed - commercial hickory nuts; wood used for wagons, axe handles, basketry and fuel</td>
<td>Howes, 1948; Uphof, 1968; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>E. North America; cultivated</strong></td>
<td></td>
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<tr>
<td><strong>Carya pallida</strong></td>
<td>sand, pale or pale leaf hickory</td>
<td>nuts with thick, hard shell, eaten by native Americans</td>
<td>Menninger, 1977; Krochmal, 1982</td>
</tr>
<tr>
<td><strong>S.E. USA</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Carya texana</strong></td>
<td>Texas, Buckley's or black hickory</td>
<td>small nuts often produced from young plants, sometimes eaten</td>
<td>Howes, 1948; Menninger, 1977</td>
</tr>
<tr>
<td>var. villosa</td>
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<tr>
<td><strong>S-central USA</strong></td>
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<tr>
<td><strong>Carya tomentosa</strong></td>
<td>mockernut; white hickory</td>
<td>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 &quot;square nut&quot;.</td>
<td>Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>E. North America</strong></td>
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<tr>
<td><strong>Carya tonkinensis</strong></td>
<td>may-chau</td>
<td>kernels source of edible oil, also used as illuminant</td>
<td>Howes, 1948</td>
</tr>
<tr>
<td><strong>N.E. India, Viet Nam, S. China</strong></td>
<td></td>
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<tr>
<td><strong>Juglans ailanthifolia</strong></td>
<td>cordate, Japanese or Siebold walnut; heatnut</td>
<td>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</td>
<td>Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td>var. cordiformis China, Japan; cultivated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Juglans australia</strong></td>
<td>Argentine walnut</td>
<td>nut small with thick shell, edible; wood prized, especially for making guitars</td>
<td>National Research Council, 1989</td>
</tr>
<tr>
<td><strong>Argentina, S. Bolivia</strong></td>
<td></td>
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<tr>
<td><strong>Juglans baccata</strong></td>
<td>walnut</td>
<td>nuts edible, rich in starch, source of oil</td>
<td>Hedrick, 1972</td>
</tr>
<tr>
<td><strong>Caribbean</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Juglans boliviana</strong></td>
<td>Bolivian black walnut</td>
<td>nuts excellent, good quality; grows well in Costa Rica</td>
<td>Uphof, 1968; Usher, 1974; National Research Council, 1989</td>
</tr>
<tr>
<td><strong>N. Bolivia, S. and Central Peru; mountains</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Juglans californica</strong></td>
<td>black walnut</td>
<td>fruit with thick husk, kernels eaten</td>
<td>Krochmal, 1982</td>
</tr>
<tr>
<td><strong>S. California</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Juglans cathayensis</strong></td>
<td>kernels eaten locally; cultivated as an ornamental</td>
<td></td>
<td>Howes, 1948; Uphof, 1968; Usher, 1974</td>
</tr>
<tr>
<td>Species</td>
<td>Origin</td>
<td>Description</td>
<td>References</td>
</tr>
<tr>
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</tr>
<tr>
<td><strong>Juglans cinerea</strong></td>
<td>central China</td>
<td>butternut; lemon nut; oil nut; white walnut kernels edible, with strong oily taste, used to thicken potage, 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</td>
<td>Howes, 1948; Uphof, 1968; Hedrick, 1972; Usher, 1974; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984;</td>
</tr>
<tr>
<td><strong>Juglans ducloxianna</strong></td>
<td></td>
<td>nuts edible</td>
<td>Uphof, 1968; Usher, 1974</td>
</tr>
<tr>
<td><strong>Juglans hindsii</strong></td>
<td>Asian mountains; cultivated in China</td>
<td>California black walnut, Hind's walnut nuts edible, harvested from the wild; grown in California as a street tree; rootstock used for <em>J. regia</em></td>
<td>Howes, 1948; Krochmal, 1982; Rosengarten, 1984</td>
</tr>
<tr>
<td><strong>Juglans kamaonia</strong></td>
<td>W. Himalayas</td>
<td>nuts edible</td>
<td>Uphof, 1968; Usher, 1974</td>
</tr>
<tr>
<td><strong>Juglans major</strong></td>
<td>E. North America; S.W. North America</td>
<td>Arizona, Arizona black or little walnut; nogal sylvestro nuts small, eaten by native Americans; leaves astringent</td>
<td>Howes, 1948; Uphof, 1968; Usher, 1974; Krochmal, 1982; Rosengarten, 1984</td>
</tr>
<tr>
<td><strong>Juglans mandshurica</strong></td>
<td>N. China</td>
<td>Manchurian walnut nuts edible; cultivated as an ornamental</td>
<td>Howes, 1948</td>
</tr>
<tr>
<td><strong>Juglans microcarpa</strong></td>
<td>W. North America; sometimes cultivated</td>
<td>Texas, Texas black, little or river walnut nuts small, sweet, edible</td>
<td>Howes, 1948; Hedrick, 1972; Krochmal 1982; Rosengarten, 1984</td>
</tr>
<tr>
<td><strong>Juglans neotropica</strong></td>
<td>W. Venezuela, Colombia, Ecuador; highlands</td>
<td>Ecuador walnut semievergreen; nuts thick-shelled, edible, marketed locally, used in sweetmeats; wood strong, used in furniture; occasionally cultivated</td>
<td>Uphof, 1968; Usher, 1974; Rosengarten, 1984; National Research Council, 1989</td>
</tr>
<tr>
<td><strong>Juglans nigra</strong></td>
<td>E. North America; cultivated</td>
<td>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 <em>J. regia</em>; husk for treating intestinal worms, syphilis, ulcers, fruit juice laxative; nuts and bark yield brown, green or blue dye</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>Juglans regia</strong></td>
<td></td>
<td>English or walnuts of commerce; timber excellent cabinet wood,</td>
<td>Howes, 1948;</td>
</tr>
<tr>
<td>Fruit Species</td>
<td>Origin</td>
<td>Uses</td>
<td>References</td>
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<tr>
<td><strong>S.E. Europe to W. Asia; cultivated</strong></td>
<td>Persian walnut</td>
<td>furniture, gunstocks, veneer; seed oil used in cooking, paints and soap; sap source of sugar; dye from husks as floor stain; cultivated as ornamental</td>
<td>Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Bianchini et al., 1988; National Research Council, 1989</td>
</tr>
<tr>
<td><strong>Juglans venezuelensis</strong></td>
<td>Venezuelan walnut</td>
<td>nuts edible, now rare</td>
<td></td>
</tr>
<tr>
<td><strong>Pterocarya fraxinifolia</strong></td>
<td>Caucasian wingnut</td>
<td>nut edible; wood used for matches and clogs; cultivated as ornamental</td>
<td>Uphof, 1968; Hedrick, 1972; Usher, 1974; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>Pterocarya rhoifolia</strong></td>
<td>Japanese wingnut</td>
<td>nut edible; wood used for chopsticks, clogs and matches</td>
<td>Uphof, 1968; Usher, 1974</td>
</tr>
<tr>
<td><strong>Pterocarya stenoptera</strong></td>
<td>wingnut</td>
<td>nut edible; bark medicinal</td>
<td>Uphof, 1968; Usher, 1974</td>
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<tr>
<td><strong>China; cultivated</strong></td>
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</table>

**LAURACEAE; fruit a 1-seeded berry or drupe, rarely dry and indehiscent**

<table>
<thead>
<tr>
<th>Fruit Species</th>
<th>Origin</th>
<th>Uses</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beilschmiedia bancroftii</strong></td>
<td>canary ash; yellow walnut; wanga</td>
<td>ground kernels eaten by Aborigines; good timber</td>
<td>Menninger, 1977; Mabberley, 1987; Lazarides et al., 1993</td>
</tr>
<tr>
<td><strong>Cryptocarya alba</strong></td>
<td>Chile</td>
<td>oily seed kernels cooked and eaten in times of scarcity; bark source of tannin; wood for firewood and charcoal</td>
<td>Howes, 1948; Menninger, 1977; Hoffman, 1978</td>
</tr>
<tr>
<td><strong>Cryptocarya latifolia</strong></td>
<td>ntonga nuts</td>
<td>fruit used locally for their oil; fatty kernels used by Zulus for flaying leather</td>
<td>Howes, 1948; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>Cryptocarya moschata</strong></td>
<td>Brazilian nutmeg</td>
<td>tree, pungent seed used as spice; timber hard, yellowish, esteemed</td>
<td>Hedrick, 1972; Menninger, 1977; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>Endiandra insignis</strong></td>
<td>Boomban</td>
<td>roasted, powdered and leached kernel eaten by Aborigines</td>
<td>Menninger, 1977</td>
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<tr>
<td><strong>Queensland</strong></td>
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<tr>
<td><strong>Endiandra palmerstonii</strong></td>
<td>Queensland walnut</td>
<td>powdered kernel eaten by Aborigines</td>
<td>Menninger, 1977; Lazarides et al., 1993</td>
</tr>
<tr>
<td><strong>Queensland</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Umbellaria californica</strong></td>
<td>California</td>
<td>aromatic evergreen, drupe with 1 nut-like seed &lt;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</td>
<td>Hedrick, 1972; Menninger, 1977; Krochmal, 1982; Mabberley, 1987</td>
</tr>
<tr>
<td><strong>S.W. USA</strong></td>
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</table>

**LECYTHIDACEAE; fruit a capsule, drupe or berry, seeds often nut-like**

| **Barringtonia asiatica** | fruits eaten as a vegetable; seeds oleaginous, toxic | Payens, 1967; Hedrick, 1972; Menninger, 1977 |
| **Madagascar to Queensland; introduced Caribbean** | | |
| **Barringtonia edulis** | cut-nut | fruit insipid, eaten raw or cooked; seeds eaten raw, flavour of raw peanuts | Payens, 1967; Hedrick, 1972; Menninger, 1977 |
| **Fiji; semi-cultivated** | | |
| **Barringtonia niedenzuana** | cut-nut | seeds eaten raw, flavour of raw peanuts | Payens, 1967; Menninger, 1977 |
| **Melanesia; semi-cultivated** | | |
| **Barringtonia novae-hiberniae** | cut-nut | seeds eaten raw, flavour of raw peanuts | Menninger, 1977 |
| **Melanesia; semi-cultivated** | | |
| **Barringtonia prodera** | 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 |
| **New Guinea, Micronesia; planted** | | |
| **Barringtonia scortechinii** | seed used to flavour food | Menninger, 1977 |
| **Borneo** |
|------------------|----------------|----------------------|------------------|
| **Bertholletia excelsa** | 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** | patana oak; slow match tree | seeds edible; leaves used for silkworms | Hedrick, 1972; Menninger, 1977; Mabberley, 1987 |
| **Chydenanthus excelsus** | | seeds eaten | Menninger, 1977 |
| **New Guinea** |
| **Eschweilera grandiflora** | seeds edible | | Hedrick, 1972 |
| **Guyana** |
| **Eschweilera jarana** | seeds edible; timber for sleepers | | Prance and Mori, 1979 |
| **South America** |
| **Lecythis lanceolata** | seeds edible | | Howes, 1948 |
| **South America** |
| **Lecythis minor** | 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 |
| **New Granada** |
| **Lecythis ollaria** | 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 |
| **tropical America** |
| **Lecythis usitata** | 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 |
| **South America; Amazon rain forest, cultivated** |
| **Lecythis zabucajo** | 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 |
**LEGUMINOSAE subfamily CAESALPINIOIDEAE**; fruit usually a dry legume (pod), usually dehiscent

*Planchonia careya*  
**Cocky apple**  
**Australia**  
fruit large, with adherent calyx, eaten by Aborigines; source of fuel, toxins, medicines and fibre  
Hedrick, 19772; Lazarides and Hince, 1993

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**LEGUMINOSAE subfamily MIMOSOIDEAE**; fruit usually a dry pod

*Cordeauxia edulis*  
**Ye-eb, yeheb or yehib**  
**Central Somalia, Ogaden**  
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*  
**Tara nut**  
**S.W. Madagascar**  
dehiscent legume with 6-12 sweet, starchy seeds which are eaten raw; shrub browsed by goats  
Willing, 1989

*Tylosolema esculentum*  
**Marama or maramba bean**  
**Southern Africa**  
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

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**LEGUMINOSAE subfamily PAPILIONOIDEAE**; fruit usually a dry pod (legume) usually dehiscent

*Pithecellobium bubalinum*  
**Madras thorn; Manila tamarind**  
**Malaysia**  
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*  
**Jering; ngapi nut**  
**Myanmar to W. Malesia**  
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
<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
<th>Use and Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Apis americana</em></td>
<td>North America; occasionally cultivated</td>
<td>potato or wild bean, groundnut; Indian potato climber; sweet tubers boiled or roasted, an important Indian food and potato substitute; cultivated as an ornamental</td>
<td>Howes, 1948; Hedrick, 1972; National Academy of Sciences, 1979; Mabberley, 1987</td>
</tr>
<tr>
<td><em>Arachis hypogaea</em></td>
<td>South America; cultivated throughout the tropics</td>
<td>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</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Verdcourt, 1979; Rosengarten, 1984; Mabberley, 1987; Purseglove, 1987</td>
</tr>
<tr>
<td><em>Arachis villosulicarpa</em></td>
<td>South America</td>
<td>seeds edible, locally cultivated</td>
<td>Rosengarten, 1984</td>
</tr>
<tr>
<td><em>Castanospermum australe</em></td>
<td>N.E. Australia, New Caledonia, Vanuatu; cultivated elsewhere</td>
<td>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</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Verdcourt, 1979; Mabberley, 1987</td>
</tr>
<tr>
<td><em>Glycine max</em></td>
<td>E. Asia, now widely cultivated</td>
<td>soya bean or soybean; annual herb bearing dehiscent, ca. 3-seeded pods containing 30-45% protein; newly germinated seeds used as &quot;bean sprouts&quot; 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.</td>
<td>Rosengarten, 1984; Menninger, 1977; Verdcourt, 1979; Mabberley, 1987; Purseglove, 1987</td>
</tr>
<tr>
<td><em>Inocarpus fagifer</em></td>
<td>Malesia to Pacific Islands, occasionally cultivated elsewhere</td>
<td>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</td>
<td>Howes, 1948; Hedrick, 1972; Verdcourt, 1979; Rosengarten, 1984; Mabberley, 1987; Macrae et al., 1993</td>
</tr>
<tr>
<td><em>Macrotyloma geocarpum</em></td>
<td>West Africa; cultivated</td>
<td>Hausa or Kersting's groundnut; annual herb with geocarpic fruit; seeds eaten; mainly cultivated in West Africa; potential for further research and development</td>
<td>Menninger, 1977; National Academy of Sciences, 1979; Mabberley, 1987;</td>
</tr>
</tbody>
</table>
### MONIMIACEAE; fruit a head of drupes or nuts

**Vigna subterranea**
- **tropical Africa; cultivated**
- **Bambara groundnut**
- annual herb with geocarpic fruit; seed eaten green and raw or mature and cooked; widely cultivated

**Laurelia sempervirens**
- **Peruvian nutmeg, tepa**
- aromatic seeds used as a spice

### MORACEAE; fruit a drupe

**Artocarpus altillis**
- **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

**Artocarpus elasticus**
- **W. Malesia**
- ripe seeds roasted and eaten, seeds source of small quantities of a solid oil; source of bark cloth

**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

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Purseglove, 1987; Peters et al., 1992


Hedrick, 1972; Mabberley, 1987


Menninger, 1977; Mabberley, 1977; Purseglove, 1987

Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1982; Rosengarten, 1984; Mabberley, 1987;
<table>
<thead>
<tr>
<th>Species</th>
<th>Origin/Use</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Artocarpus integer</em></td>
<td>Myanmar, malesia; cultivated, 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</td>
<td>Menninger, 1977; Purseglove, 1987; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Artocarpus odoratissimus</em></td>
<td>Myanmar, malesia; cultivated, marang, evergreen tree; seeds eaten roasted or boiled, pulp eaten fresh, cooked as a vegetable or in cakes</td>
<td>Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Artocarpus ovatus</em></td>
<td>Borneo, cultivated in the Philippines, evergreen tree; seeds eaten roasted or boiled, pulp eaten fresh, cooked as a vegetable or in cakes</td>
<td>FAO, 1984; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Brosimum alicastrum</em></td>
<td>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</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td><em>Treculia africana</em></td>
<td>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</td>
<td>Howes, 1948; Hedrick, 1972; Mabberley, 1987; Purseglove, 1987; Peters et al., 1992</td>
</tr>
</tbody>
</table>

**OLACACEAE; fruit usually a 1-seeded drupe or nut**

<table>
<thead>
<tr>
<th>Species</th>
<th>Origin/Use</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Anacolosa frutescens</em></td>
<td>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</td>
<td>Howes, 1948; Menninger, 1977; Mabberley, 1987; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Coula edulis</em></td>
<td>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</td>
<td>Howes, 1948; Menninger, 1977; FAO, 1982; Mabberley, 1987; Peters et al., 1992; Macrae et al., 1993</td>
</tr>
<tr>
<td><em>Heisteria parvifolia</em></td>
<td>shrub; kernels eaten</td>
<td>Menninger,</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Location</td>
<td>Information</td>
</tr>
<tr>
<td>------------</td>
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</tr>
<tr>
<td><strong>West Africa</strong></td>
<td></td>
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<tr>
<td><strong>Ongokea gore</strong></td>
<td>West Africa</td>
<td>tree; fruit an offensive smelling drupe; ripe flesh eaten; seed kernels little eaten; seed yields a drying oil - isano oil</td>
</tr>
<tr>
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<tr>
<td><strong>Scorodocarpus borneensis</strong></td>
<td></td>
<td>fruit edible; hard, onion-scented wood used for construction</td>
</tr>
<tr>
<td><strong>Malesia</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Strombosia grandifolia</strong></td>
<td></td>
<td>kernels roasted and eaten</td>
</tr>
<tr>
<td><strong>Strombosia pustulata</strong></td>
<td>West Africa</td>
<td>evergreen tree; seed kernel eaten as famine food</td>
</tr>
<tr>
<td><strong>Strombosia scheffleri</strong></td>
<td></td>
<td>kernels eaten in small quantities in times of scarcity as they can cause vomiting</td>
</tr>
<tr>
<td><strong>Ximenia americana</strong></td>
<td>tropical Africa</td>
<td>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</td>
</tr>
</tbody>
</table>

**PROTEACEAE; fruit a follicle, nut, achene or drupe**

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Location</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brabejum stellatifolium</strong></td>
<td></td>
<td>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</td>
</tr>
<tr>
<td><strong>South Africa; cultivated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Finschia carrii</strong></td>
<td></td>
<td>kernels eaten</td>
</tr>
<tr>
<td><strong>W. Pacific</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Finschia chloroxantha</strong></td>
<td></td>
<td>tree; kernels eaten, locally important food; timber for cabinet work; potential ornamental</td>
</tr>
<tr>
<td><strong>Papua New Guinea, Solomon</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Islands

**Finschia ferruginiflora**  
New Guinea  
kernels cooked and eaten  
*Menninger, 1977*

**Finschia rufa**  
W. Pacific  
kernels eaten  
*Menninger, 1977*

**Finschia sp.**  
W. Pacific  
nuts eaten in Vanuatu

**Gevuina avellana**  
Chile  
Chilean wild nut; gevúina 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**  
W. Australia  
kernels eaten  
*Menninger, 1977*

**Micronesia**

**Helicia cochinchinesis**  
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*

**Queensland**

**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**  
Queensland  
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*

**Macadamia ternifolia**  
Queensland  
macadamia (thick-shell)  
seeds edible  
*Howes, 1948; Menninger, 1977; Mabberley, 1987; Purseglove, 1987;*
Macadamia
tetraphylla
Queensland, New South Wales
Panopsis
suaveolens
Costa Rica

ROSACEAE; fruit a head of follicles or achenes in swollen hypanthium or a pome, rarely a capsule

Prinsepia utilis
Himalayas
Prunus armeniaca
N. China; widely cultivated in Eurasia and America
Prunus bucharica
Central Asia
Prunus dulcis
W. Asia; cultivated

RUTACEAE; fruit schizocarp, berry or drupe
**SANTALACEAE; fruit a nut or drupe, 1-seeded**

**Calodendrum capensis**  
Cape chestnut  
nuts eaten; seeds source of an oil used in cosmetics; timber useful; cultivated as an ornamental  
*East Africa to Cape*

**SAPINDACEAE Fruit fleshy or dry, dehiscent or indehiscent, seeds with arils or sarcotestas**

**Calodendrum capensis**  
East Africa to Cape

**Santalum acuminata**  
quandong; native 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  
*Australia; cultivated*

**Santalum spicatum**  
sandalwood  
parasitic tree; fruit pulp thin, seed shell thin, crushed by hand, kernels eaten; timber, fuelwood  
*W. Australia*

**Alectryon macrococcus**  
mahoe  
aril and kernel eaten  
*Hawaii*

**Blighia sapida**  
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  
*West Africa; cultivated*

**Cubilia cubili**  
kubili nut  
seeds eaten boiled or roasted, leaves used as vegetable; cultivated in Java  
*central Malesia*

**Cupania americana**  
seeds sweet, chestnut-like, eaten in the Caribbean, also source of fermented liquor  
*Mexico*

**Deinbollia grandifolia**  
fruit pulp edible, seeds slightly oily and eaten  
*West Africa*

**Glenniea penangensis**  
kernal boiled and eaten  
*West Africa*

**Lepisanthes fruticosa**  
lunan nut  
fruit with edible flesh and kernel, the latter roasted and chestnut flavoured; root used in traditional  
*Malesia*

Howes, 1948; Hedrick, 1972; Menninger, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Martin et al., 1988
<table>
<thead>
<tr>
<th>Species</th>
<th>Location/Region</th>
<th>Uses</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Magonia pubescens</em></td>
<td>Paraguay, Brazil</td>
<td>seed oil used for cooking and soap making</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td><em>Melicococcus bijugatus</em></td>
<td>Caribbean</td>
<td>fruit pulp eaten, seeds usually eaten after roasting</td>
<td>Hedrick, 1972; Menninger, 1977</td>
</tr>
<tr>
<td><em>Nephelium lappaceum</em></td>
<td>Malesia; widely cultivated in the humid tropics</td>
<td>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</td>
<td>Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td><em>Nephelium ramboutan-ake</em></td>
<td>Philippines; cultivated</td>
<td>fruit pulp edible; seeds boiled or roasted for a cocoa-like beverage, also source of an edible cocoa-butter, also used as an illuminant</td>
<td>Hedrick, 1972; Menninger, 1977; Mabberley, 1987; Purseglove, 1987</td>
</tr>
<tr>
<td><em>Paullinia cupana</em></td>
<td>South America; cultivated</td>
<td>climbing shrub; whole roasted seeds source of commercial &quot;guarana&quot;, 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</td>
<td>Hedrick, 1973; Menninger, 1977</td>
</tr>
<tr>
<td><em>Paullinia subrotunda</em></td>
<td>Asia</td>
<td>aril and seeds eaten</td>
<td>Hedrick, 1972; Menninger, 1977</td>
</tr>
<tr>
<td><em>Pometia pinnata</em></td>
<td>Malesia</td>
<td>raw fruit eaten; oily seeds boiled or roasted and eaten; timber used locally for construction purposes</td>
<td>Hedrick, 1972; Menninger, 1977; FAO, 1984; Mabberley, 1987</td>
</tr>
<tr>
<td><em>Sapindus indicum</em></td>
<td>Asia</td>
<td>fruit latex caustic, ripe seed eaten, contain 50% oil</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td><em>Schleichera oleosa</em></td>
<td>Indo-Malesia</td>
<td>unripe fruit pickled; aril eaten; seeds commercial source of the edible &quot;Macassar oil&quot;, used for candles, hair dressing, batik work, soap and illuminant; leaves edible; timber hard, used for mortars; bark for tanning; host of lac insects</td>
<td>Menninger, 1977; Mabberley, 1987; Purseglove, 1987</td>
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<tr>
<td>Species</td>
<td>Common Name</td>
<td>Description</td>
<td>References</td>
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</tr>
<tr>
<td><em>Argania spinosa</em></td>
<td>argan tree</td>
<td>seed oil used for cooking and illuminant; drupe eaten by livestock</td>
<td>Hedrick, 1972; Menninger, 1977;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mabberley, 1987</td>
</tr>
<tr>
<td><em>Morocco; cultivated</em></td>
<td></td>
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</tr>
<tr>
<td><em>Baillonella toxisperma</em></td>
<td>djave; false shea</td>
<td>forest tree; fruits source of edible seed oil; good timber</td>
<td>Menninger, 1977;</td>
</tr>
<tr>
<td></td>
<td>butternut; African</td>
<td></td>
<td>Mabberley, 1987; Falconer, 1990;</td>
</tr>
<tr>
<td></td>
<td>pearwood</td>
<td></td>
<td>Peters et al. 1992</td>
</tr>
<tr>
<td><em>(Nigeria to Zaire)</em></td>
<td></td>
<td></td>
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<tr>
<td><em>Diploknema butyracea</em></td>
<td>Indian butter tree;</td>
<td>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</td>
<td>Menninger, 1977; FAO, 1982;</td>
</tr>
<tr>
<td></td>
<td>pholwara</td>
<td></td>
<td>Mabberley, 1987</td>
</tr>
<tr>
<td><em>(India)</em></td>
<td></td>
<td>kernel contains 60-67% fat</td>
<td></td>
</tr>
<tr>
<td><em>Madhuca longifolia</em></td>
<td>ilipe nut; mahua</td>
<td>kernel commercial source of &quot;ilipe butter&quot; used in margarine and soap; seed-cake, &quot;mahua meal&quot;, used as worm-killer on lawns; flowers edible</td>
<td>Howes, 1948; Menninger, 1977;</td>
</tr>
<tr>
<td><em>(India)</em></td>
<td></td>
<td></td>
<td>Mabberley, 1987; Purseglove, 1987</td>
</tr>
<tr>
<td><em>Madhuca motleyana</em></td>
<td></td>
<td>seed source of edible oil</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td><em>(Malesia)</em></td>
<td></td>
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<tr>
<td><em>Palaquium amboinense</em></td>
<td></td>
<td>seed source of fat</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td><em>(S.E. Asia)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Palaquium gutta</em></td>
<td>gutta-percha</td>
<td>evergreen tree; seed source of fat; latex commercial source of &quot;gutta-percha&quot;</td>
<td>Menninger, 1977; Mabberley, 1987;</td>
</tr>
<tr>
<td><em>(Malaysia)</em></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><em>Palaquium hexandrum</em></td>
<td>fruit sour, edible,</td>
<td>seed source of fat, used for food</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td><em>(Sumatra)</em></td>
<td>seed source of fat,</td>
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</tr>
<tr>
<td></td>
<td>used for food and as an illuminant</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Philippines)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Palaquium rostratum</em></td>
<td>fruit green, sweet and edible, seed source of a bitter oil</td>
<td>Menninger, 1977</td>
<td></td>
</tr>
<tr>
<td><em>(Peru; cultivated)</em></td>
<td>egg fruit; abiu</td>
<td>evergreen tree; fruit 4-12 cm in diameter, seeds 1-5, edible, fresh mucilaginous pulp eaten</td>
<td>Menninger, 1977; FAO, 1986</td>
</tr>
<tr>
<td><em>Pouteria caimito</em></td>
<td>canistel; egg-fruit;</td>
<td>fruit pulp edible, dehydrated, powdered and used as food additive; seed edible</td>
<td>Menninger, 1977; Mabberley, 1987;</td>
</tr>
<tr>
<td></td>
<td>yellow sapote</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Pouteria campechiana)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Family</td>
<td>Country/Region</td>
<td>Description</td>
<td>Reference</td>
</tr>
<tr>
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</tr>
<tr>
<td>SIMMONDSIACEAE</td>
<td>Pouteria glomerata</td>
<td>fruit a loculicidal capsule, 2 empty locules</td>
<td>Menninger, 1977</td>
</tr>
<tr>
<td></td>
<td>Pouteria obovata</td>
<td>lucuma seed edible; fruit pulp edible, dehydrated, powdered and used as food additive</td>
<td>Menninger, 1977; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td></td>
<td>Pouteria sapota</td>
<td>sapote; mamee; zapote; marmalade plum</td>
<td>Hedrick, 1972; Menninger, 1977; Verheij and Coronel, 1991</td>
</tr>
<tr>
<td></td>
<td>Pouteria viridis</td>
<td>green apote</td>
<td>Menninger, 1977; Peters et al., 1992</td>
</tr>
<tr>
<td></td>
<td>Tieghemella heckelii</td>
<td>makore; cherry mahogany; baku</td>
<td>Menninger, 1977; Peters et al., 1992</td>
</tr>
<tr>
<td></td>
<td>Vitellaria paradoxa</td>
<td>shea nut; shea butternut</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Purseglove, 1987; Peters et al., 1992</td>
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<td>N. tropical Africa</td>
<td>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.</td>
<td>Howes, 1948; Hedrick, 1972; Menninger, 1977; FAO, 1982; Mabberley, 1987; Purseglove, 1987; Peters et al., 1992</td>
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</table>

**SIMMONDSIACEAE**; fruit a loculicidal capsule, 2 empty locules

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<tr>
<th>Plant Family</th>
<th>Country/Region</th>
<th>Description</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Simmondsia chinensis</td>
<td>S. California, Arizona and northern Mexico</td>
<td>dioecious, evergreen shrub bearing 1-seeded, acomlike 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</td>
<td>Howes, 1948; Hedrick, 1972; Saunders, 1976; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987</td>
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**STAPHYLEACEAE**; fruit a head of follicles, drupe or berry or inflated capsule
<table>
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<tr>
<th><strong>STERCULIACEAE</strong>; fruit dehiscent or indehiscent, fleshy to leathery or woody, often separating into mericarps</th>
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<td><strong>Brachychiton acerifolius</strong></td>
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<td><strong>Cola acuminata</strong></td>
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<td><strong>Cola heterophylla</strong></td>
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<td><strong>Cola millenii</strong></td>
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<td><strong>Cola nitida</strong></td>
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<td><em>Sterculia foetida</em></td>
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<td><em>Sterculia oblongata</em></td>
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<td><strong>Sterculia quadrifida</strong></td>
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<td><strong>Sterculia setigera</strong></td>
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<td><strong>Sterculia treubii</strong></td>
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<td><strong>Lesser Sunda Islands</strong></td>
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<td><strong>Sterculia trichosiphon</strong></td>
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<td><strong>Sterculia urceolata</strong></td>
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<td><strong>Lesser Sunda Islands</strong></td>
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<td><strong>Sterculia urens</strong></td>
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<td><strong>India</strong></td>
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| **Tropical central and South America** | **FAO, 1986** |
|**Theobroma bicolor** | 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 |

| **Tropical South America; widely cultivated** | **Menninger, 1977; FAO, 1986; Mabberley, 1987; Purseglove, 1987** |
|**Theobroma cacao** | 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 |

**STYLOBASIACEAE; nut-like**
**TILIACEAE; fruit a dry or not, dehiscent or indehiscent**

**Stylobasium spathulatum**  
Nut bush  
nut eaten by Australian aborigines  
*Australia*

**TRAPACEAE; fruit indehiscent, persistent stony endocarp, one cotyledon retained in fruit**

**Diplodiscus paniculatus**  
Baroba nut  
tree; starchy seeds boiled and eaten; bark used for cordage; wood for light construction and domestic utensils  
*Philippines*

**Trapa bicornis**  
S.E. Asia; cultivated  
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; Verheij and Coronel, 1991*

**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**  
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  
*North America; cultivated*

**Trapa natans var. natans**  
Eurasia, Africa, naturalized North America; cultivated  
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*

**Trapa natans var. bispinosa**  
tropical Asia; cultivated  
Annual aquatic herb; fruit eaten by the Waganda  
*Howes, 1948; Hedrick, 1972; Menninger, 1977; Rosengarten, 1984; Mabberley, 1987; Peters et al., 1992*
UMBELLIFERAE; fruit a schizocarp of 2 mericarps facially united

*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

Continue appendix A Species with edible "nuts" listed by families
### APPENDIX B

**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)*

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<th>Protein</th>
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*Average daily requirements: 3005 KJ 800 800 800 800 2200 330 15 15 800 1.4 1.1 1.3 60*

*Note: Data may vary depending on the source and method of analysis.*
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<th>Family</th>
<th>Species</th>
<th>Part</th>
<th>Weight (kg)</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Thickness (mm)</th>
<th>Density (g/cm³)</th>
<th>Moisture (%)</th>
<th>Ash (%)</th>
<th>Ash (mg/g)</th>
<th>Crude Protein (%)</th>
<th>Minerals (%)</th>
<th>Total Minerals (%)</th>
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<td>Prunus dulcis</td>
<td>dried, roasted and salted</td>
<td>627</td>
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<td>Pinus edulis</td>
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<td>PINACEAE</td>
<td>Pinus pinea</td>
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<td>Pinus sabiniana</td>
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<td>17.1</td>
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<td>5.1</td>
<td>604</td>
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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. total 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. ulmitolia (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 spinosa_ 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

Butoyospermum 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. rutum* 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

Cupernicia 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 laeavigata Forster & Forster CORYNOCARPACEAE

Couepia edulis (Prance) Prance CHRYSOBALANACEAE

C. longipendula Pilger

Coulia 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. jaranaum (Huber) Ducke

E. subglandulosa Miers = E. jarana

Eucarya acuminata (R.Br.) Sprague = Santalum acuminata SANTALACEAE

Eugeissona utilis Becc. PALMAE

Euryale ferox Salisb. NYMPHAEACEAE

Fagus terruginea 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 sisyridchium (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 sisyridchium L. = Gynandriris sisyridchium 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 ailandifolia 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. ailandifolia* var. *cordiformis*

var. *sieboldiana* = *J. ailandifolia* 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 (Ruiz & 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

Lemunopisum 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. philippinensis (A.DC) Rehder

Livistonia cochinchinensis Blume PALMAE

L. saribus (Lour.) Chev.

Lodoicea callipyge Comm. = L. maldivica PALMAE

L. maldivica (J.Gmel.) Pers.

Lucuma caimito (Ruiz & Pav.) Roem. & Schult. = Pouteria caimito SAPOTACEAE

Macadamia integrifolia Maiden & Betch PROTEACEAE

M. ternifolia F.Muell.

M. ternifolia F.Muell. var. integrifolia (Maiden & Betch) Maiden & Betch = 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 saccfera 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 Württemb. 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 nelsonbo 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* (Ruiz & 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 (Ruiz & 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. kelloggi
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

Schleicheria oleosa (Lour.) Oken SAPINDACEAE
S. trijuga Willd. = S. oleosa

Sclerocarya birrea (A. Rich.) Hochst. ANACARDIACEAE

subsp. birrea

subsp. caffra (Sond.) Kokwaro

Scorodoarpus borneensis (Baill.) Becc. OLACEAE

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. meciostopteryx 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. platyphyla 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. cochinchinesis 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
Washingtonia 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