

FRUITING AFRICA

FRUIT TREES AND SHRUBS OF KENYA



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Pithecellobium dulce – ripe, just opened fruit showing the red arils around brown seeds: https://en.wikipedia.org/wiki/Pithecellobium_dulce#/media/File:Pithecellobium_dulce_beans.JPG

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Author Contributions

This book has been a true labour of love with vital contributions from a number of people. The concept for the publication was initially conceived by Ramni Jamnadass and Katja Kehlenbeck. Najma Dharani prepared the initial descriptions, and delivered the photographs (unless otherwise specified) for all 49 species presented. With a wealth of information available from the first draft, subsequent colleagues were involved – Stepha McMullin undertook the

overall co-ordination of content, contributors and final editing; Katja Kehlenbeck provided additional technical content on the species descriptions, updating species botanical names and editing; Stepha and Katja co-wrote the introduction; Barbara Stadlmayr compiled the nutrient content data for species following international food composition standards; Rose Kigathi provided additional edits to the technical content; Roeland Kindt prepared species suitability maps for the 27 indigenous species; Erick Ng'ethe provided data input support on general content and the suitability maps; Betty Rabar and Anne Downes undertook proofreading and copy editing (on two versions, an earlier and a final one); Tabitha Obara finalized the formatting and design; and Ramni Jamnadass sourced funding, and provided oversight and input during various stages of bringing this book to life.

Foreword

The cultivation of edible fruit trees is one of the most beneficial enterprises individual farmers and communities in East Africa can engage in. Their advantage lies in the dual benefits of being able to be used for both household consumption as well as market sale. The proportions being consumed and marketed may vary from 0% to 100% depending on fruit tree species characteristics, household circumstances, market demand and prevailing weather. For most species the decisions may be somewhat opportunistic rather than planned. In general, most fruit tree value chains are under-developed and a key underlying reason for this situation is a lack of knowledge and evidence on the horticultural, nutritional and market issues of fruit trees. Addressing these key knowledge gaps, the authors of this book have provided a comprehensive resource to improve the quality, diversity and volume of fruit tree cultivation and use in Kenya specifically, and East Africa in general. Whilst most of the information is about the role of individual tree species on livelihoods and nutrition, there is also useful consideration of the contribution of fruit trees to the overall floristic diversity on farms as well as their broader roles in landscape ecology.

An interesting and important framing of fruit tree cultivation reinforced in this book is the concept of fruit tree portfolios. This looks at two dimensions of: (a) what fruit at different months of the year can give calorific input to households or sales opportunities;

and (b) what nutritional inputs can be provided by different species including micronutrients, vitamins and anti-oxidants. This is particularly important for nine water soluble vitamins (folate, thiamine, riboflavin, niacin, pantothenic acid, biotin, vitamin B6, vitamin B12 and vitamin C) as well as the three main micronutrient deficiencies of concern in Kenya, namely iron, iodine and zinc.

Unlike several previous volumes on fruit trees of East Africa where authors restricted themselves to either indigenous or exotic trees, the authors of this book have usefully included a mixture of 49 indigenous, naturalized and exotic tree species. Whilst some previous volumes may have included longer lists of species, none have treated each species with as much breadth as this book. However, FAOSTAT and UN member countries record production data for only 5 of the 49 tree species treated in this book (avocado, citrus, date, mango, papaya). This underlies the orphan or neglected nature of these valuable fruit trees. More than 200 references are cited and the inclusion of many references from the grey literature is useful to elevate the knowledge outside of conventional scientific literature.

Another useful inclusion in each of the 49 accounts of individual tree species are the Wikimedia distribution maps. These maps show the geographic extent of suitable areas for cultivation of the fruit trees to complement the descriptive species domains

relating to specific agroclimatic zones in the text. Given the dynamic nature of the team behind this publication we can likely look forward to increased species coverage, greater economic analyses and more on market differentiation in local, national and international markets.

It is hard to choose an individual favorite fruit tree species from this volume but together they make an appealing fruit tree knowledge salad to be digested

at one's leisure and for one's pleasure. The authors and their institutions are to be congratulated for a seminal work bringing together the multiple and interdependent topics associated with fruit tree cultivation.

Tony Simons, Professor

**Executive Director
CIFOR-ICRAF**

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LIST OF ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi-arid Land
BBQ	Barbeque
DFID	Department for International Development
EC	European Commission
ECA	Eastern and Central Africa
EP	Edible Portion
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FTA	Forests, Trees and Agroforestry
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
ICRAF	World Agroforestry
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
INFOODS	International Network of Food Data Systems
masl	metres above sea level
MC	Moisture Content
NCD	Non-communicable Disease
NUS	Neglected and Underutilized Species
RE	Retinol Equivalents
RNI	Recommended Nutrient Intake
RSCU	Regional Soil Conservation Unit
SD	Standard Deviation
SIDA	Swedish International Development Authority
UK	United Kingdom
UNIDO	United Nations Industrial Development Organization
US	United States
USDA	United States Department of Agriculture
WHO	World Health Organization

INTRODUCTION

Fruits are important for human nutrition as they provide energy, fibre, vitamins and minerals as well as healthy compounds such as polyphenols and antioxidants. Cultivation of fruit species can also contribute to livelihoods by the generation of cash income and job creation. In addition, growing trees – including fruit species – is beneficial to the environment through several ecosystem service functions, such as soil improvement, microclimate enhancement and carbon sequestration. Trees play a key, but often undervalued role in supporting food security and nutrition through these various pathways (Gitz et al. 2021). For example, in many parts of Africa including Kenya, the potential of fruit cultivation and utilization is not fully exploited. This is due to several constraints such as difficulty in accessing planting material, knowledge gaps regarding tree management, fruit handling and processing, poor marketing and infrastructure as well as low demand for fruit due to high prices and lack of awareness on the nutritional value of fruits.

The aim of this book is to document and share knowledge about the cultivation and utilization of fruit tree species in Kenya. The publication presents an overview of 49 species. In part one, 27 indigenous fruit tree species which belong to the natural vegetation of Kenya are described. Most of these species are underutilized, i.e., they are usually not cultivated

but collected from the wild and there is almost no processing and very limited marketing of these fruits. They are often also considered neglected due to limited agricultural research and investment. In part two, 11 important exotic fruit tree species are presented; these were once introduced into the country and are now commonly cultivated for home consumption and income generation, and regional and international markets. Part three presents 11 introduced, but still underutilized exotic fruit tree species with future potential. For each of the 49 species, the following information is provided: common and local names, botanical description (including cultivar diversity) and ecological requirements, uses (food and non-food uses as well as service functions), nutritional composition of the fruit, harvest season, propagation and cultivation, pests and diseases, commercial value, and a bibliography for further reading. For each of the indigenous species, a map is also provided, showing the current occurrence of the species and suitable areas for its cultivation. Before embarking on the description of the 49 fruit tree species, this introduction explains the many benefits of fruit trees in more detail, including their contribution to family nutrition and wellbeing as well as to landscape health. In addition, the diversity of different species suitable for different climatic zones is presented, including challenges and the potential of fruit tree production.

1. The multiple benefits of fruit trees

1.1. The contribution of fruits to diets and nutrition

Fruits – along with other nutrient-rich foods such as vegetables, legumes, wholegrains and animal source foods – play an important role in healthy diets. Poor quality diets, with low consumption of healthy foods and overconsumption of unhealthy foods (i.e., high in sugar and fats, plus highly processed foods) result in high morbidity and mortality rates. Fruits (and vegetables) contain high levels of vitamins and minerals as well as phytochemicals (e.g., antioxidants) (FAO/INFOODS 2017; Stadlmayr et al. 2013). Frequent consumption of fruits is associated with a reduced risk of a number of diet-related non-communicable diseases (NCDs) including cardiovascular disease, cancers, respiratory diseases and type 2 diabetes (Aune et al. 2017; Boeing et al. 2012). In many parts of the world, however, the consumption of fruits (and vegetables) is inadequate. In Kenya, for example, only 6% of individuals (≥ 15 years) meet the World Health Organization (WHO) recommendation to consume 400 g of fruits and vegetables per day, (Frank et al. 2019; WHO 2019). The seasonal nature of different fruit tree species means that they are available at differing times of the year, hence providing essential foods and nutrients during periods of food insecurity, when other food

sources may be in short supply (Dawson et al. 2019; McMullin et al. 2019a). Even during drought, fruit trees with their extensive root system can provide a substantial harvest, thus contributing to food security (Jamnadass et al. 2011; Kehlenbeck et al. 2013), and to climate change adaptation of farming systems (Jamnadass et al. 2015).

1.2. The contribution of fruit tree cultivation to wellbeing

Cultivation of fruit trees can contribute to smallholder family wellbeing through income generation and job creation. This is particularly important in remote areas with few other job opportunities, in regions where farm sizes are too small to provide families with sufficient amounts of staples and/or in areas with challenging climatic conditions such as dry spells and unreliable rainfall. The deep roots of fruit trees ensure sufficient water supply to the trees during seasons of drought, resulting in fruit harvests even when the usual field crops such as maize and beans fail. The inclusion of trees in farms is well documented to support livelihood resilience in the face of economic and environmental shocks (Jamnadass et al. 2015; Quandt et al. 2017; Thorlakson & Neufeldt 2012). Some fruit trees also provide other important products including medicines, timber and fodder, which further supports the wellbeing and resilience of farming households (Prabhu et al. 2015).



Different cultivars of mango are sold along the roadside along the Nairobi-Mombasa Highway.



Mango fruit of the cultivar 'Apple' sold at a roadside stall in Watamu along Kenya's coast.

Exotic fruit species such as mango, avocado or orange are commonly grown on farms in Kenya as they are both valued for home consumption and are in high demand in both rural and urban markets. Producing such fruits can contribute to the income of farmers' families. Some high-quality produce is exported, e.g., mangos to countries in the Near East or avocados to European countries. To a certain extent, exotic fruits are also processed in Kenya, e.g., into juice, jam or dried fruit. Processed fruit products have local, regional and even international market potential. Value addition can thus offer micro-processors opportunities for employment and income generation, and processing reduces post-harvest losses of highly seasonal fruits (Keding et al. 2013).

Indigenous fruits – usually collected from wild trees in natural habitats or on farms – are hardly ever sold in markets in Kenya, and are commonly found in locations along the coast or in the drylands. In general, indigenous fruits are often considered 'food for children' or 'food for the poor' and are sold at very

low prices. In addition, traditional knowledge about the many indigenous fruit species and their uses is being lost, particularly among young Kenyans in urban areas, thus the demand is low. Usually, indigenous fruits are sold using informal marketing pathways, e.g., by street vendors or at small roadside stands. The most commonly sold indigenous fruit species are tamarind (*Tamarindus indica*), baobab (*Adansonia digitata*), ber (*Ziziphus mauritiana* & *Z. mucronata*) and *Dialium orientalis*. Despite the low selling price for indigenous fruits, cash generated from this activity can contribute to incomes, particularly for women, as well as during times of scarcity.

In addition to producing fruits for sale, farmers can also enter the fruit tree nursery business if they know how to propagate fruit trees. Producing high-quality, grafted fruit tree seedlings of improved cultivars of species that are in high demand can result in good economic returns for private and community nursery managers.



Fruit of *Berchemia discolor* are sold in the local market in Matuu, Kitui County.



Fruit of *Ziziphus mauritiana* sold by young street vendors in Kilifi along Kenya's coast.



De-pulped *Tamarindus indica* fruit sold in Mombasa town at the main market.

1.3. The contribution of fruit tree cultivation to landscape health

The huge diversity of tropical tree species is increasingly recognized to be vital to planetary health and especially important for supporting climate change mitigation (Jansen et al. 2020) and providing other ecosystem services (Rosenstock et al. 2019). Trees, including fruit trees, have a number of service functions and are thus greatly beneficial to the environment and to landscape health. Cultivation of fruit trees, for example, contributes to climate change mitigation as trees sequester carbon from the atmosphere (Reppin et al. 2020). Trees on farms – including fruit trees – also reduce soil erosion via their dense root system and enhance soil fertility through litter fall (Kuyah et al. 2016; Rosenstock et al. 2019). In addition, fruit trees enhance the rainwater infiltration and storage capacity of soils and, under suitable conditions, improve groundwater recharge, while precipitation filtered through tree roots delivers

purified ground and surface water for drinking (Ellison et al. 2017). Fruit trees on farms and in other agroforestry systems can improve microclimates at the field scale, resulting in increased growth and yield of crops close to the trees due to reduced temperature and evapotranspiration (Rosenstock et al. 2019).

Fruit trees on farms provide habitats for many animals including pollinators that are needed for good crop yields and for beneficial birds and insects that feed on crop pests. Integration of fruit trees also contributes to general biodiversity improvement and conservation (Kuyah et al. 2016). In addition, cultivation of indigenous fruit tree species on farms does not only improve connectivity of remaining natural habitats for biodiversity conservation, but also decreases the utilization pressure on natural indigenous fruit tree stands thus further contributing to conservation of genetic resources of these species (Kehlenbeck et al. 2013). Indeed, for many tropical tree-sourced foods and vegetable species, their resource base is being undermined and documenting genetic diversity

“hotspots” and appropriate conservation strategies has been identified as a priority (van Zonneveld et al. 2021; 2020). Finally, fruit trees can be used in productive restoration of degraded landscapes (Prabhu et al. 2015).

2. Diversity of fruit tree species and their suitability for different agro-ecological zones

Kenya has a huge diversity of fruit tree species due to its many different climatic and agro-ecological zones. However, there is no comprehensive list of the occurring indigenous and exotic fruit tree species available. In their book, “Useful trees and shrubs for Kenya”, Maundu and Tengnas (2005) documented a total of 324 useful tree species, including 132 fruit and nut tree species (109 indigenous and 23 exotic). The authors’ own research added a further 20 exotic fruit tree species to that list. Most probably, several more fruit and nut tree species currently present in Kenya are still not documented.

Most of the reported fruit tree species can be found in specific climatic and agro-ecological zones. Certain species are, for example, adapted to drylands, others to cold highlands, some are only found along Kenya’s coast, and others in western Kenya. For each of the 49 fruit tree species described in the chapters below, we included information on the ecological requirements of the species, particularly on suitable altitude ranges and required amounts of rainfall. Species distribution maps for the 27 indigenous fruit tree species are presented to illustrate documented occurrences as well as potentially suitable regions of Kenya. The method used to compile these maps is described in detail in Appendix 3. Tables 1 and 2 list selected important species – both exotic and indigenous – that are suitable for cultivation in cool highlands (altitude above 1500 masl; Table 1) or in dry regions located at intermediate or low altitudes (Table 2). Please see the information provided in each of the species sections for further details and for identification of suitable species for certain regions.

Table 1. Selection of important fruit tree species suitable for cultivation in the cool highlands of Kenya (altitude above 1500 masl)

Exotic species for highlands		Indigenous species for highlands	
Scientific name	English name	Scientific name	English name
<i>Annona cherimola</i>	Cherimoya	<i>Annona senegalensis</i>	Wild custard apple
<i>Carica papaya</i>	Pawpaw	<i>Balanites aegyptiaca</i>	Desert date
<i>Casimiroa edulis</i>	White sapote	<i>Myrianthus holstii</i>	Giant yellow mulberry
<i>Cyphomandra betacea</i>	Tree tomato	<i>Pappea capensis</i>	Jacket plum
<i>Eriobotrya japonica</i>	Loquat	<i>Phoenix reclinata</i>	African wild date palm
<i>Malus domestica</i>	Apple	<i>Syzygium guineense</i>	Guinea water berry
<i>Passiflora edulis</i>	Passion fruit	<i>Vangueria madagascariensis</i>	Wild medlar
<i>Persea americana</i>	Avocado	<i>Vitex doniana</i>	Black plum
<i>Prunus domestica</i>	Plum	<i>Ximenia americana</i>	Wild plum
<i>Prunus persica</i>	Peach		
<i>Psidium guajava</i>	Guava		
<i>Syzygium cumini</i>	Jambolan		

Table 2. Selection of important fruit tree species suitable for cultivation in dry midlands (below 1500 masl) and lowlands of Kenya

Exotic species for drylands		Indigenous species for drylands	
Scientific name	English name	Scientific name	English name
<i>Annona squamosa</i>	Custard apple	<i>Adansonia digitata</i>	Baobab
<i>Citrus sinensis</i>	Orange	<i>Balanites aegyptiaca</i>	Desert date
<i>Mangifera indica</i>	Mango	<i>Diospyros mespiliformis</i>	African ebony
<i>Psidium guajava</i>	Guava	<i>Phoenix reclinata</i>	Wild date palm
<i>Punica granatum</i>	Pomegranate	<i>Sclerocarya birrea</i>	Marula
		<i>Strychnos spinosa</i>	Monkey orange
		<i>Tamarindus indica</i>	Tamarind
		<i>Vangueria madagascariensis</i>	Wild medlar
		<i>Ximenia americana</i>	Wild plum
		<i>Ziziphus mauritiana</i>	Jujube

3. Challenges of fruit production

Despite the huge diversity of fruit species and the many benefits from fruit trees presented above, fruit production is still low in many low- and middle-income countries, including Kenya, where the agricultural focus is on a few important staple crops such as maize, rice and tubers. There are a number of constraints to both fruit supply (i.e., production) and fruit demand (i.e., consumption) in Kenya and neighbouring countries. Some of the main reasons for inadequate fruit consumption in low- and middle-income countries include:

- Limited availability and quality of fruits available in markets in certain regions (particularly in remote, rural locations) and during certain times of the year (during off-season, e.g., the dry or cold season);
- The relatively high cost of fruits as compared to staple food items, which limits their consumption, particularly amongst the poor (Darmon and Drewnowski 2015);
- Lack of awareness on the nutritional value of fruits in general, but specifically of indigenous

fruits for which even basic food composition data is often lacking;

- Sometimes, traditional beliefs and taboos have a negative impact on consumption of certain foods such as fruits for particular populations (e.g., women or children) and during different lifecycle stages (e.g., pregnant or lactating women).

Regarding low demand for fruits, food choices in general are affected not only by availability and affordability of foods such as fruits, but also by other aspects of the food environment. Some of these include desirability and convenience of particular foods and socio-cultural practices, awareness of healthy foods and diets and food marketing (Keats and Wiggins 2014; Keding et al. 2013; Ruel et al. 2005).

In addition to the low demand, there is usually a shortage of fruits, both regarding production and supply. The global supply of fruits (and vegetables) was on average 22% short of population needs in 2009, assuming that every person consumes fruits and vegetables according to dietary recommendations (Lock et al. 2004). Low- and middle-income countries were particularly affected by

shortages as they produced only 42% of the required fruits and vegetables in 2009 (Siegel et al. 2014). In the same year, Kenya produced 56% of its population consumption needs. Moreover, this gap is projected to widen by 2050, particularly in low-income countries with supply of only 30% projected to meet growing population needs (Siegel et al. 2014). National and international agricultural research and policies may have a negative impact where staple crops and export commodities are prioritized with fewer investments in fruits (and vegetables) and particularly in local indigenous and underutilized species. Amongst the issues impeding fruit production are:

- Loss of the traditional food and nutrition systems based on local agro-biodiversity including indigenous fruits, which leads to erosion of both the plant genetic resources and related traditional knowledge;
- Degradation of natural vegetation such as forests used for gathering wild indigenous fruits for home consumption and sale in the past;
- Lack of improved fruit tree varieties that are well adapted to the sometimes challenging ecological conditions in tropical countries;
- Poor availability and dissemination of quality planting material due to lack of efficient supply systems (i.e., tree nurseries) for fruit tree seeds and seedlings;
- Low on-farm fruit tree productivity due to poor farming practices, lack of knowledge about fruit tree management and poor availability (or affordability) of needed inputs such as fertilizers and pesticides;
- High seasonality of the commonly grown exotic fruit species, which results in many periods of the year when there are limited fruits available, and other times of the year when there are gluts, resulting in loss, waste and lower prices at the farm gate;
- Lack of infrastructure and technologies for cooling and fruit processing facilities, which

leads to high post-harvest losses, particularly in tropical countries, and;

- Poorly organized fruit marketing pathways along the value chain resulting in low producer prices for fruit farmers, high fruit prices for consumers and high post-harvest losses during transport and sale.

Anthropogenic climate change will most likely worsen some of the challenges mentioned above by shifting the geographic ranges and reducing density and productivity of some fruit species (Dawson et al. 2011). For example, indigenous fruit tree species such as baobab that grow in natural habitats could become extinct over time, due to longer dry spells. This could result in limited rejuvenation to replace older trees in the long term. Furthermore, environmental changes could have an impact on the yields and nutritional value of fruits (Alae-Carew et al. 2020). Increasing resilience of food systems to environmental shocks could be addressed through selection of tree cultivars, species and breeds that are less susceptible to stresses such as drought, pests and salinity, and those that support other production strategies such as diversifying farms, shifting the timing and patterns of planting, and adopting agroforestry practices (Davis et al. 2021).

4. The potential of fruit tree cultivation in Kenya

Integrating fruit trees into farms has a great potential for smallholder farmers and their families in Kenya and neighbouring countries. About 80% of fruits (and vegetables) produced in low- and middle-income countries are grown on smallholder family farms (< 20 hectares) (FAO 2020). Cultivation of fruit trees can diversify crop production options of smallholder farmers, and improve health and generate economic and ecological benefits (Keatinge et al. 2010; Weinberger and Lumpkin 2005). The varied agro-ecological zones found in Kenya and other parts of sub-Saharan Africa offer opportunities to support a great diversity of both cultivated and wild fruit tree species (Akinnifesi et al. 2008).

4.1. Potential of indigenous fruit tree species

Indigenous fruit tree species could provide much needed nutrients in human diets. However, greater recognition of their role in healthier diets requires knowledge of the nutritional value of their fruits. Where data for indigenous fruits is available, the nutritional value for certain micronutrients is often superior to that of more common exotic species. Examples are the African species *Adansonia digitata* (baobab), *Sclerocarya birrea* (marula) or *Sorindeia*

madagascariensis (sorindeia). Studies indicate that the vitamin C content of their fruits can be up to five times higher than that of *Citrus sinensis* (orange) which is commonly used as a reference source high in vitamin C (McMullin et al. 2020; Stadlmayr et al. 2019). Fruits of baobab and sorindeia are, in addition, excellent sources of the minerals, calcium and potassium, while baobab, marula and wild medlar (*Vangueria infausta*) fruits have a high iron content (Table 3).

Table 3. Contents of vitamin C, calcium, potassium and iron (all given in mg per 100 g edible portion of the fruit) for selected indigenous fruit tree species and the exotic species, orange, for comparison

Scientific species name	English species name	Vit C content (mg/100 g)	Calcium content (mg/100 g)	Potassium content (mg/100 g)	Iron content (mg/100 g)
<i>Adansonia digitata</i>	Baobab	273	275	1730	5.0
<i>Sclerocarya birrea</i>	Marula	168	34	325	3.4
<i>Sorindeia madagascariensis</i>	Sorindeia	107	255	597	n.a.
<i>Vangueria infausta</i>	Wild medlar	5	14	502	4.3
<i>Citrus sinensis</i>	Orange	53	40	181	0.1

For details, please refer to the nutrient content tables in the chapters of the respective species.

However, high-quality food composition data for most of the numerous indigenous fruit tree species in Africa is often missing (Stadlmayr et al. 2013). This is due to lack of research, plus private sector interest and investment in these species. They are often considered underutilized due to their limited presence in international markets despite their importance in local food systems (Dawson et al. 2018; Padulosi et al. 2013). More research and investment is needed to produce high-quality food composition data for these under-researched indigenous species, since understanding their nutritional value would allow for better mainstreaming, and future scaling of their use in food systems. Such knowledge can support selection of suitable species for domestication programs and allow for their inclusion and promotion in national food-based dietary guidelines (Elmadfa and Meyer 2010). Another important intervention area

is producing quality seed and seedlings and ensuring they are available to farmers for successful fruit production. Attention should be focused on delivery systems (i.e., tree nurseries) for planting material that has been identified as a key success factor for mainstreaming indigenous and underutilized food crops (McMullin et al. 2021).

4.2. Fruit tree portfolios for year-round supply of fruits

One challenge in fruit production is the seasonality of fruit harvest resulting in seasons of over-supply – with low prices for farmers and high post-harvest losses – and in seasons of short supply, when few fruits are available. To address this challenge, various fruit tree species with different harvest seasons should be cultivated in one location. Selection of vitamin-rich

fruit tree species – the ‘fruit tree portfolios’ – were developed for some regions of Kenya, combining certain species for year-round fruit supply (McMullin et al. 2019b). While the fruit tree portfolios were originally developed for subsistence of smallholder farming families, the same approach can also be applied for larger scale commercial fruit production. These portfolios can also be established in schools, and other places that communities have access to (McMullin et al. 2020). Figure 1 presents an example of a fruit tree portfolio for Machakos in Eastern Kenya.

Comprising ten species that could be grown on a farm for year-round supply of fruits (Table 4), it presents a design of a small orchard with the recommended fruit tree species for Machakos area (modified after Kehlenbeck & McMullin 2015). Customized fruit tree portfolios could be developed for each region by considering the most suitable fruit tree species and their respective harvest seasons in that specific climatic zone, plus their nutritional value (McMullin et al. 2019b).

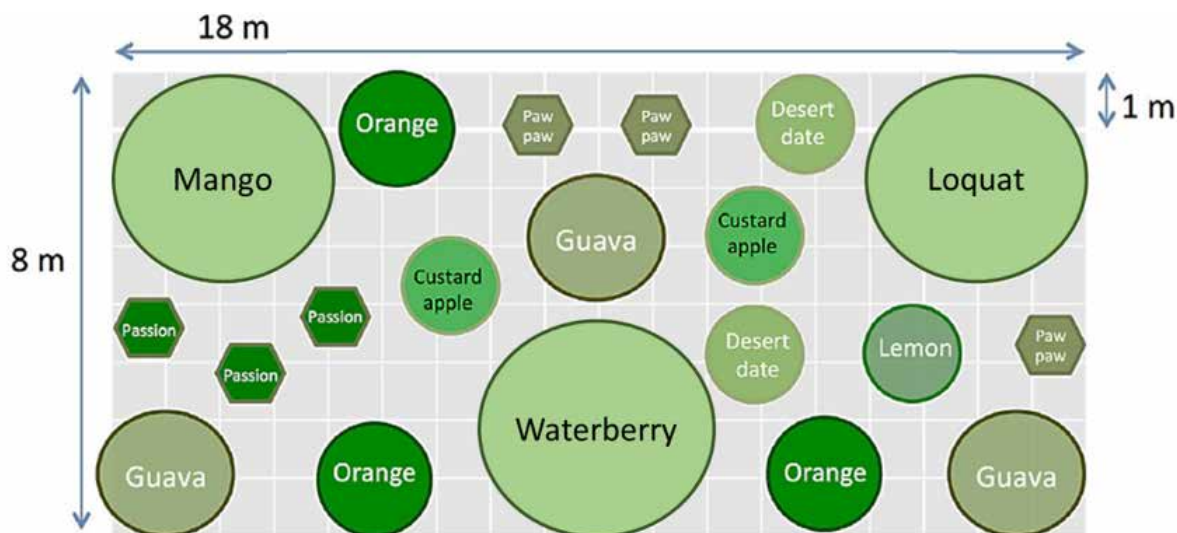
Table 4. Fruit Tree Portfolio developed for Machakos, Eastern Kenya (modified after McMullin et al. 2019b)

English Name	Scientific Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	VIT C	VIT A
Pawpaw	<i>Carica papaya</i>													+++	++
Mango	<i>Mangifera indica</i>													++	+++
Loquat	<i>Eriobotrya japonica</i>													-	+++
Waterberry	<i>Syzygium</i> spp.													~	No data
Custard apple	<i>Annona reticulata</i>													++	-
Guava	<i>Psidium guajava</i>													+++	~
Lemon	<i>Citrus limon</i>													+++	-
Orange	<i>Citrus sinensis</i>													+++	-
Passion fruit	<i>Passifora edulis</i>													++	++
Desert date	<i>Balanites aegyptiaca</i>													+++	No data

The table shows selected 10 fruit tree species with moderate to high vitamin A and/or vitamin C contents and their months of harvest, indicated by the green shaded boxes. Ratings of vitamin A and vitamin C contents are given as +++ (high source); ++ (source); ~ (present, but low); - (no source*).

*For explanation of vitamins A and C content scores, visit http://apps.worldagroforestry.org/products/nutrition/index.php/food/food_scoring

Figure 1. Example of an orchard design that contains 20 trees of the 10 species recommended in the fruit tree portfolio for Machakos, Eastern Kenya, that can be planted in an orchard of 8 x 18 m size (modified after Kehlenbeck & McMullin 2015).



4.3. Conclusion

The high potential of fruit tree cultivation in Kenya and neighbouring countries could be better exploited, if the challenges mentioned in part three of this introduction were addressed. To maximize the benefits of fruits for delivering nutrition and improving health, enabling income and livelihoods, and supporting landscape health, a number of research and action areas include: promoting fruit production and engaging smallholder farmers, particularly women and youth, for livelihood benefits; improving fruit availability for consumers through value chain connections and innovations which could reduce loss and waste, and retain nutrition; addressing affordability of fruits through lower retail prices (through productivity improvements, reduced postharvest losses, or increased market efficiencies), through subsidies or taxing unhealthy food (such as ultra-processed foods); and promoting fruit consumption through appropriate messaging and marketing using various channels relevant to the context (FAO 2020; Harris et al. 2021).

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PART ONE: INDIGENOUS FRUIT TREES AND SHRUBS



Balanites aegyptiaca (Desert date)



Sclerocarya birrea (Marula)





Syzygium guineense (Water berry)



Tamarindus indica (Tamarind)



Grewia tenax (White cross-berry)



Garcinia livingstonei (African mangosteen)



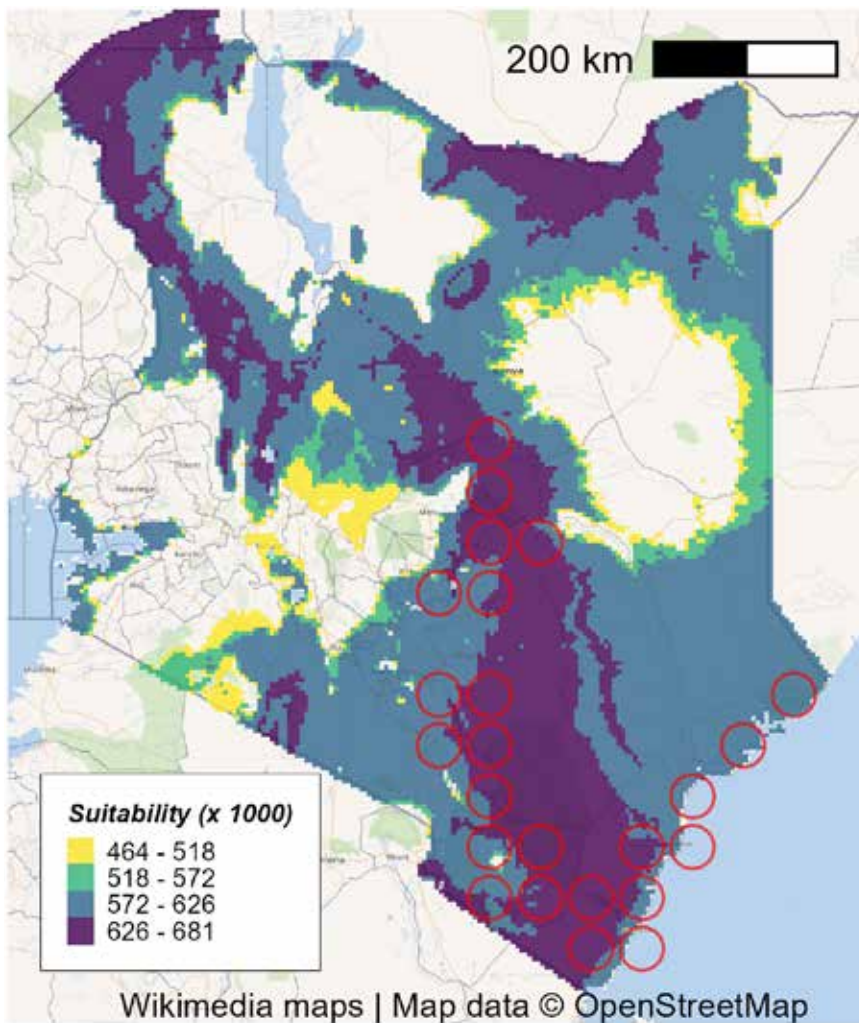
Dovyalis macrocalyx (Dovyalis)

1. *Adansonia digitata* L.

MALVACEAE

Common name: Baobab, Monkey-bread, Africa's Upside-Down Tree

Local names: Muyu (Bajun); Jah (Boni); Mbuyu/Muuyu (Digo, Giriama, Swahili); Muramba (Embu, Meru), Muamba/Mwaamba/Mauyu (Kamba); Ol-mesera (Maasai); Yak (Orma, Somali); Lamai (Samburu); Mlamba (Taita).



* See Appendix 3 for full description of methodology used to develop species suitability maps

Description and ecology: A large, deciduous tree with an enormously wide, swollen trunk and often branching near the ground, growing up to 20 m in height. The trunk diameter may reach 6–8 m and it is sometimes hollow. Tree remains without leaves for up to 8–9 months, stiff branches look like roots ('upside-down tree'). **Bark:** Smooth, shiny; grey and fibrous; branches stout and stiff. Young, spongy wood can store a lot of water. **Leaves:** Mature leaf is compound digitate (finger-like) with up to 9 leaflets, usually 5, with long leaf stalks of about 100 mm; tapering base and apex; lower leaflets smaller. **Flowers:** Large, solitary; 5 waxy, white petals surrounding a ball of fine stamens; hanging on stalks; very short-lived and unpleasantly scented, attracts pollinating fruit bats and moths; open at night. **Fruit:** Large; hard-shelled capsules; covered in greyish, velvety hairs; hanging on long stalks; many-seeded; seeds embedded in white, dry, edible pulp; seeds brown with a hard shell, kidney-shaped, with a white endosperm.

One of the longest living trees in the world, the baobab is commonly found in coastal and inland bush and woodland, but also grows further inland, e.g., in dry parts of Kitui, Taveta, Kibwezi, southeastern Makuani and Meru National Park. It grows in well-drained soils; it is common on red soils, sandy loam and in rocky areas. Trees are deep-rooted and drought-resistant. It grows at altitudes from sea level up to 1200 metres above sea level (masl).

Uses: It is a sacred tree among the Giriama community. The fruit contains a white, mealy, acidic-tasting, nutritious pulp that can be eaten raw and used to make refreshing drinks and ice-creams or to curdle milk. The pulp can also be used for flavouring (souring porridge) or soaked in water to make a refreshing drink when coconut juice is added to it. The pulp-coated seeds (*mabuyu*) are coloured, sugar-coated and sold as sweet snacks in the coastal towns of Kenya. The seeds are edible and yield a pleasant tasting oil. In Bicha and Mondo villages in Tanzania, oil from *A. digitata* seeds is used as a substitute for cooking oil. A red dye is obtained from the roots. The fibrous bark is used for weaving and making ropes, baskets, musical-instrument strings and hats. The tree is used for fodder (e.g., leaves, branches and fruit), mulch, resin and gum, and also serves as an ornament. The bark is used for roofing and making temporary structures. The fruit shells are used as fuelwood, containers and bowls and for making rat traps. The leaves are used as a vegetable by the Giriama people. The tree is fire- and termite-resistant, and a preferred food of elephants that eat the spongy tissues of the bole and can damage trees. The seeds are eaten by monkeys and humans, while the bark, roots, fruit juice and leaves are used in human and veterinary medicine.



Adansonia digitata – tree



Adansonia digitata – young fruit



Adansonia digitata – leaves



White, dry, edible pulp and pulp-coated seeds of *Adansonia digitata* (right) can be made into coloured, sweet snacks (mabuyu) and drinks (left) and used for flavouring food. Open fruit (top) showing the white, mealy fruit pulp that covers the seeds

Nutrient composition

Baobab fruit, pulp, raw (<i>Adansonia digitata</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy¹ kcal (kJ)	327 (1380)		
Water (g)	11.0 ± 5.0	4.5-27.6	41
Protein² (g)	2.4		
Fat (g)	0.5 ± 0.3	0.2- 1.2	19
Carbohydrate, available³ (g)	75.0		
Fibre, crude (g)	6.2		1
Ash (g)	5.0 ± 0.7	3.7- 6.3	28
Calcium (mg)	275 ± 141	60-611	14
Iron (mg)	6.1 ± 3.6	1.5- 13.4	10
Potassium (mg)	1730 ± 510	1141- 2500	8
Magnesium (mg)	232 ± 133	90- 420	10
Phosphorus (mg)	51 ± 21	35-98	8
Copper (mg)	0.82 ± 0.47	0.49-1.60	5
Zinc (mg)	1.36 ± 0.79	0.42- 2.40	5
Vitamin A (RE)⁴ (mcg)	0		
β-carotene (mcg)	0		
Thiamine (mg)	0.31	0.04- 0.57	2
Riboflavin (mg)	0.18	0.16-0.20	2
Niacin (mg)	1.5		1
Folate (mcg)	50		1
Vitamin C (mg)	269 ± 101	126-509	31

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 β-carotene + 1/12 β-cryptoxanthin

Baobab fruit is characterized by its dry, powdery fruit pulp. Its low water content concentrates other components. Baobab is an excellent source of vitamin C, potassium, calcium and magnesium. One can cover twice the recommended daily intake of vitamin C¹ by consuming the pulp of a medium-sized baobab fruit (33 g pulp²). The seeds and leaves of baobab are also edible. The seeds are a good source of protein and fat, while the leaves provide minerals. The young, fresh leaves are a good source of vitamin A.



Season: Leaves appear in November–December, flowers in April, capsules emerge in June and fruit ripen in September at the coast.



Cultivation: There are three methods of propagation: by direct sowing of the seed, using stem cuttings and grafting. Pre-treatment of seeds is not necessary. However, germination is more successful if the seeds are nicked, or when boiling water is poured on them and soaked for 24 hours. This softens the seed coat and makes water absorption for germination easier. Germination is 90–100% and usually takes 1–3 months. It will take only 6 days for the seed to germinate if the seed coat is nicked. As pruned branches frequently sprout young leaves when minimal conditions are present, stem cuttings may be taken, rooted in the nursery and transplanted to the field. A study in Kenya has proved that it is easy to graft baobab. Both side-veneer and top-cleft grafting is used with a plastic film to control transpiration. The rootstocks used are 3–24-month-old seedlings.

Once established, the seedlings grow well, to about 2 m tall in 2 years and 7 m in 10 years. They are later very slow growing but live long; under favourable



conditions some *A. digitata* may live for more than 1000 years. Baobab produces its first fruit after 25–60 years and then produces an abundant amount of fruit (an average of 210 fruits per tree). *A. digitata* may be pollarded or lopped to encourage the growth of leaves for use as fodder or vegetable. Seeds can be stored for a long time if they are kept cool and dry. Seeds are probably orthodox; they show no loss in viability during one year of hermetic storage at 4°C; viability can be maintained for several years in hermetic storage at 3°C with 8–11% moisture content. There are usually 2000–3000 seeds/kg.

Pests and diseases: Cotton bollworms, cotton stainer bugs and flea beetles are the main insect pests of this species. The first two species destroy baobab fruits by feeding on pulp and seeds. Black beetles and certain longhorn beetles are reported to damage and eventually destroy branches of older and the stem of younger trees by girdling. *A. digitata* is also host to members of the *Pseudococcoidae* family, the mealybugs, which act as vectors for various viral diseases. The sooty baobab syndrome is an episodic, drought-induced phenomenon related to climatic change, made worse in recent times by human interference that limits local availability of soil moisture. Affected trees, which appear dead or dying display a striking, blackened or burnt appearance, hence are commonly known as ‘sooty baobabs’.



Commercial/market value: Large quantities of fruit are harvested and sold in coastal and semi-arid areas of Eastern Kenya (Kitui, Mwingi, Kibwezi, Mbeere and Tharaka). Coloured pulp and pulp-covered seeds are sold as snacks in cities

1 Calculations based on recommended nutrient intake (RNI) of vitamin C, adults (19 to > 65 years): 45 mg vitamin C/day. www.fao.org/nutrition/requirements/vitamins/en/

2 Average weight of baobab fruit pulp (33 g), based on the analysis of baobab fruits, sampled in Kenya from inland to coast.

such as Nairobi, Mombasa and Malindi. Baobab has the potential to become a major regional export commodity. A sustainable potential supply of 700,000 t of baobab fruit per annum could be sourced from countries in the southern and Eastern African regions. There is potential demand for baobab as a novel food, cosmetic and pharmaceutical ingredient. Focus markets include the European Union (EU), United States (US), Japan and South Africa.

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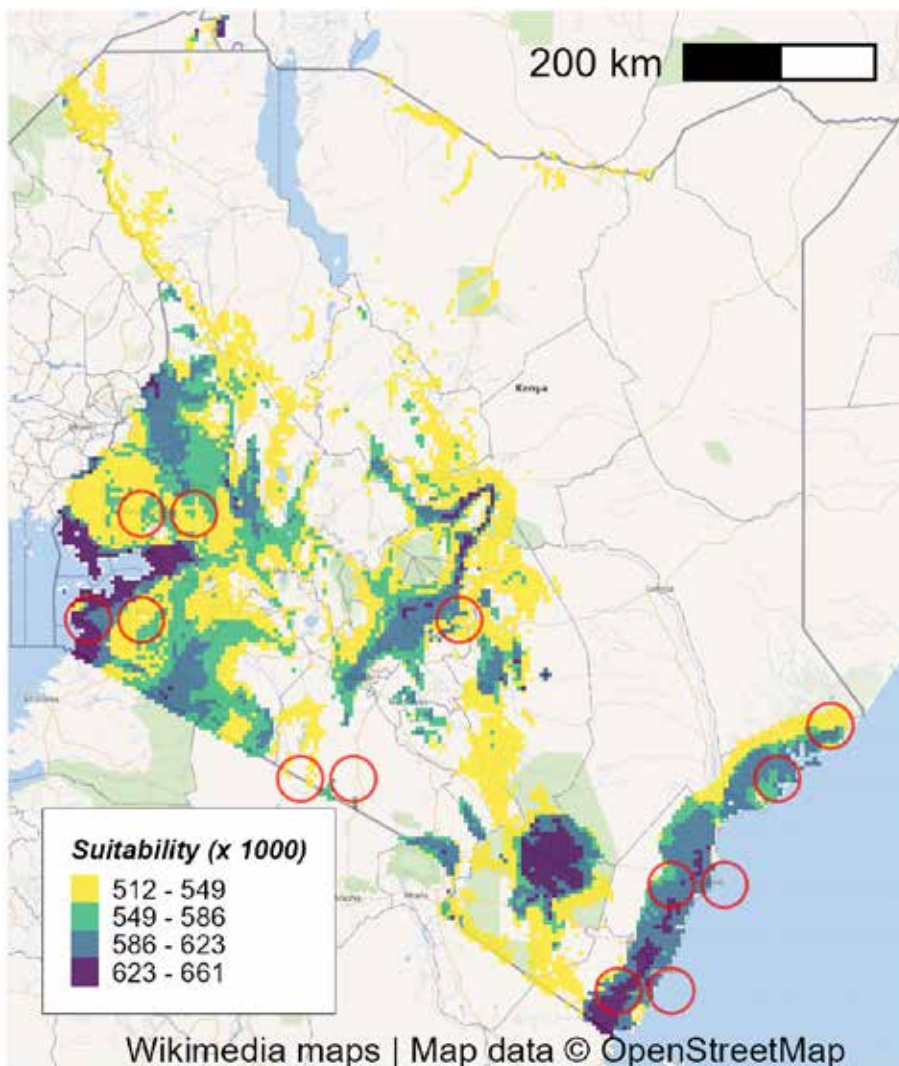
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2. *Annona senegalensis* Pers.

ANNONACEAE

Common name: Wild custard apple; African custard apple; Wild soursop

Local names: Malamuti/Mlamote (Boni); Mbokwe (Digo); Mutakuma (Giriama); Makulo, Matimoko (Embu); Kitomoko/Matomoko (Kamba); Muvulu (Luhya); Obolobolo/Obolo, Nyabolo (Luo); Mtomoko mwitu/Mbokwe/Mtonkwe/Mkonokono (Swahili); Ebwolo (Teso).



Description and ecology: A spreading shrub or small tree, usually 2–6 m. **Bark:** White/grey; smooth; young stems hairy and orange/red. **Leaves:** Broadly oval; large, blue/green; hairy below; smells when crushed. **Flowers:** Green/yellow or cream; with numerous stamens; 1–2 small flowers hang down below twigs. **Fruit:** Compound or multiple; syncarpous; rounded or sometimes oval; up to 5 cm in diameter; smooth, with divisions; green when young, turning orange/yellow when ripe; smells like pineapple when ripening. Fruit packed with many brown-coloured, oblong, cylindrical seeds embedded in the cream-white fruit pulp.

In Kenya, it grows along coastal areas, in the highlands east of Mt Kenya, including Kitui Hills, Kisii, in the lake basin around Nyanza (hilly areas in Homa Bay) in bushed grassland, riverine woodland,

coastal bushed grassland and forests, mostly as an understory shrub. It is common within its areas of distribution. It grows well in a variety of soils including deep sandy, alluvial or light red loam, at altitudes ranging from 0–2400 masl.

Uses: Ripe, yellow fruit is very sweet and edible with acidic taste and aroma of pineapple. Ripe fruit is usually eaten raw once collected from the tree. Sometimes green, almost mature fruit is collected and stored for some days to ripen. Its bark is a source of brown dye. Bark, root and fruit are used in traditional medicine. Leaves are browsed by domestic animals. Wood is soft and is used as fuelwood, but is usually of low quality. The tree is grown as an ornament and windbreak on small farms. Ripe fruit is also eaten raw in Ethiopia, Tanzania and Uganda by local communities.



Annona senegalensis – tree



Annona senegalensis – leaves



Annona senegalensis – unripe fruit



Annona senegalensis – shrub



Annona senegalensis - ripe fruit

Nutrient composition

African custard apple, pulp, raw (<i>Annona senegalensis</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy ¹ kcal (kJ)	95 (398)		
Water (g)	74.8 ± 4.0	70.2-77.2	3
Protein ² (g)	1.6		
Fat (g)	1.7 ± 0.7	1.1-2.5	3
Carbohydrate, available ³ (g)	16.0		
Fibre, crude (g)	4.6	3.9-5.3	2
Ash (g)	1.3	1.2-1.5	2
Calcium (mg)	41	40-42	2
Iron (mg)	1.7 ± 0.9	0.74-2.5	3
Potassium (mg)	522 ± 11	451-650	3

African custard apple, pulp, raw (<i>Annona senegalensis</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Magnesium (mg)	59 ± 23	40-84	3
Phosphorus (mg)	45	45	1
Copper (mg)	0.21	0.21	1
Zinc (mg)	0.26		1
Thiamine (mg)	0.10		1
Riboflavin (mg)	0.10	0.05-0.14	2
Niacin (mg)	0.9	0.8-0.9	2
Vitamin C (mg)	12	5-18	2

SD, standard deviation, calculated when the number of data points (n) ≥ 3;

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

African custard apple is a good source of minerals. It has high levels of vitamins from the B-complex including thiamine, riboflavin and niacin, and moderate levels of vitamin C.



Season: Flowers in February–March and fruits ripen in June–August.



Cultivation: Propagated by seeds (no treatment required) and by vegetative propagation. Seedlings can be used either as rootstock or as plant material for production. Vegetative propagation involves grafting or budding rootstocks with the desired cultivar to produce trees of uniform genetic characteristics. This species coppices well. Seedling trees live longer (about 15 years) than grafted trees (maximum 10 years). On disintegration of the fruit, seeds that fall on the ground can germinate if conditions are favourable. Germination is good on recently cultivated or burnt areas. For plants that are to be raised in the nursery, scarification of seeds improves germination rates. Root suckers are produced after wounding of



roots by fire or trampling by cultivators and animals. Seed is orthodox, thus easy to store. Seeds are susceptible to insect damage and lose viability within 6 months under natural conditions. However, viability can be maintained for more than 2 years in cool air-dry storage containers at 5°C. There are about 2500 to 3000 seeds/kg.

The ideal time for transplanting seedlings is when plants are 30–45 cm high or when 4 to 6 leaves have matured. Spacing should be 5 m x 5 m. *A. senegalensis* should be protected from fire and browsing. The planting site should be cleared and weeded, as the young plants are not hardy enough to compete with weeds. A light shade should also be provided. Growers can intercrop *A. senegalensis* with annual or vegetable crops to get additional income and to compensate for labour and other costs in the orchard during the first 2–3 years after planting.



Pests and diseases: Mealybugs, various species of scales or cochineals and spider mites cause damage to plants and fruit. Aphids, fruit-spotting bugs and other hemipterous bugs (stink bugs), leafhoppers, leaf miner larvae, root grubs and ants can damage *Annona* trees or fruit, thus making them unmarketable. Sucking insect pests may be important economically, when they attack young, growing fruit. The removal of affected branches (for trunk borer) or attacked fruit (for moth and wasp attacks) is the first recommended method of control.



Commercial/market value:

The ripe *A. senegalensis* fruits are harvested from the trees, or more rarely collected from the ground. Ripe fruits are occasionally sold in local markets. This species is also used in the production of essential oils (esters of aliphatic acids) present in the seeds, while the fruit pulp is used to improve the flavour of processed fruit products. This species has potential for domestication.

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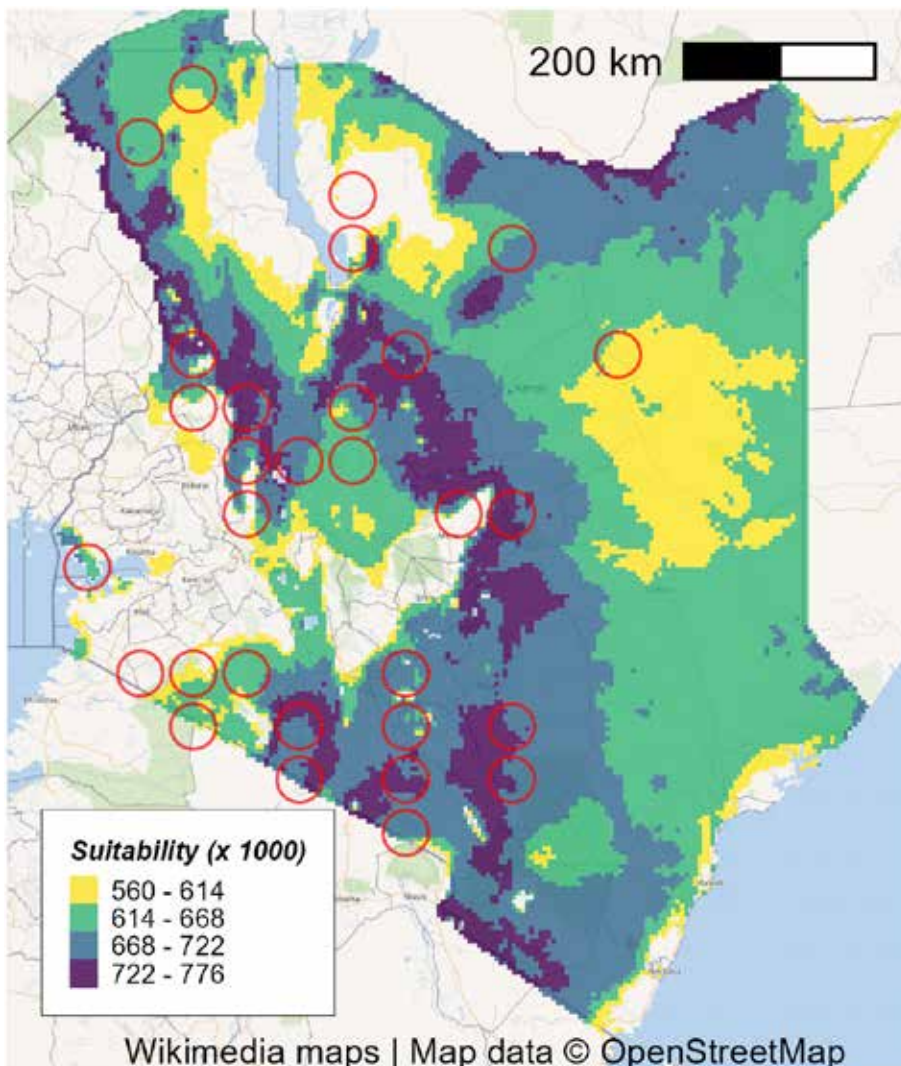
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3. *Balanites aegyptiaca* (L.) Delile

ZYGOPHYLLACEAE

Common name: Desert date

Local name(s): Baddan (Borana, Orma); Mwambangoma (Digo); Baddana (Gabra), Lowei, Lowa (Ilchamus); Mulului/Kilului (Kamba), Ng'oswet (Kipsigis); Othoo/Otho (Luo), Olng'oswa/Olokwai/Ilokwa (Maasai); Tuyun/Tuyunwo (Marakwet); Tuyunwo (Pokot), Lowvai/Lowwai (Samburu); Kullan/Kulung (Somali); Mjunju/Mchunju (Swahili), Kiwowa (Taita); Lungoswa (Taveta), Ng'oswo/Ngosyek/Ngoswa (Tugen); Eroronyit (Turkana).



Description and ecology: A slow-growing, evergreen, much-branched, spiny shrub or tree that reaches 6–10 m in height, with a rounded crown and a tangled mass of arching, thorny branches. Thorn: Soft at first, then woody, up to 8–10 cm long. **Bark:** Dark brown; deeply fissured longitudinally; young branchlets green and smooth; soft at first, then woody. **Leaves:** Distinctive pairs of grey/green leaflets with a conspicuous petiole about 2 cm long; oval tapering to the base. **Flowers:** Small, green/yellow clusters, in leaf axils; sweet-scented. **Fruit:** A drupe; oblong, up to 4 cm long; both ends round; green, turns pale yellow when ripe; hard, pointed

seed inside surrounded by yellow/brown, bittersweet flesh. Seed is the pyrene (stone), 1.5 to 3 cm long, light brown, fibrous and extremely hard.

The species has a large distribution and is found in many parts of Kenya, e.g., in the dry parts of Nyanza, the Rift Valley and semi-arid areas in the eastern region, but is rare in the coastal areas. It is common in Kajiado, Machakos, Makueni, Garissa, Isiolo, Kisumu, Narok, Nakuru, Baringo and Marigat areas. The trees are found in bushland and wooded grassland at 250–2000 masl. It is also common in open grassland with black cotton soil. It also grows in sandy, clay, alluvial and stony soils.



Balanites aegyptiaca – ripe and unripe fruit



Balanites aegyptiaca – fruit shell removed exhibit yellow-brown or greenish sweet-bitter pulp



Balanites aegyptiaca – branches with leaves and fruit



Balanites aegyptiaca – tree

Uses: The fleshy pulp of both unripe and ripe fruit is edible and can be eaten dried or fresh. The fruit shell is removed from the yellow/brown pulp. The pulp is sucked and the seed discarded. It has a sweet taste but is bitter nearer the seed. The fruit is processed into a drink and sweetmeats in Ghana, into alcoholic liqueur in Nigeria, and is used as a soup ingredient in Sudan. In Tanzania, ripe, fallen fruit are collected and the fresh pulp is eaten by Gogo and Zigua people. In Kenya, young leaves and soft, tender branches are used as a vegetable (by Pokot, Tugen, Keiyo, Ilchamus, Marakwet and Turkana people). Seeds

are a source of oil and seeds with shell or cotyledons (shell removed) boiled for a few hours and eaten (by Pokot, Tugen and Marakwet people). The oil is used for cooking vegetables by the Zigua people of Tanzania. The wood is heavy, durable and termite-resistant and is used for furniture, tool handles, poles, carvings and as construction timber. The fruit and leaves are browsed by goats, camels and game, especially giraffes. The gum is edible and is used to fix arrowheads and spearheads to the shafts.

Nutrient composition

100 g edible portion on fresh weight basis (EP)	Desert date, dried, raw		Desert date, fresh, raw	
	<i>(Balanites aegyptiaca)</i>			
Component	Mean	n	Mean	n
Energy ¹ kcal (kJ)	307 (1300)		110 (467)	
Water (g)	17.3	1	70.4	1
Protein ² (g)	4.2		1.8	1
Fat (g)	0.6	1	0.3	1
Carbohydrate, available ³ (g)	68.6		24.1	
Fibre, crude (g)	5.3	1	2.0	1
Ash (g)	4.0	1	1.4	1
Calcium (mg)	164	1	53	1
Iron (mg)	4.4	1	3.3	1
Potassium (mg)	1110	1		
Magnesium (mg)	44	1		
Phosphorus (mg)	61	1	24	1
Copper (mg)	0.29	1		
Zinc (mg)	0.89	1		
Thiamine (mg)	0.2	1		
Riboflavin (mg)	0.1	1		
Vitamin B6 (mg)	0.3	1		
Folate (mcg)	50	1		
Vitamin C (mg)	0-9	1	51 (12- 90)	2

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Desert dates can be consumed dried or fresh. The dried fruits are low in water, but higher concentrated in most of the other components. They provide three times more energy than fresh dates. Both date forms are good sources of fibre and while the dried desert date is an excellent source of all minerals, the fresh date is superior in terms of its vitamin C content.



Season: Fresh, new leaves in July–August; fruit in March–April.

Cultivation: Seed may be collected directly from trees or from dung. Soaking seed in water for several hours and then stirring vigorously helps to separate the stones from remaining pulp. Germination can be improved by placing seed in boiling



water for 7–10 minutes and then cooling slowly. The effect that the passage of seed through an animal's intestinal tract has on germination is unclear.



Seed storage behaviour is orthodox, and viability can be maintained for several years when seed is stored in cool hermetic storage at 3°C and if moisture content is 6–10%.

Natural regeneration is primarily through seed, although because of a high demand for fruit, few seeds are available in some locations. The tree is propagated by planting seeds directly or by raising seedlings in a nursery. The tree coppices successfully and produces abundant root suckers. It also pollards well and can regenerate after looping and heavy browsing. Pollination is presumably by insects as flowers are scented and flower structure facilitates insect activity. The first fruiting is at 5–8 years after planting; yields increase until the tree is 25 years of age.



Pests and diseases: *B. aegyptiaca* suffer from repeated locust and beetle attack, and a high degree of parasitic infestation. In Gountoure, Burkina Faso, 50% of the population had leaf galls, bugs or scales. Two micro fungi, *Phoma balanites* and *Septoria balanites*, are the only reported dependent fungi.



Commercial/market value: A bilateral aid program, supported by the United Nations Industrial Development Organization (UNIDO) is exploring oil extraction and refinement from *Balanites aegyptiaca* seeds in Sudan. Oil processing offers potential given the large, unsupplied market and its high market value. In Eastern Africa including Kenya, this species is not marketed but is an important tree species for arid and

semi-arid lands (ASALs) as it produces fruit even during very dry seasons. Improved varieties grow in India.

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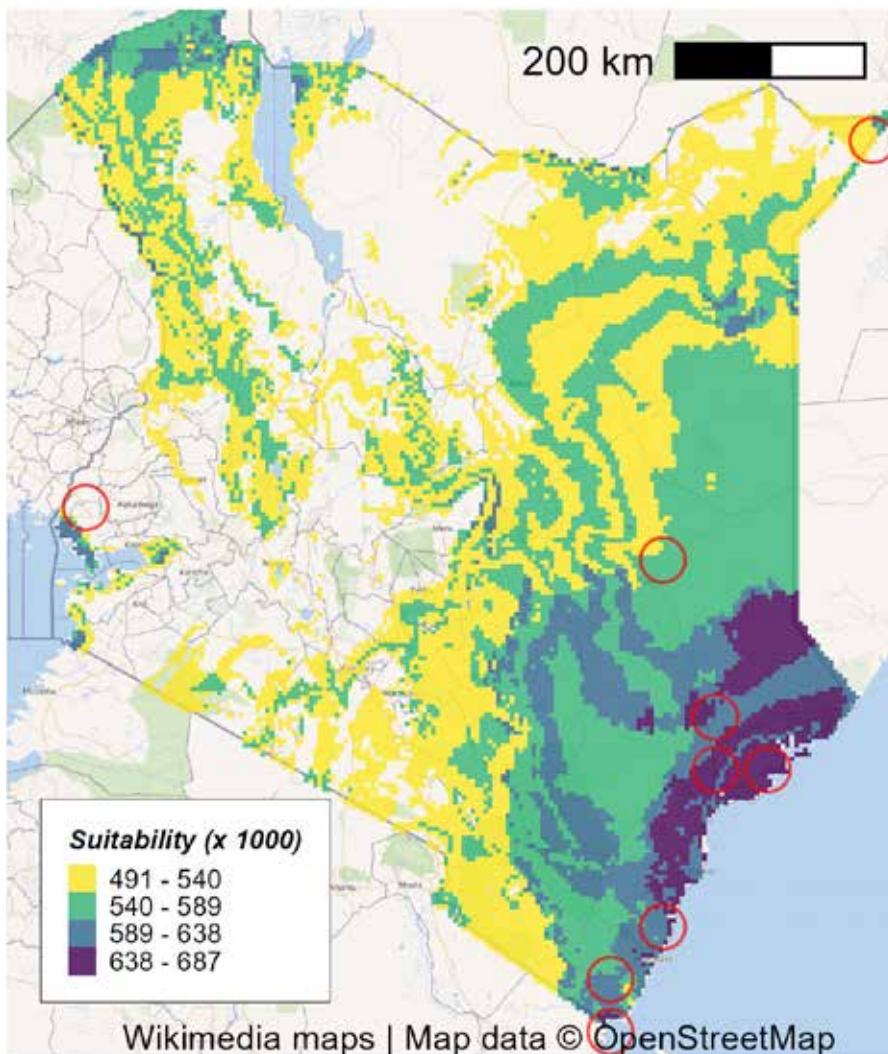
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4. *Borassus aethiopum* Mart.

ARECACEAE (PALMAE)

Common name: African fan palm, Borassus palm

Local names: Ong (Boni); Mvumo/Dzova/Ngolokolo (Digo); Mugumo (Giriama); Marafa (Orma); Mutapa (Pokomo); Mardafa (Somali); Mvumo/Mtapa/Mchapa (Swahili); Edukut (Teso).



Description and ecology: The tallest of the indigenous palms; unbranched; reaching 25 m in height sometimes even higher; very slow growing. **Trunk:** Smooth to rough; grey; thickened above the middle; below crown leaf scars prominent and less prominent further down; young stems are clad with persistent dead leaves. **Leaves:** Fan-shaped; very large; up to 4 x 3 m across; divided into numerous deep segments; edge of the leaf stalk with curved, sharp teeth. Leaves vibrate loudly in the wind. **Flowers:** Green; dioecious; male trees produce very large, pollen-bearing catkins. **Fruit:** Large bunches of drupe; smooth; orange to orange/brown; cupped in the enlarged calyx; round or slightly oval-shaped; about 15 x 12 cm across; the fibrous, edible pulp containing up to 3 seeds; seeds are brown and woody, each up to 8 cm long.

It occurs in the coastal belt, lower Tana and Shimba Hills. Commonly found growing in open grassland with higher water table, along watercourses, flood plains or on coastal coral sands, often singly or many trees, e.g., Gede Ruins, Madunguni (Kilifi), Tana Primate Reserve and Garsen. Also found around Mandera and in western Kenya; altitude: 0–1400 masl.

Uses: Fruit pulp and seeds are edible. The large fruit with fibrous pulp (around 500 g each) that has a strong smell of turpentine, is consumed raw or cooked, preferably with rice. Fresh stem sap is used as yeast or made into vinegar; the sap is also fermented into an excellent palm wine. The immature seeds can be eaten and contain a sweet jelly that has a refreshing taste. Both the immature seeds and germinating seedlings are eaten as a vegetable. In Tanzania, the ripe, fallen fruit are collected, peeled and the juicy pulp is squeezed into water to form a solution which is added to porridge during cooking to improve its flavour by the Nyamwezi and Nyiramba communities. The leaves are used as material for thatch, and in the weaving (mat and basket) industry. The trunk is tough and is termite- and fungus-resistant; it is used as timber, for poles, in construction, and for making beehives and tool handles. Elephants eat the fruit and thus contribute to disbursement of seeds. In Uganda, borassus palms are cut and hollowed out to make beehives.



Borassus aethiopum – bunches of fruit



Borassus aethiopum – palm tree



Borassus aethiopum – ripe and unripe fruit

Nutrient composition

Borassus palm, pulp, raw (<i>Borassus aethiopum</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy¹ kcal (kJ)	63 (266)		
Water (g)	82.7 ± 4.4	79.1-87.6	3
Protein² (g)	0.8		
Fat (g)	0.1 ± 0.0	0.1-0.2	3
Carbohydrate, available³ (g)	13.6		
Fibre, crude (g)	2.0		1
Ash (g)	0.7		1
Calcium (mg)	27		13
Iron (mg)	1.7 ± 0.6	1-2.2	3
Magnesium (mg)	21	20-21	2
Phosphorus (mg)	30	30	1
Thiamine (mg)	0.04		1
Riboflavin (mg)	0.02		1
Niacin (mg)	0.3		1
Folate (mcg)	24		1
Vitamin C (mg)	103 ± 88	4-171	3

SD, standard deviation, calculated when the number of data points (n) ≥ 3;

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Vitamin C values vary greatly in the literature, from 4–171 mg/100 g EP. This can be due to differences in post-harvest handling, storage conditions and maturity stages. Vitamin C is labile to heat and light, thus the fruit is best consumed in its ripe and fresh form. Next to vitamin C, *Borassus aethiopum* contains moderate values of minerals and B-vitamins including thiamine, riboflavin, niacin and folate. Increasing interest exists in the fruit for food processing purposes. *Borassus* fruit is rich in galacturonic acid, a main component of pectin, which in turn is used in the manufacture of jams and in bakeries due to its gelling properties.



Season: Flowers from May to June and young fruit develops from August to September; ripe, mature fruit is ready for harvest from October to December.



Cultivation: It is propagated by seed which are best sown directly on site. Seed can be sown without removing the surrounding pulp. Germination takes one month. Pre-treatment is not necessary. However, removal of the seed coat by excision breaks the long and unpredictable dormancy and results



in a higher germination percentage. Once it sprouts, the seedling cannot be transplanted or planted out due to its very long taproot. The mature seeds can be buried in pits and allowed to germinate. It is best to use fresh seeds. However, seeds dried in shade remains viable for about 2–3 months. There are 2-3 seeds/kg.

It is a slow-growing palm. It takes about 40 years to reach maturity for flowering and rotation periods depend on the site, but can be 60–140 years. Growth of the palms highly depend on site conditions. Little care is required if palms are established on a good site. However, young leaves should be harvested only under very controlled conditions if the palm is to grow properly. For palm wine tapping, the terminal bud of the tree is cut and the dripping sap of the phloem collected in a receptacle. The cut is renewed twice every day for 3–4 weeks until the tree is exhausted and dies. During this period *B. aethiopum* can yield about 200–500 litres of sap. Over-tapping of the tree for its sap (palm wine) has made the tree rare as it is always killed through tapping.



Pests and diseases: There is no information about diseases and pests that affect *Borassus aethiopum*.



Commercial/market value: The seedling shoots are said to be a delicacy. Although it is common within its area of distribution and is a useful palm, its full potential has yet to be recognized in Kenya. However, in West Africa, it is an important oil crop (seeds), as oil is used in the manufacture of margarine, soap and as a lubricant. Palm wine is tapped from the palm in Uganda and West Africa, but not in Kenya.

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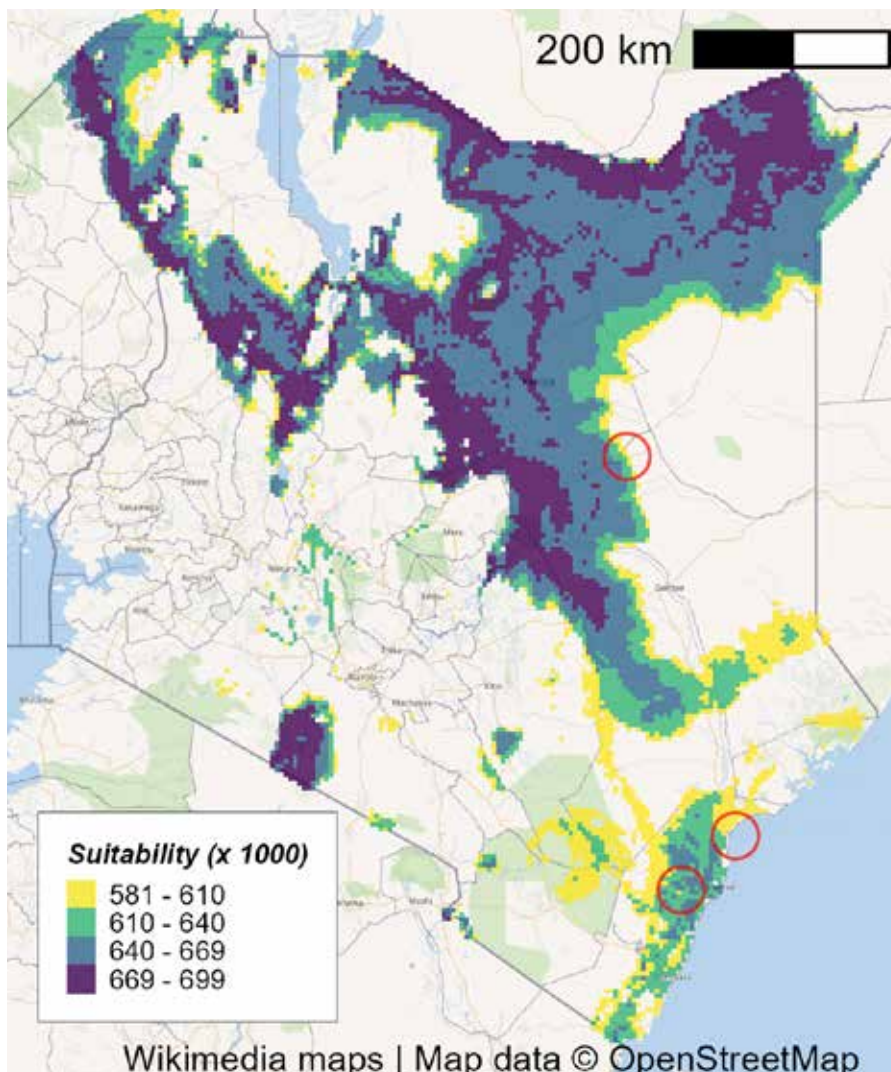
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5. *Canthium glaucum* Hiern

RUBIACEAE

Common name: Canthium

Local names: Mtambachiko (Chonyi); Mfuranje (Giriama); Mtengeji (Swahili).



Description and ecology: A spiny shrub, usually 2–4 m high. **Bark:** Brown to grey. **Leaves:** Elliptic, 2–5 cm long, with very short petioles, borne at nodes or on short shoots below the paired spines. **Flowers:** Few, greenish, in cymes. **Fruit:** Green, turning yellow/brown or yellow/orange when ripe, two-seeded, roundish or square outline, sweet and juicy.

In Kenya, it is found in the coastal bushland, usually in open places with deep sandy soils; common in Marafa and in Arabuko Forest in Kilifi; altitude ranges between 0–150 masl.

Uses: Ripe fruit is juicy and fleshy with a sweet taste; it is a favourite among the Mijikenda people at the coast. Spiny branches are used for fencing.



Canthium glaucum – ripe and unripe fruit



Canthium glaucum – ripe fruit and seeds



Canthium glaucum – shrub

Nutrient composition

No food composition data could be found for this fruit in the literature. Research is necessary to evaluate the nutritional potential of *Canthium glaucum*.



Season: Flowers from March to April. Fruit ripens from June to August in Kilifi and Malindi.



Cultivation: It is a very rare species in its natural habitat. Seeds can be collected from the wild, sown and propagated fresh. Seeds have recalcitrant storage behaviour and cannot be stored.



Pests and diseases: There is no information about the diseases and pests that affect *C. glaucum*.



Commercial/market value: Ripe fruits are directly picked from the plant and eaten raw. Fruit is not sold in local coastal markets. The fruit is mainly collected and eaten by children as a sweet snack.

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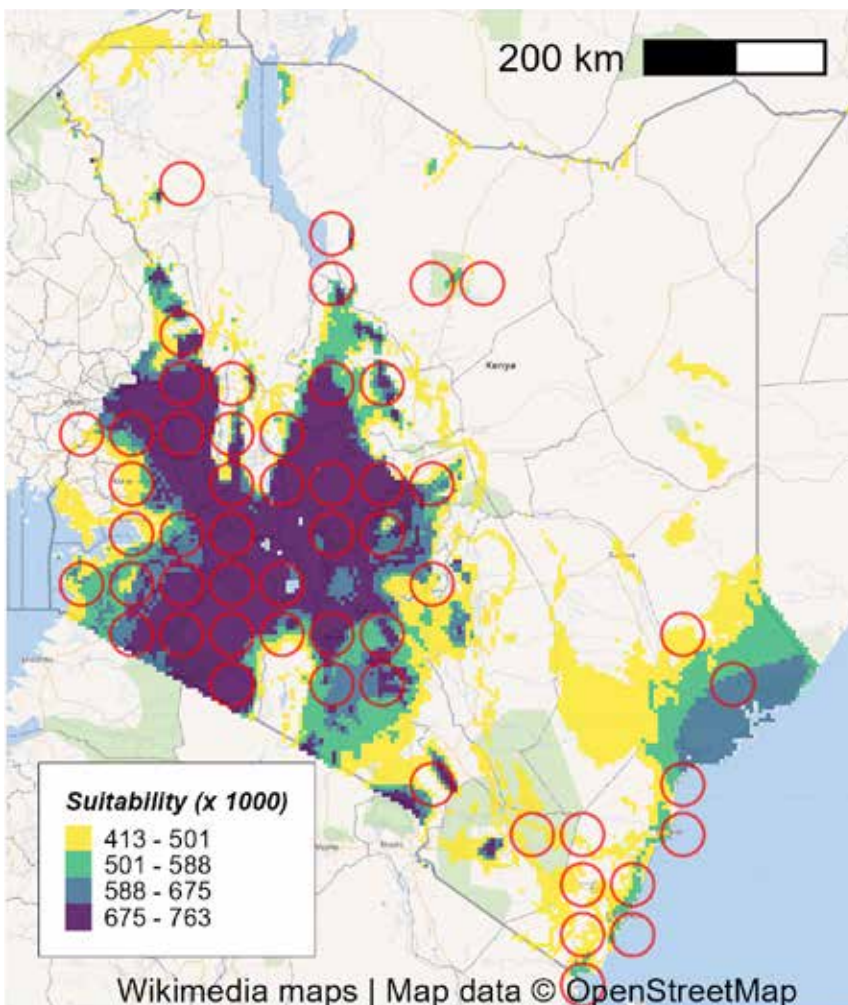
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6. *Carissa spinarum* L.

APOCYNACEAE

Common names: Simple-spined carissa, Carissa

Local name(s): Mulimuli (Boni); Dagams (Borana); Mtambuu (Digo); Mukawa/Nkawa (Embu); Dagams/Dagamsa (Gabra); Mtandamboo (Giriama); Kikawa/Mukawa (Kamba-Machakos/Makueni); Mutote/Ndote (Kamba-Kitui); Mukawa (Kikuyu, Mbeere); Legetetyet/Legetiet (Kipsigis); Omonyangateti (Kisii); Kumurwa/Burwa/Sirwa (Luhya); Ochuoga (Luo); Olamuriaki/Ilamuriak (Maasai); Kamuria (Meru); Legetetuet/Legetetwa (Nandi); Lokotetwo (Pokot); Godhoom boor (Rendille); Lamuriai/Lmuria (Samburu); Adishabel (Somali); Mtandamboo (Swahili); Kirimba (Taita); Legetetik/Legatetwo (Tugen); Ekamura (Turkana).



Description and ecology: A scrambling bush, sometimes found as a spiny, evergreen shrub, grows up to 5 m, occasionally more in height. **Bark:** Grey; smooth; with straight, woody spines up to 5 cm long; often in pairs; rarely branching; milky latex is present. **Leaves:** Opposite; leathery; dark green; shiny; up to 5 cm long; pointed tip; rounded base; very short stalk. **Flowers:** In pink/white, terminal clusters; each flower up to 2 cm across; highly scented. **Fruit:** Red/black berries; about 1 cm across; can be either round or ellipsoid. Seeds black, lance-shaped, 5–6 mm in length, 4 mm in width.

Carissa is a common species in Kenya. Widely found in the coastal bushland, wooded grassland, e.g., Kilifi and Kwale; also commonly found growing in bushland and thickets, especially around rocky hillsides and

dry forest edges in Kitui, Machakos, Makueni, Embu, Samburu; at altitudes from sea level to 2000 masl. The plant tolerates dry and most soil conditions.

Uses: The ripe purple/black berries are sweet, pleasant to eat and are popular among both children and adults. Unripe green to purple berries are edible but taste acidic. Vinegar can be made from them by fermentation. In Kenya and Sudan, they are made into a jam and used as flavouring for soups and stews. In Ghana, they are usually added to the food as an appetizer. It also grows as an attractive and impenetrable hedge and as live fencing. The plant is good fodder for goats and camels, and for bee forage. The species is a source of excellent fuelwood. Silk-moth cocoons are occasionally found on the plant.



Carissa spinarum – shrub



Carissa spinarum – branch with leaves, flowers and buds



Carissa spinarum – ripe bunch of fruit

Nutrient composition

Carissa fruit, raw (<i>Carissa spinarum</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean (min-max)	n
Energy ¹ kcal (kJ)	72 (306)	
Water (g)	81.1	1
Protein ² (g)	2.1	
Fat (g)	1.3	1
Carbohydrate, total ³ (g)	13.1	
Ash (g)	2.5	1
Calcium (mg)	29	1
Iron (mg)	3.5	1
Phosphorus (mg)	32	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates total, calculated by difference: 100 - (water + protein + fat + ash + alcohol)

There is hardly any data on the nutrient composition of *Carissa spinarum*. According to the data found in the literature, the fruit is a source of iron and contains slightly higher protein and fat values compared to other fruits.



Season: Generally, flowering takes place during April and May. The small fruit takes a lot of time to develop and mature. They start ripening from November and continue to do so until the end of January.



Cultivation: *Carissa spinarum* can be propagated from seed, which should germinate within 2 weeks. The species can also be easily propagated vegetatively, through cuttings, air layering, ground layering and shield budding. Seeds have recalcitrant storage behaviour and cannot be stored. Use fresh seeds for best results. There are approximately 28,000 to 30,000 seeds/kg.



C. spinarum is slow growing but responds well to pruning. It is one of a number of thorny species that is planted to form dense hedges. It is used mainly for boundaries on household plots and for cattle enclosures on farms, and is very common throughout Eastern Africa.



Pests and diseases: Fungal pathogens and diseases such as root rot and leaf spots are common, but detailed information is lacking.



Commercial/market value: Fruit is edible, but only when fully ripe; they have a sweet flavour, but the milky sap of this plant and its unripe fruit is poisonous. Surveys of farmers indicate that food (fruit for local use and sale) and medicinal uses are important in the region.

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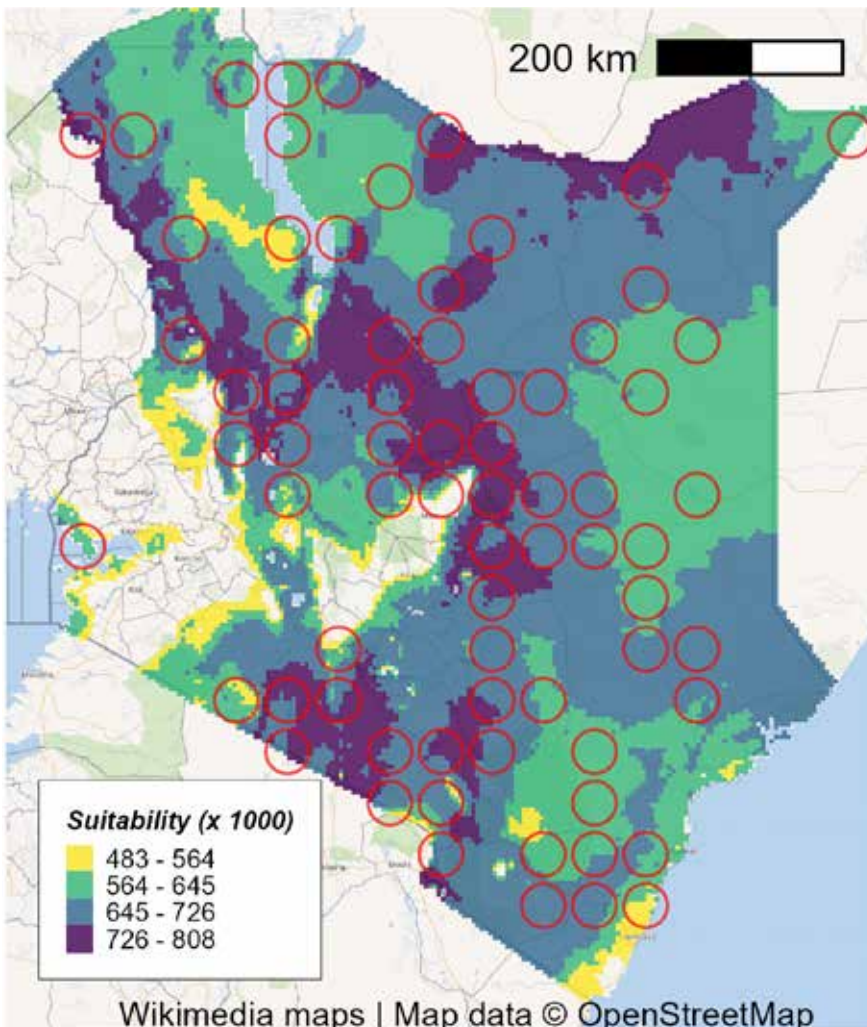
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7. *Cordia sinensis* Lam.

BORAGINACEAE

Common names: Grey-leaved cordia; Grey-leaved saucer berry

Local names: Harores/Mader-boor/Madee'r (Borana); Mad'eera (Gabra); Mderia/Mkayukayu (Giriama); Salapani (Ilchamus); Kithea/Muthei-munini/Kithia (Kamba); Nokirwet (Kipsigis); Ol-durgo/Ol-dorko/Ol-olgot (Maasai); Mader (Orma); Muhale/Muhali/Mtale (Pokomo), Adomeyon/Adomeon/Adome (Pokot); Gaer/Gayer (Rendille); Dorgo/Igueita/Igweita-orok (Samburu); Mareer/Marer (Somali); Mkamasi/Mnya mate (Swahili); Adumewa/Edoma/Adomewa (Tugen); Edome (Turkana).



Description and ecology: A low, leafy, multi-stemmed shrub or bush, or rarely a small tree up to 6–12 m high, often with drooping branches. **Bark:** Smooth, grey/white when young, later finely longitudinally fissured, yellow/brown to black, roughly grooved. **Leaves:** Variable, smooth or slightly rough; long; narrow; up to 80 mm long; grey/green; rounded or notched tip; on a stalk about 1 cm long; more or less opposite. **Flowers:** Tubular; small; cream, turning brown when old; in terminal clusters, on branched hairy stalks; fragrant. **Fruit:** Fleshy drupe;

egg-shaped; up to 2 cm; conspicuously pointed tip; held in a calyx cup; orange/red; with sticky, edible pulp; viscid pulp overlying 1–4 large seeds. Seeds are hard, rough and yellow/cream.

It is widespread in drier areas of Kenya including dry, riverine vegetation, in open, dry bushland, bushed or scattered tree grassland; at an altitude from sea level to 1800 masl. It mainly grows in alluvial, sandy, red loam and rocky soils.



Cordia sinensis – shrub



Cordia sinensis – a bunch of ripe fruit



Cordia sinensis – unripe fruit



Cordia sinensis – leaves

Uses: The sweet, mucilaginous pulp of the ripe fruit may be eaten fresh, while cover and seeds are discarded. The sweet pulp is often added to porridge instead of sugar. Alternatively, fruits are gathered, pounded to a sticky mass, sun-dried and stored in a wooden container known as *eburr* by the Turkana people. The fruit pulp is sometimes used to make juice or brew local beer, and at times mixed with tamarind (*Tamarindus indica*) juice and fermented. The Turkana community prepares fresh juice from it.

A clear gum produced by the tree is edible. Stems are widely used as poles in *boma* or hut construction. The wood is used for making carvings, beehives, tool handles and walking sticks, and for fuelwood and charcoal. Leaves serve as fodder for livestock. Fruits are eaten by monkeys, baboons and birds; they are the main dispersal agents.

Genus *Cordia* consists of several species including well-known *Cordia monoica* Roxb. (Common name: Sandpaper tree; Swahili: *Msasa*; Maasai: *Oseki/Eseki/Isek/Ilsek*). It is widely distributed in Kenya and occurs in many habitats, from *Acacia–Euphorbia* bush or wet or riverine forest to woodland or bushed grassland, on rocks or along dry rivers, usually with *Salvadora persica* vegetation; also found growing in arid and semi-arid areas on termite mounds and in littoral scrub in dry thickets. Grows at altitudes of 0–2200 masl. Fruits of *C. monoica* are yellow or orange, oval, up to 2 cm across, with sweet and sticky, tasty pulp surrounding a hard seed. The pulp of the fruit is eaten fresh and often used in porridge as a substitute for sugar.



Cordia monoica – leaves and ripe fruit



Cordia monoica – leafy branch

Nutrient composition

Grey-leaved saucer berry, pulp, raw (<i>Cordia sinensis</i>)			
100 g edible portion on fresh weight basis (EP)			
Component	Mean	min-max	n
Energy ¹ kcal (kJ)	100 (423)		
Water (g)	72.0	71.0-73.0	2
Protein ² (g)	3.9		
Fat (g)	0.5		1
Carbohydrate, available ³ (g)	18.2		
Fibre, total dietary (g)	3.5	3.1-3.9	2
Ash (g)	2	1-2	2

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Data on the nutrient composition of the fruit are scarce and does not support an evaluation of its micronutrient characteristics.



Season: *Cordia sinensis* flowers in April–May in Turkana; fruits in March (Kilifi), May–June (Kajiado, Kitui), or August–September (Garissa, Samburu, Turkana, Kajiado). *C. monoica* flowers in March–April and October and fruits in July–August and December.



Cultivation: Both described *Cordia* species can be propagated by seedlings. Seeds are best sown directly on site. No treatment is necessary for fresh seeds. Collect the fruit when they turn bright orange for maximum viability. The fresh fruit should be de-pulped immediately after collection by rubbing it over a wire mesh under running water. Seeds cannot be stored (recalcitrant). Fresh seeds germinate up to 70–80% after 30 days.



These species are fairly fast-growing and tolerate lopping, pollarding and coppicing. There are 14,000 to 18,000 seeds/kg for *C. sinensis* and 6500 seeds/kg for *C. monoica*.

Pests and diseases: Trees of both species are prone to attack by mosaic viruses, caterpillars and weevils, but detailed information is lacking.



Commercial/market value: A very useful tree for dry areas; the sweet ripe fruit is very common locally and is eaten raw as a snack, especially by children while herding grazing animals. Fruits of *C. sinensis* are sold in Lodwar's local market in Turkana and are consumed in homes. Fruits of *C. monoica* are not sold in any local markets.

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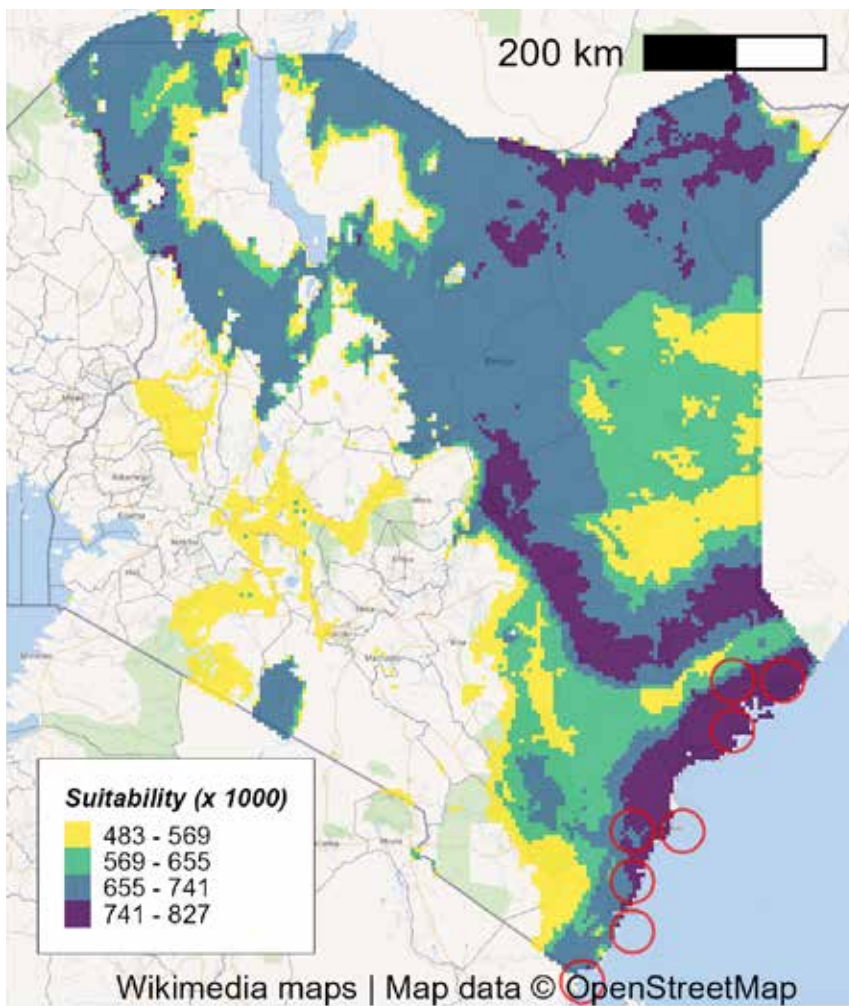
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8. *Dialium orientale* Baker f.

FABACEAE (LEGUMINOSAE)

Common name: Dialium, Velvet tamarind

Local names: Sheshubla/Shishshobli (Boni); Mtumbwi/Mutumbwi (Giriama); Frim (Somali); Mpepeta (Swahili).



Description and ecology: A spreading, often multi-stemmed shrub or small tree, usually up to 5 m tall, but can sometimes reach 15 m. Branches droop, occasionally touching the ground. **Bark:** Smooth, pale grey. **Leaves:** Compound, odd-pinnate with 7–9 small leaflets, oval, base wide to rounded, 1.5–5 cm long, midrib hairy, tips rounded to obtuse, on a stalk up to 5 cm long. **Flowers:** Small, green/cream/yellow, in large, dense heads up to 30 cm x 20 cm. **Fruit:** Red/brown, more or less round, up to 1.8 cm

long, with a thin, dry, brittle shell enclosing a dry red/brown pulp. Seeds: 1-2, grey/brown, smooth, shiny and enclosed in a thin, soft membrane.

In Kenya, it is found only in the coastal areas (Kilifi, Tana River and Lamu), in dry coastal forests, in *Brachystegia*, *Azelia*, *Manilkara* woodland and in coastal riverine vegetation. It grows at an altitude of 0–100 masl, and is mainly found growing in sandy or in alluvial soils.



Dialium orientale – unripe fruit hanging on the tree



Dialium orientale – tree



Dialium orientale – ripe and unripe fruit



Dialium orientale – dry ripe fruit, sold with (below) or without shell (top right), partly also sweetened and coloured (top left)

Uses: Fruit is eaten raw and has a sweet, acidic taste. The outer dry shell can easily be removed, reddish-brown pulp sucked, and seed discarded. The fruit is mainly eaten as a snack after adding sugar syrup and colouring in Kenya's coastal towns. Fruit pulp is used to flavour porridge or as a substitute for *Tamarind* in

cooking. It may also be made into an energy drink, especially in the hot coastal climate of Tanzania and Kenya. The wood is used for boatbuilding (dhows), building poles, fuelwood, in charcoal production and to make tool handles and utensils (grain mortars).

Nutrient composition

Fruit, raw (<i>Dialium</i> sp.) 100 g edible portion on fresh weight basis (EP)		
Component	Mean	n
Energy ¹ kcal (kJ)	254 (1080)	
Water (g)	34.8	1
Protein ² (g)	2.9	1
Fat (g)	0.9	1
Carbohydrate, available ³ (g)	57.0	
Fibre, crude (g)	3.2	1
Ash (g)	1.2	1
Calcium (mg)	156	1
Iron (mg)	4.2	1
Potassium (mg)	690	1
Phosphorus (mg)	46	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Information on the nutrient composition of *Dialium orientale* was scarce in the literature. Hence, the table presents information at genus level – *Dialium* sp. – including data from *Dialium guineense*. The fruit shows low water and fat values, while protein is comparatively high. In addition, minerals such as calcium and potassium are well represented. More data on food composition is required to assess the nutritional potential at species level.



Season: Flowers from August to September. Fruits from November to December.



Cultivation: Propagated by seeds sown directly on site. Seed storage behaviour is orthodox; viability can be maintained for 2 years at normal room temperature. Dry, peeled fruit may be stored for over 2–3 years. It is a locally threatened species in its natural habitat in the coastal areas of Kenya.



Pests and diseases: There is no information about diseases and pests that affect *D. orientale*.



Commercial/market value: Fruit is sold in local markets in Malindi, Mombasa, Kilifi and Lamu as a snack coated with sugar and colouring. Dry fruits are also packed and sold in the markets without sugar and colouring, and used for flavouring, souring porridge and making juice and chutneys.

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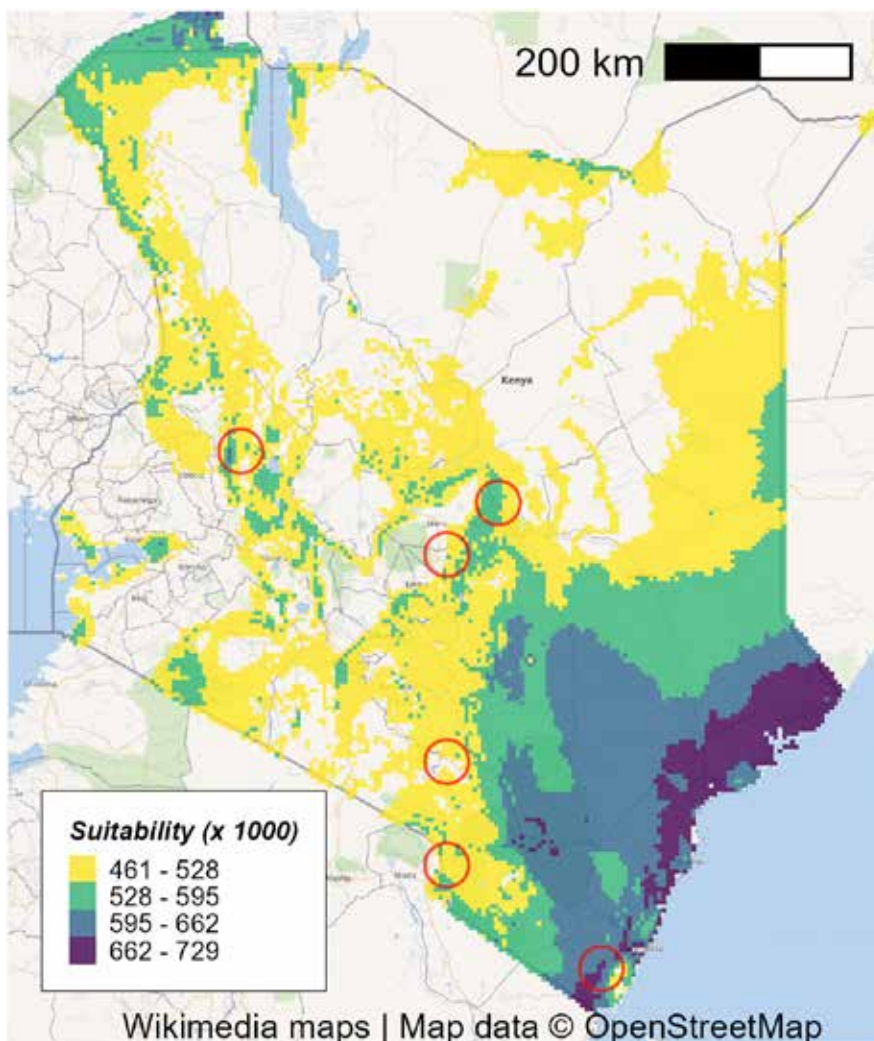
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9. *Diospyros mespiliformis* Hochst. ex A.DC.

EBENACEAE

Common name: African ebony

Local names: Mbara/Mkulu (Digo); Mkulwe/Mkuluye (Giriama); Chumo/Chumu (Luo); Mukoro (Mbeere); Muroko (Meru); Kolati-gurati (Orma); Korati/Kolati (Somali); Msindi/Mgombe/Mgiriti/Mpweke (Swahili); Mugongolo (Taveta); Ekum (Teso); Egum/Egumoit (Turkana).



Description and ecology: An evergreen, medium-sized to large tree that can grow up to 25 m or more; with a tall, clear bole from a buttressed base to a dense, usually narrow, rounded crown with drooping, smaller branches. **Bark:** Grey/black, rough and squared, grooved and longitudinally fissured or scaly. **Leaves:** Shiny, dark green, entire, alternate, up to 14 x 3 cm, elliptic to oblong, midrib prominent below, edge wavy, with pointed tip. **Flowers:** Bell-shaped, creamy-white, dioecious, sweet-scented. Male flowers in clusters, female flowers solitary. **Fruit:** Rounded, to 2.5 cm in diameter, in a calyx cup, the 5 segments curling back; smooth with tough, glossy skin; green, turning to yellow, purple when ripe; pulp soft and sweet. Fruit contains 4–6 seeds, dark brown, bean-shaped, shiny and glabrous.

In Kenya, the species is more common around Kibwezi in Makueni County, Meru, Kwale and in Taita-Taveta County, where it is found near watercourses and rivers in dry bushland, on termite mounds, on lava flows in semi-evergreen thickets and along rocky hillsides especially in gullies; grows at 0–1500 masl.



Diospyros mespiliformis – ripe fruit



Diospyros mespiliformis – tree

Uses: Ripe fruit is sweet and eaten raw, mainly by the Digo, Turkana, Taita, Embu and Mbeere. Fruits are collected from the ground, washed and eaten fresh. The pulp has a lemony taste, with a chalky consistency. Seeds may be eaten or discarded. Fruit is collected in bulk and a kind of fermented porridge made from them; this is usually eaten in times of famine by the Mbeere community in Kenya. Fruit can be dried and ground into flour; it is often used for brewing beer. In Tanzania ripe fruit can be dried in the sun and stored for several weeks. *Diospyros* produce the valuable black heartwood 'ebony', which is an excellent source of timber. The wood is hard, heavy, with a fine grain, very durable, even in damp conditions and termite-resistant. It is used for making carvings and furniture, construction and walking sticks; also used as fuelwood and in charcoal-making. The tree is suitable for bee forage, medicine (bark, roots, fruit) and as an ornamental. It is ideal for large gardens and makes an excellent shade tree.

Nutrient composition

African ebony, fruit, raw (<i>Diospyros mespiliformis</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean	min-max	n
Energy ¹ kcal (kJ)	130 (550)		
Water (g)	66.6	64.2-69.0	2
Protein ² (g)	1.1		
Fat (g)	0.8	0.4-1.1	2
Carbohydrate, available ³ (g)	29.1		
Fibre, crude (g)	1.2		1
Ash (g)	1.3		1
Calcium (mg)	80	64-96	2
Iron (mg)	1.5	1.0-1.9	2
Potassium (mg)	417		1
Magnesium (mg)	23		1
Phosphorus (mg)	37	28-46	2
Copper (mg)	0.11		1
Zinc (mg)	0.21		1
Thiamine (mg)	0.01		1
Riboflavin (mg)	0.04		1
Niacin (mg)	0.2		1
Vitamin C (mg)	19	13-25	2

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Diospyros mespiliformis is a good source of minerals, overall calcium and potassium. The fruit is a good source of vitamin C; the vitamins thiamine and riboflavin are available in small amounts.



Season: Flowers November to December. Ripe fruit is available from March to June.



Cultivation: Propagation from seeds (seedlings), coppice and root suckers. Because of competition by birds, seeds should be collected immediately after the fruit turns yellow. De-pulp and clean under water. Dry in the sun if seed is to be stored. Seed storage behaviour is orthodox. Viability can be maintained for one season in open storage, but can be maintained for several years in hermetic storage at 3 °C with 5–6% MC. On

average there are 2400–3200 seeds/kg. Under ideal conditions seeds germinate within 50 days.

D. mespiliformis prefers moist areas and grows well in red loam soil. It is fairly slow growing and requires plenty of water to speed up the growth rate. Prune off unnecessary shoots to encourage an upright growth form. Slashing and weeding should be practised until the trees are well established. Protection from fire helps improve crop stocking in natural forests, and trees should be sheltered in cold areas. The tree can be coppiced.



Pests and diseases: Fruit is eaten by numerous animals, especially birds, before they are fully ripe. Seeds are commonly attacked by boring insects and should be protected when stored.



Commercial/market value: Fruit is not sold in any local market in Kenya. The fruit has potential to improve nutrition, boost food security, foster rural development and support sustainable land care.

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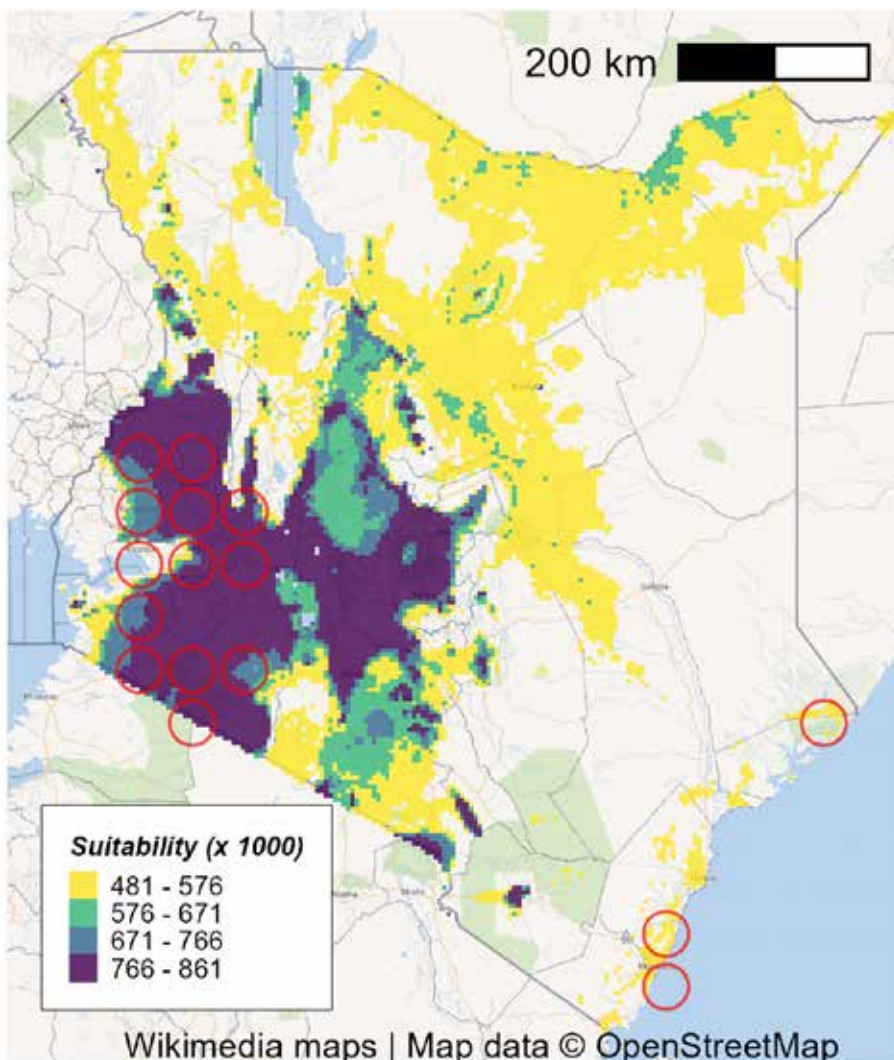
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10. *Dovyalis macrocalyx* (Oliv.) Warb.

SALICACEAE

Common name: Dovyalis

Local names: Munyahee/Munyee (Giriama); Kumusongolomunwa/Busongolomunwa (Luhya); Olaimurunyai/Enkoshopini (Maasai); Kaptowinet (Nandi); Chuchwenion/Chuchween (Pokot).



Description and ecology: A dioecious forest shrub or small tree that grows up to 3–8 m in height, often in dense shade. It is multi-stemmed with drooping, slender branches arching over. **Bark:** Smooth, grey. **Branches:** Grey/brown, often dotted with breathing pores (lenticels), bearing straight, axillary, slender spines, 1–6 cm long beside leaves but sometimes absent. **Leaves:** Simple, oval, entire, 4–9 cm long, pale green, thin, pointed apex and base broadly rounded to a short stalk (only 3 mm). **Flowers:** Yellow/green; small flowers with no petals. Male flowers are hairy, in clusters, 1–4, beside leaves, with about 20 stamens. Female flowers are

short stalked, solitary, beside leaves, 6–10 thin lobes of the calyx, sticky, densely covered with hairs. **Fruit:** Bright red, fleshy, plum-shaped berries, 2–2.5 cm long, oval-shaped, with a persistent beautiful green/yellow hairy calyx, hanging on a stalk up to 0.8 cm; fruit contains a single seed.

In Kenya, it is found from the coast to western region. It is very common around Nairobi, along the Maasai River, in Uasin Gishu, Bungoma, West Pokot and Kisumu in forests, forest edges or riverine areas; at altitudes from sea level to 2600 masl. It is mainly found growing in well-drained, deep red soils.



Dovyalis macrocalyx – shrub



Dovyalis macrocalyx – ripe fruit



Dovyalis macrocalyx – leaves and unripe fruit

Uses: The ripe, bright-red fruit has a sweet and sour taste. Fruits are collected from the wild and eaten as a snack, especially by children. This shrubby species makes a good live fence, its flower attracts bees and has ornamental value. The wood is hard and is used as fuelwood, for building poles and as tool handles.

Dovyalis abyssinica (A. Rich.) Warb. is another related species that belongs to the Salicaceae family. It is a small, spiny evergreen shrub or tree, often growing up to 5 m but occasionally reaching a height of 9 m; with a rounded crown. In Kenya this shrubby tree is found in Embu, Nyambene Hills, Taita Hills, the Central Highlands, Loita Hills and highlands of the

Rift Valley; in upland moist or dry forest edges, along riverbanks and in evergreen bushland. Sometimes it is found as a remnant tree or shrub in coffee plantations; it grows on red soils. It occurs at altitudes of 1450–2500 masl. The fruit is light green turning yellow/orange on ripening, up to 2 cm in diameter. Ripe fruit is edible but very acidic. The thin fruit cover can be peeled off and the fruit (together with seeds) eaten. The fruit pulp of *D. abyssinica* can be used for making jelly, juice, salad dressing, dipping sauce, hot sauce, BBQ sauce, pickles, chutney, soup, wine and brandy. The fruit is also excellent for flavouring porridge (souring porridge).



Dovyalis abyssinica – tree



Dovyalis abyssinica - leafy branches



Dovyalis abyssinica - ripe fruit



Dovyalis abyssinica - unripe fruit and leaves

Nutrient composition

No food composition data could be found for this fruit in the literature. Research is needed to fully evaluate the nutritional potential of *Dovyalis macrocalyx*.



Season: *D. macrocalyx* flowers in January to March and fruits in April to June in Bungoma. In Nairobi, it flowers in August to September and fruits in November to December. *D. abyssinica* flowers from November to January. Ripe fruits are collected from April to June.



Cultivation: Propagation of *Dovyalis* species is by seeds. Sow fresh seeds for best germination results. After collection, the fruits are soaked in water for 2–3 days. The water is then drained off and the fruit squeezed by hand to separate seeds from the pulp. After washing with water, the seeds can be dried and stored for a very short time. For *D. abyssinica* viability of seeds is maintained for over 2 years in hermetic air-dry storage at 5 °C. Seeds are sown in a seedbed or in flat seedling trays and covered with a layer

of fine sand and kept moist. Under ideal conditions, germination occurs within 18–20 days. There are about 27,000 to 47,000 seeds/kg. *D. abyssinica* can also be propagated from hardwood cuttings but cut tips should be treated with root-stimulating hormones before planting out into river sand. Seedlings transplant well. *D. macrocalyx* may not produce fruit every year and is a fairly fast-growing species once established.

If both species are grown as live fences, trees should be trimmed regularly to form a dense hedge. Lopping, coppicing, trimming and pruning are recommended management strategies.



Pests and diseases: Birds are the main pests and enjoy eating the ripe fruit but are not a major problem. No diseases have been observed on fruiting trees. The fruit is susceptible to fruit fly infestation.



Commercial/market value: This species has considerable potential and has received little attention to date. The fruits of *Dovyalis* are not sold in any

markets in Kenya. Both *Dovyalis* species are locally common and easily accessible within their areas of distribution. The fruit is said to have great potential for the development of value-added products. As fresh fruit, those who prefer a unique sour taste enjoy it.

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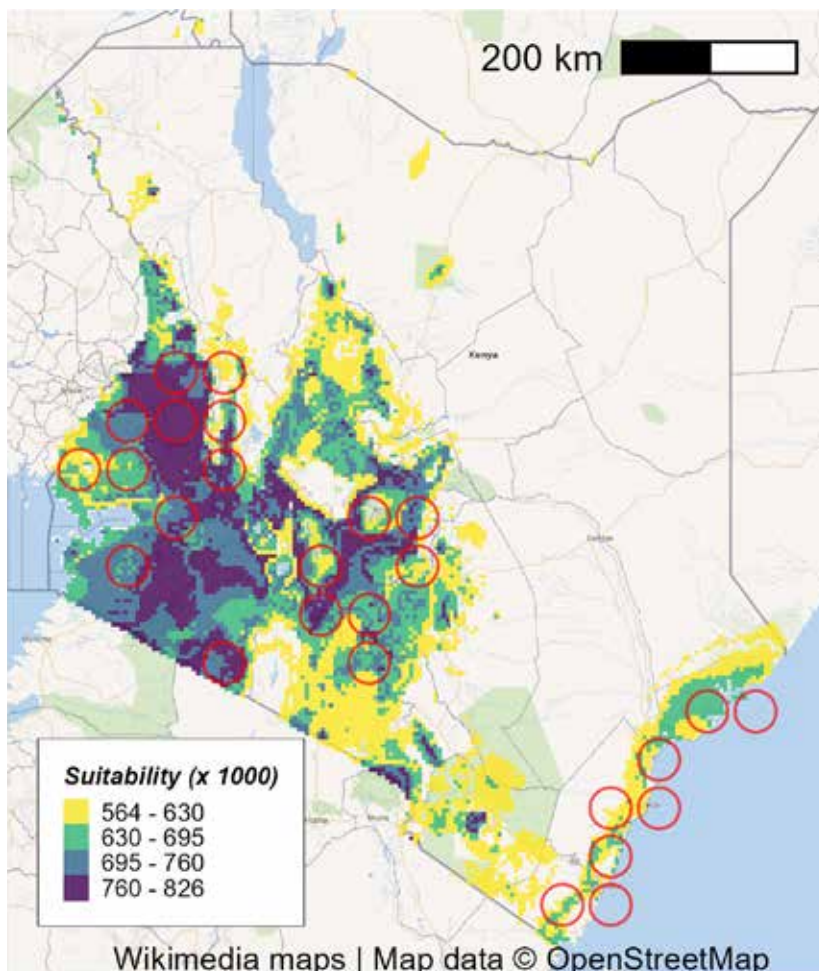
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11. *Flacourtia indica* (Burm.f.) Merr.

SALICACEAE

Common name: Governor's plum, Indian plum, Madagascar plum

Local names: Mnyondoiya (Digo); Mdungatundu/Mdevere/Mugereaka (Giriama); Kiathani, Kikathani (Kamba); Muroro, Mutuhacu (Kikuyu); Tunguroloet (Kipsigis); Kumunyungululwe/Bunyunggululwe (Luhya); Ol-loiroroi/Oldonggurgurwo/Oltangururua (Maasai); Mudundi/Muraga (Mbeere); Muraga/Muuga ruturu/Muroo (Meru); Tungururiet/Lichet (Nandi); Tingoswo/Tingas (Pokot); Loloroi (Samburu); Mkingili/Mkingiri/Mchongoma/Mgovigovi (Swahili); Tingoswo, Tungururwo, Talatany (Tugen), Echoge (Turkana).



Description and ecology: A dioecious, deciduous, much-branched, spiny shrub or small tree; usually 3–5 m, sometimes reaching up to 10 m height; with a narrow or spreading crown. Spines on the trunk are usually straight, sometimes branched, up to 12 cm long but quite variable. **Bark:** Grey or pale yellow, smooth or rough, scaling; branches may have yellow powder when young. Branches may or may not be spiny. **Leaves:** Glossy, usually oval-shaped, toothed or serrated margin, variable in size, up to 12 cm; veins clear on both upper and lower surfaces, petiole up to 2 cm long. **Flowers:** Yellow/green or cream, small, fragrant, male flowers with mass of yellow stamens and female flowers with spreading divided style. **Fruit:** Round, green, turning red/purple to black, soft and juicy on ripening but acidic taste, to

2.5 cm across, remaining on the tree, contains up to 10 small seeds that are hard and flat.

This species is widespread in Kenya from the coast to the highlands, e.g., Karura, Thika, Machakos, Embu, Chepareria (West Pokot), Baringo, Nandi, Bungoma, Elgeyo, Malindi, Kilifi, Kwale and Gede. Although it is widely distributed in the country, it may be locally rare. It grows wild in bushland on rocky hillsides, woodland, riparian forest; sometimes cultivated for its edible fruit. It can be grown in a variety of climates and soils – mainly on red clay, sandy and rocky soil – and prefers a high water table and full sun. The species is drought-resistant but somewhat frost tender; altitude ranges from 0–2400 masl.



Flacourtia indica – tree



Flacourtia indica – leaves and unripe fruit



Flacourtia indica – ripe fruit



Flacourtia indica – flowers turning into young fruit

Uses: Ripe, soft, sweet-sour fruit is eaten raw in Kenya, Tanzania and Uganda. In South Africa, fruit is eaten fresh as well as used in making sweet jam. Seeds are usually discarded. Fruit can be fermented to alcoholic wine and beer in South Africa or stewed in sugar as a dessert. Fruit can be sun-dried, stored and soaked in water before being eaten. Wood is used as

fuelwood, for making charcoal, as small timber, poles, tool handles, utensils and farm implements. Tree is used for fodder (leaves for goats), live fences and windbreaks, medicine (roots, bark) and bee forage. Fruit is also eaten by birds that disperse the seed. The bark is used for tanning animal skins.

Nutrient composition

Indian plum, pulp, raw (<i>Flacourtia indica</i>)			
100 g edible portion on fresh weight basis (EP)			
Component	Mean	min-max	n
Energy ¹ kcal (kJ)	93 (395)		
Water (g)	76.3	71.8-80.8	2
Protein ² (g)	0.9		
Fat (g)	0.8	0.7-1.0	2
Carbohydrate, available ³ (g)	20.1		

Indian plum, pulp, raw (<i>Flacourtia indica</i>)			
100 g edible portion on fresh weight basis (EP)			
Component	Mean	min-max	n
Fibre, crude (g)	1.1		1
Ash (g)	0.9	0.6-1.1	2
Calcium (mg)	28	7-48	2
Iron (mg)	1.2		1
Potassium (mg)	327	188-466	2
Magnesium (mg)	27	26-27	2
Phosphorus (mg)	18	16-20	2
Copper (mg)	0.36		1
Zinc (mg)	0.40		1
Thiamine (mg)	0.03		1
Riboflavin (mg)	0.06		1
Niacin (mg)	0.2		1
Vitamin C (mg)	5		1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

The fruit pulp of *Flacourtia indica* is rich in minerals. Vitamins of the B-complex, such as thiamine, riboflavin and niacin are represented in moderate values, while vitamin C is low. As with many indigenous fruits, the Indian plum has a high antioxidant capacity, particularly in the peel of the fruit.



in existing stands; they can spread to new localities even though they are readily browsed. Germination is slow and usually completed in 9 weeks. Pierce, nick or crack the hard seed coat for improved germination. Seed storage behaviour is orthodox; viability can be maintained for over 1 year in air-dry hermetic storage at 5°C. There are about 200 000 seeds/kg.



Season: Flowers November to December. Fruits February to April in Embu, Machakos, Nairobi, Kilifi, Malindi, in October in Elgeyo and in December in Nandi and Bungoma.



Cultivation: Propagation is by seedlings. The natural reproduction of the species is satisfactory, and seeds are widely dispersed by birds. Young seedlings and saplings are drought-resistant and can maintain their proportion

F. indica is a slow-growing tree. Trees can be managed by coppicing, pollarding, trimming and pruning. Seedlings need weeding around them until they are well developed. When closely planted, it forms a closed impenetrable barrier that serves as a hedge; it tolerates frequent trimming.



Pests and diseases: Beetles and larvae of some insects are known to defoliate the tree, feed on the sap or damage dead wood. However, detailed information on the species' pests and diseases is lacking.



Commercial/market value: In Kenya, the fruit is not sold in local markets as it is in Tanzania. Fruits have high potential for processing into jams and jellies. This fruit tree deserves to be more widely cultivated as a homestead fruit and is a promising tree suitable for agroforestry.

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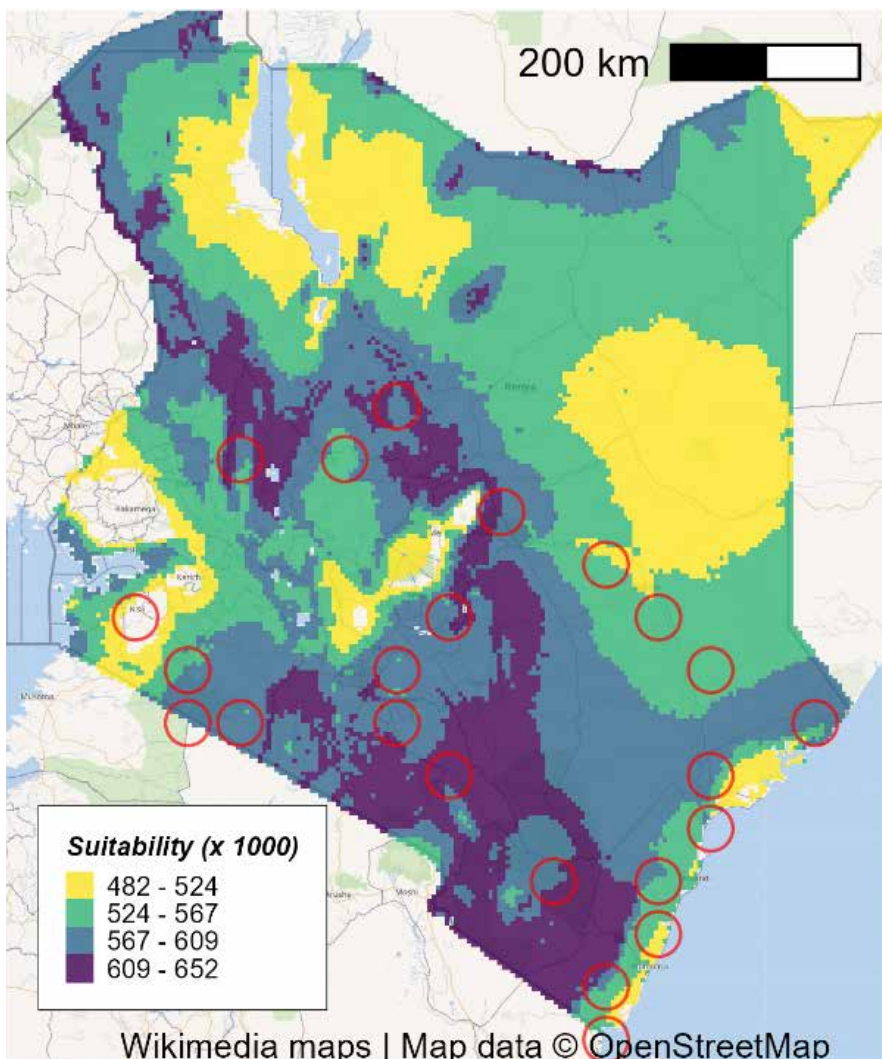
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12. *Garcinia livingstonei* T. Anderson

CLUSIACEAE (GUTTIFERAE)

Common name: Garcinia, African mangosteen

Local names: Mangales/Unglise (Boni); Kisambwe/Mfunga-tanza (Digo); Mufodzohi (Giriama); Mukanga/Kikaanga kanywa/Ngaanga kanywa (Kamba); Eshimwani (Luhya); Olkifulwa/Enongeperen (Maasai); Nerkwo (Marakwet); Muchochozi (Pokomo); Merwo (Pokot); Lkasiyoi/Lyoret (Samburu); Daresa (Somali); Mpekechu/Mpeketo/Mtotozi (Swahili); Mnganga/Munyanga (Taita); Atenum/Ekwalakwala (Teso); Muthuthuura (Tharaka).



Description and ecology: A distinctive evergreen shrub or a small, narrow-crowned tree, 2–10 m high with a short bole. In large trees the branches are characteristically arching. Branches often in threes. **Bark:** Dark grey/black, ridged, exudes oily yellow to red latex when injured. **Leaves:** Shiny, leathery, in opposite pairs or usually in threes, 4–14 cm long, edges usually wavy. **Flowers:** Cream/pale green, in small clusters, sweet-scented, small, green buds sticky with resin. **Fruit:** Oval or round, green at first, turning yellow to orange on ripening, 2.5 cm in diameter, with a single, large seed.

This species is widely distributed in Kenya, especially along the major rivers, forests and thickets but is also found on rocky outcrops, away from water. Altitude ranges from 0–1900 masl.

Uses: Juicy, ripe, fleshy fruit is edible with a pleasant, sweet, acidic taste. Fruit is eaten raw or cooked with porridge. In Eastern Africa the fruit is used to make an alcoholic drink. In Southern Africa, fruits are eaten raw and are used for brewing beer. The wood is used as a fuelwood, for making charcoal, as small timber, poles, tool handles, utensils (three-branched twigs for stirrers, and wooden spoons) and roots are used in traditional medicine. The tree is used as a fodder, to help soil conservation and to make a dye, a yellow oily sap used to decorate arrows as well as in the manufacture of arrow poison. It is also used as a shade tree and grown as an ornamental.



Garcinia livingstonei – tree



Garcinia livingstonei – flowers turning into young fruit



Garcinia livingstonei - ripe fruit



Garcinia livingstonei – leaves, ripe and unripe fruit

Nutrient composition

African mangosteen (<i>Garcinia livingstonei</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy¹ kcal (kJ)	63 (267)	
Water (g)	83.9	1
Protein² (g)	0.8	
Fat (g)	0.3	1
Carbohydrate, available³ (g)	13.9	
Fibre, crude (g)	0.7	1
Ash (g)	0.4	1
Calcium (mg)	5	1
Iron (mg)	0.3	1
Potassium (mg)	134	1
Magnesium (mg)	12	1
Phosphorus (mg)	20	1
Copper (mg)	0.07	1
Zinc (mg)	0.19	1
Riboflavin (mg)	0.05	1
Niacin (mg)	0.4	1
Vitamin C (mg)	5	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

African mangosteen is very high in water and low in fat and energy. The fruit contains moderate to low values of minerals and vitamins. African mangosteen is rich in phytochemicals such as phenols and flavonoids.



Season: Flowers in October to November and fruits in late December to January at the coast and February to March in Embu and in West Pokot.



Cultivation: It can be propagated by seedlings by sowing fresh seeds in pots or by direct sowing seeds on site. Seed treatment is not necessary but nicking the seeds coat or soaking in cold water overnight may enhance germination. After collection, ripe fruits are stored in a cool place for the pulp to rot and fall away. Then dry and separate the seed from the pulp residue. Seeds should not be stored as they lose viability within a few weeks (recalcitrant). When using fresh seeds, the germination rate is good. There are about 2000–2500 seeds/kg.



G. livingstonei is a fairly fast-growing species. The young seedling develops a strong root before shoots, so it is worth trying to sow the tree directly at the site where it is to grow.



Pests and diseases: Generally, there are no problems with pests and diseases, but detailed information is missing.



Commercial/market value: One of the most delicious wild fruits in Kenya with great potential for domestication and commercialization, however, not available in markets. It deserves to be more widely cultivated as a homestead tree.

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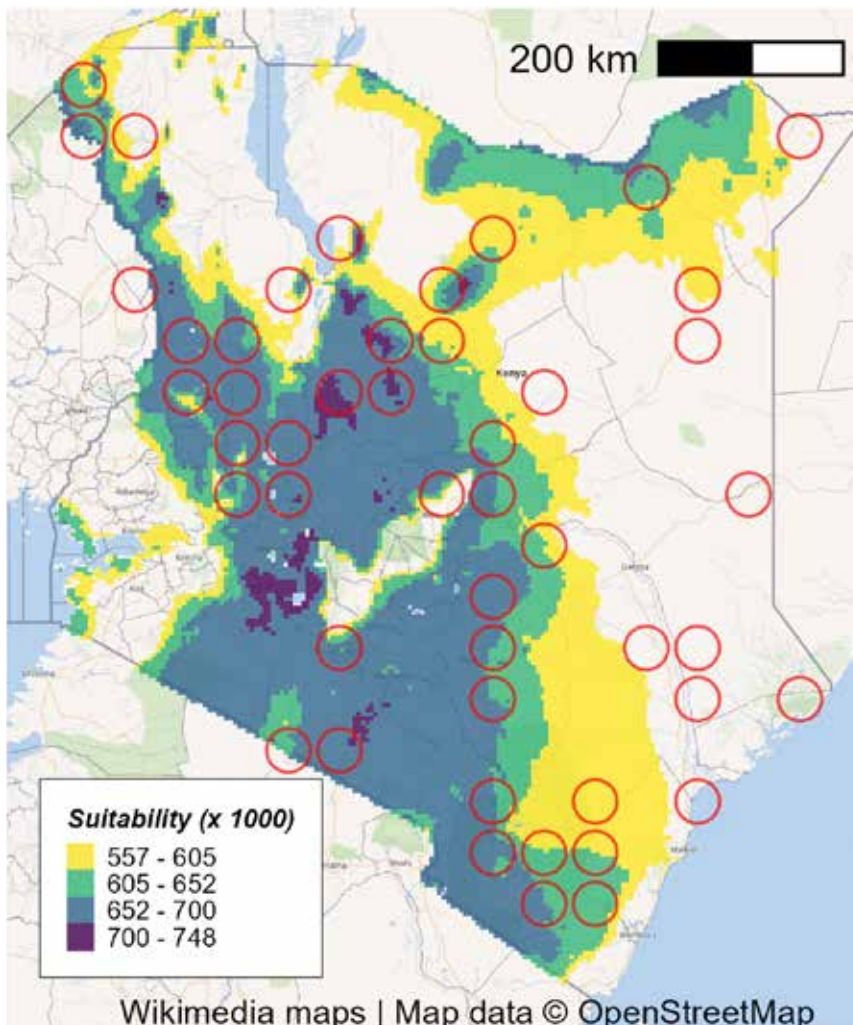
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13. *Grewia villosa* Willd.

MALVACEAE

Common name: Mallow raisin, Mallow-leaved cross berry

Local names: Mukorobasha/Mukorobasho (Bajun); Ogumdi/Ogomdi/Muruudo (Borana); Ogomdi (Gabra); Ner powo (Luo); Ol-mankulai/Olpompoi/Imangulai (Maasai); Mongurwa (Marakwet); Mubuu (Mbeere); Mokoghio/Mokuwo/Makow (Pokot); Obhoob (Rendille); Lpupoi/Lpopoi (Samburu); Mukorobosho (Swahili); Mshoshote/Shoshoti/Mshashote (Taita); Mubuu (Tharaka); Mokuwo (Tugen); Epoko/Epongae/Epokoo (Turkana).



Description and ecology: A deciduous shrub with spreading branches up to 3.5 m high but often 1–2 m; with very distinctive leaves. Young branches are covered with pale silky hairs, branches purple/brown. **Leaves:** Distinctive, large, round with heart-shaped base, on stalks up to 4 cm, covered with pale, silky hairs; margin toothed, underside of leaves light green and more hairy with 5 prominent veins. **Flowers:** Pink, turning brown/yellow when older; in small clusters, without stalks. **Fruit:** Fleshy drupe, without lobes, green when unripe, copper red when ripe, brittle on drying; about 1 cm across; covered with soft hairs. 1–2 seeds within each fruit.

It is found in all drier areas of Kenya in *Acacia commiphora* bushland and thickets and in the Nyanza region near Lake Victoria in dry bushland. It grows on a variety of soils including red, sandy, rocky, and occasionally black-cotton soil. Grows from sea level up to 1500 masl.

Uses: The genus *Grewia* of the family Malvaceae includes *Grewia villosa* Willd., *Grewia similis* K. Schum. and *Grewia tenax* (Forssk.) Fiori and several others. Most of the ripe fruit of the *Grewia* species are very sweet, edible by humans as snacks and much favoured by birds. Ripe fruits are picked from the tree and eaten in small amounts, especially by children and herdsman. Fruits of *G. villosa* are sweet and edible (raw, dried, or cooked); the sweet juice

is usually swallowed, and seed discarded. Juice may also be made by Turkana people by extracting the pulp in water. Also in South Africa, berries of *G. villosa* are soaked in water for 2–3 days to make a refreshing drink. Stems are used as fuelwood, in construction of small huts and grain stores and to make poles, tool handles, walking sticks, utensils, bows and arrows. Leaves make good fodder for domestic (goats and camels) and wild animals (giraffe, black rhino). It is also a good shrub for bee foraging and is used in traditional medicine. Fibre from the bark is used to make strings for musical instruments.

Grewia tenax (White cross-berry, Raisin bush) is a small, much-branched, multi-stemmed, straggling deciduous shrub that grows up to 4 m or more. It is widely distributed in most of Kenya except in the western part. It is found in dry acacia bushland at 0–1250 masl. Its fruit is a small drupe, usually 2–4 lobed, lobes 5–7 mm in diameter, glabrous, rarely with sprinkled stellate hairs, light green, turning to yellow/orange when ripe. The ripe fruit is very sweet and eaten raw or juice may also be made by Turkana people by extracting the pulp in water. The fruits of this species are the most preferred of all dryland *Grewia* species. *Grewia similis* is a small shrub, growing up to 3 m; found at 600–2200 masl. Fruits are fleshy drupes, first green, orange/red when ripe; deeply 4-lobed. The ripe fruit is sweet and edible.



Grewia villosa – ripe fruit, partly open and showing pulp



Grewia villosa – ripe fruit



Grewia villosa – shrub



Grewia tenax – ripe fruit and leaves



Grewia villosa – leaves and unripe fruit



Grewia similis – branch with ripe fruit and leaves

Nutrient composition

Mallow raisin, raw (*Grewia villosa*)

100 g edible portion on fresh weight basis (EP)

Component	Mean	n
Energy ¹ kcal (kJ)	105 (444)	
Water (g)	70.0	1
Protein ² (g)	3.3	
Fat (g)	0.2	1
Carbohydrate, available ³ (g)	20.5	
Fibre, total dietary (g)	4.0	1
Ash (g)	2.0	1
Iron (mg)	0.9	1
Potassium (mg)	224	1

Mallow raisin, raw (*Grewia villosa*)*100 g edible portion on fresh weight basis (EP)*

Component	Mean	n
Magnesium (mg)	35	1
Phosphorus (mg)	41	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

The fruit of *Grewia villosa* is a good source of potassium, calcium, magnesium and phosphorus.



Season: *G. villosa* and *G. tenax* flower from July to September; fruit from November to January. *Grewia similis* flowers from July to August, and fruits are collected from October to November.



Cultivation: All *Grewia* species can be propagated by seedlings or by direct sowing on site. After collection, soak seeds in cold water for 12 hours. Germination is good and is completed in 6 weeks. Seeds can be stored for a year if kept cool in airtight containers. For *G. villosa*, there are about 16 000 to 17 000 seeds/kg. It is a very slow-growing species. For *G. similis*, there are about 22 000 seeds/kg and for *G. tenax* there are 18 000–21 000 seeds/kg. These shrubs can be managed by coppicing and trimming if grown as a hedge. All *Grewia* species reproduce well by natural propagation in the wild if they are protected from fire and browsing.



Pests and diseases: *Grewia* species are not affected by any known pest or diseases, but more detailed information is lacking.



Commercial/market value: None of *Grewia* species fruit are sold in the local markets. *Grewia* species are very common and easily accessible within their area of distribution. But trees are heavily browsed in their natural habitats by goats and wild animals.

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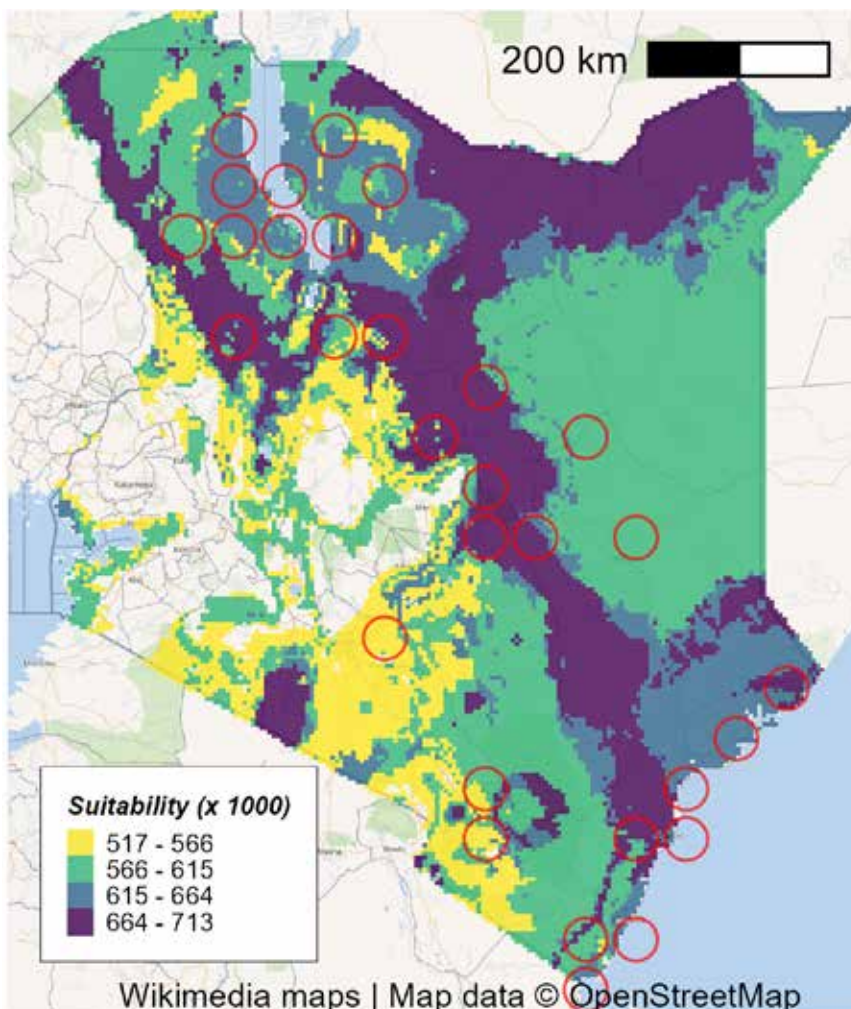
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14. *Hyphaene compressa* H. Wendl.

ARECACEAE (PALMAE)

Common name: Doum palm

Local names: Medi/Meeti/Kone (Boni); Mkoma/Mkoma lume (Digo); Meetti (Gabra); Mkoma/Mlala (Giriama); Lparruai/Lparrua (Ilchamus); Mukoma/Ilala (Kamba); Irara (Mbeere); Kone/Meti – young (Orma); Mkoma/Mlala/Milala (Pokomo); Tangayween/Tangayua (Pokot); Grey-i-khoona/Baar (Rendille); Iparwa/Malala/Lparwai/Nkujit ae nkeok (Samburu); Baar/Qoona/Debell (Somali); Mkoma/Mkoche/Mlala/Mnyaa/Muaa (Swahili); Irara (Taveta); Muruguyu (Tharaka); Eeng'ol/Eng'ol (Turkana).



Description and ecology: One of the few truly branching palms, with the stems dividing regularly. Unmistakable and beautiful, it reaches 18 m in height and occasionally reaches up to 25 m. **Trunk:** Slender, but much branched, each branch dividing again and again and ending in a crown of leaves. **Leaves:** Fan-shaped, hard, waxy and durable; each leaf with petiole up to 2 m long, leaf lamina up to 0.8 m long, spreading, with numerous longitudinal folds and segmented in the upper (third) part into up to 60 segments. Dead leaves often persist around the higher stems. **Flowers:** Borne on long inflorescences up to 1–1.5 m, male and female flowers found on separate trees (dioecious). Male flowers are pale green while female flowers are bright green in colour. **Fruit:** Pear-shaped, very hard, orange/brown, each

fruit up to 10 cm long, 2 sides flattened, with one large, hard seed, fruit hanging down in bunches.

In Kenya, it is widely distributed in hot areas. It is common at the coast, and in dry northern areas along river courses and lakes in Turkana. It is the most prominent and abundant tree palm along River Turkwel near Lodwar, River Galana (Tsavo East), and in Kwale, Kilifi and Malindi. Also very commonly found growing in parts of the north coast, especially along the Witu–Lamu road. At the coast, the tree tends to be branched while in northwestern Kenya it remains single stemmed. The tree prefers a high water table and a hot, dry climate for good growth. In dense riverine forests, such as in lower parts of Tana River, the tree can easily reach up to 30 m high. It grows from 0–1400 masl.



Hyphaene compressa – palm tree



Hyphaene compressa – ripe fruit



Hyphaene compressa – unripe fruit and leaves

Uses: The brown pulp of ripe fruit is eaten raw. The fruit is also used in beer making. The fruit's outer cover is peeled, pulp is removed from hard stony seed and sun-dried for later use. In Turkana, this dried pulp is ground and mixed with livestock blood to a brown, sticky, fibrous mixture (lokot) and eaten or sold in local markets. As with the coconut, the juice/water in immature fruit kernels is drunk by the Turkana and Pokot people, and is also used in beer making. The kernels are also eaten after breaking the nut. In Tanzania, palm wine is produced from sap obtained

by tapping the tip of the main stem. In addition, young germinating seedlings are dug up and embryos eaten by the Turkana people. Fruit pulp is eaten as medicine against intestinal worms by Giriama people. Young leaves are used to make finely woven baskets, thatched roofs (makuti), brooms, hammocks and mats. Wood is used as fuelwood, timber (for making cabinets), poles, posts, beehives (trunk) and fishing rafts. The trees make good live fences and are good for dune fixation. Fruits are eaten by baboons, monkeys and elephants, who distribute the seeds.

Nutrient composition

Doum palm, pulp, raw (<i>Hyphaene compressa</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean	n
Energy ¹ kcal (kJ)	117 (492)	
Water (g)	69.4	1
Protein ² (g)	0.7	

Doum palm, pulp, raw (<i>Hyphaene compressa</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean	n
Fat (g)	1.2	1
Carbohydrate, available ³ (g)	23.9	
Fibre, crude(g)	3.6	1
Ash (g)	1.2	1
Calcium (mg)	119	1
Potassium (mg)	597	1
Magnesium (mg)	73	1
Vitamin C (mg)	295	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Doum palm is an excellent source of vitamin C. 100 g EP of the fruit can meet 6 times the recommended daily intake of vitamin C³. Vitamin C is a good antioxidant, protecting the body from radicals and improving the absorption of non-haem (plant-based) iron in the gut. In addition, the fruit contains excellent values of calcium and potassium.



germination, which under normal conditions may take several months to a year to germinate. Seed viability is maintained only for a short period. A thousand seeds weigh 20–50 kg.

It is a very slow growing species. The palm can be coppiced and lopped.



Season: Fruit available in all seasons in coastal and other areas. Usually, fruits are collected during the dry season, i.e., April to July. But in Turkana fruit is mainly collected from July to November.



Cultivation: Propagated by direct sowing at site or by suckers. Not suitable for growing in nurseries since long taproot grows down to 50–100 cm before the leaves appear. The seeds do not germinate easily; for seed germination, pulp should be removed; preferably the kernel should be scarified to hasten



Pests and diseases: The fruit and leading shoot are occasionally infested with a cochineal bug, in poorly aerated, dense canopy forests. Infestation causes arrested growth and premature fruit dehiscence. A borer, *Coccotrypes dactyliperda*, may spoil the fruit. Wood from female palms is susceptible to attack by termites and borers. The nuts are frequently infested with three species of beetles: *Coccotrypes dactyliperda*, *Oryzaephilus surinamensis* and *Tribolium castaneum*.

³ Calculations based on recommended nutrient intake (RNI) of vitamin C/day, adults, 19 to > 65 years: 45 mg/d www.fao.org/nutrition/requirements/vitamins/en/



Commercial/market value: A very important fruit palm in Turkana County. The fruit and its produce are sold in Lodwar market. Turkana people are heavily dependent on the fruit as a source of food in times of food shortage, and the leaves are a source of income. To ensure its availability in the future, care should be taken that the species is exploited in a sustainable way. Variability in the fruit quality may offer scope for selection and breeding.

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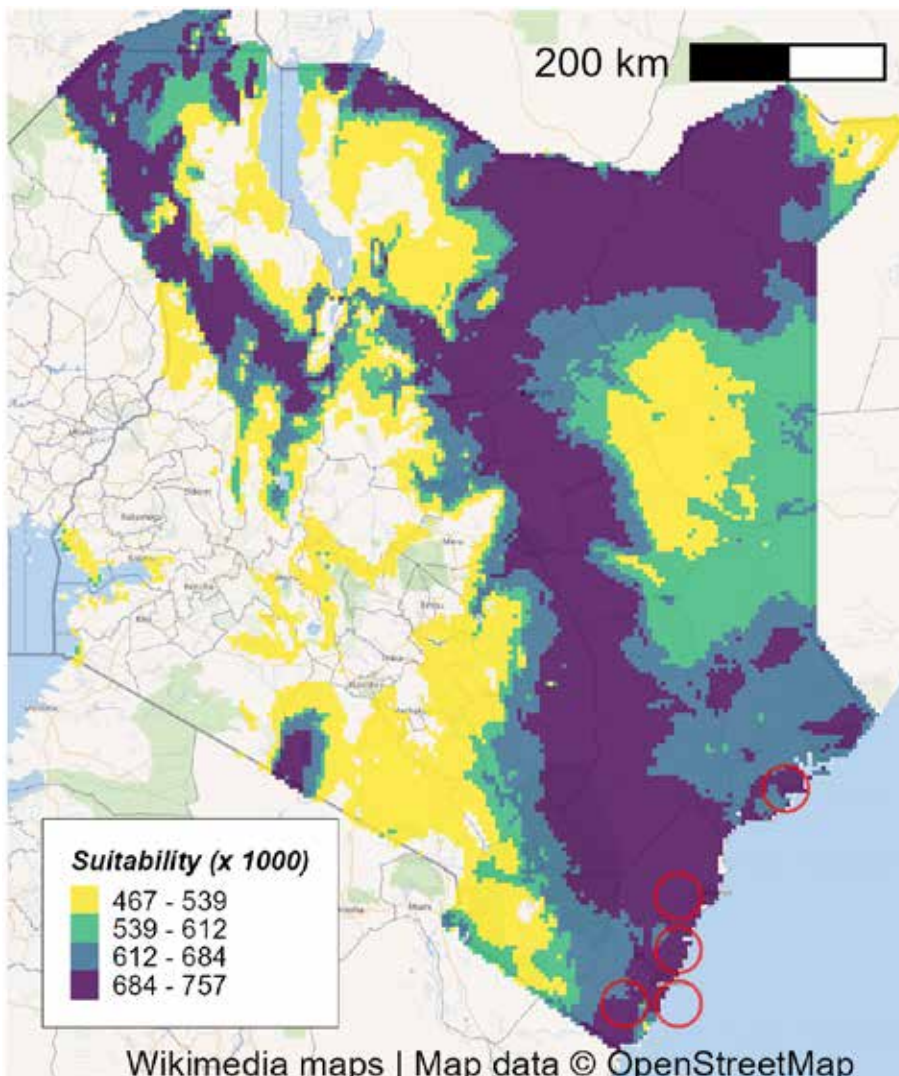
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15. *Manilkara sansibarensis* (Engl.) Dubard

SAPOTACEAE

Common name: Manilkara

Local names: Mng'ambo/Mungambo (Digo); Mng'ambo maziya/Mungambo/Ngambo (Giriama); Mshonjie/Mguvi/Mchegi/Mng'ambo (Swahili).



Description and ecology: A medium-sized evergreen tree with a bushy crown, sometimes with a slightly buttressed base and fluted bole. **Bark:** Grey/brown/black, rough, producing white latex when cut. **Leaves:** Oblong, simple, dull green, very stiff, with apex rounded or notched, up to 14 cm long, on stalks up to 3 cm. **Flowers:** Very small, green/white, scented, in groups of 4–12 in leaf axils, flower stalk

and outer calyx densely hairy. **Fruit:** Round or oval, tough berries, up to 1.2–1.4 cm, containing 1–4 shiny flat seeds. Seeds are 7–11 mm long.

In Kenya, it is found along the coast in *Brachystegia* and *Azelia* woodland and forests, e.g., in Marafa and the Arabuko-Sokoke Forest. It grows on deep coastal red sandy soils; altitude ranges from 0–300 masl.



Manilkara sansibarensis – tree



Manilkara sansibarensis – ripe fruit



Manilkara sansibarensis – leaves and unripe fruit on the tree

Uses: Ripe fruit has milky sweet pulp which is edible. Fruit is collected from the ground or picked from the tree and eaten raw as a snack. The sweet pulp is swallowed and the seeds discarded. Wood is strong and long-lasting, it is used for making tool handles, furniture and carvings, boatbuilding (dhows) and used as fuelwood. It is an ornamental tree and is also good for shade.

Nutrient composition

No data on the nutrient composition of this fruit could be found in the literature. Research is needed to fully evaluate its nutritional potential.



Season: Flowers in May to June, November to December and fruits in February to March and August to September in Kwale and Kilifi.



Cultivation: Propagated by seeds (seedlings) and cuttings. Seeds are usually collected from the wild and soaked in cold water for 24 hours before germination. Seeds cannot be stored (recalcitrant); fresh seeds are used to ensure good germination. It is a common species in its natural distribution areas.



Pests and diseases: Mediterranean fruit fly (*Ceratitis capitata*) damages the fruit and is one of the main pests of this species. Detailed information on the species' pests and diseases is lacking.



Commercial/market value: It is an important fruit tree for the coastal areas of Kenya with unexploited potential, often eaten in sufficient quantities to stave off hunger in emergency situations. The fruit is not sold in local markets but collected directly from the wild and eaten as a snack.

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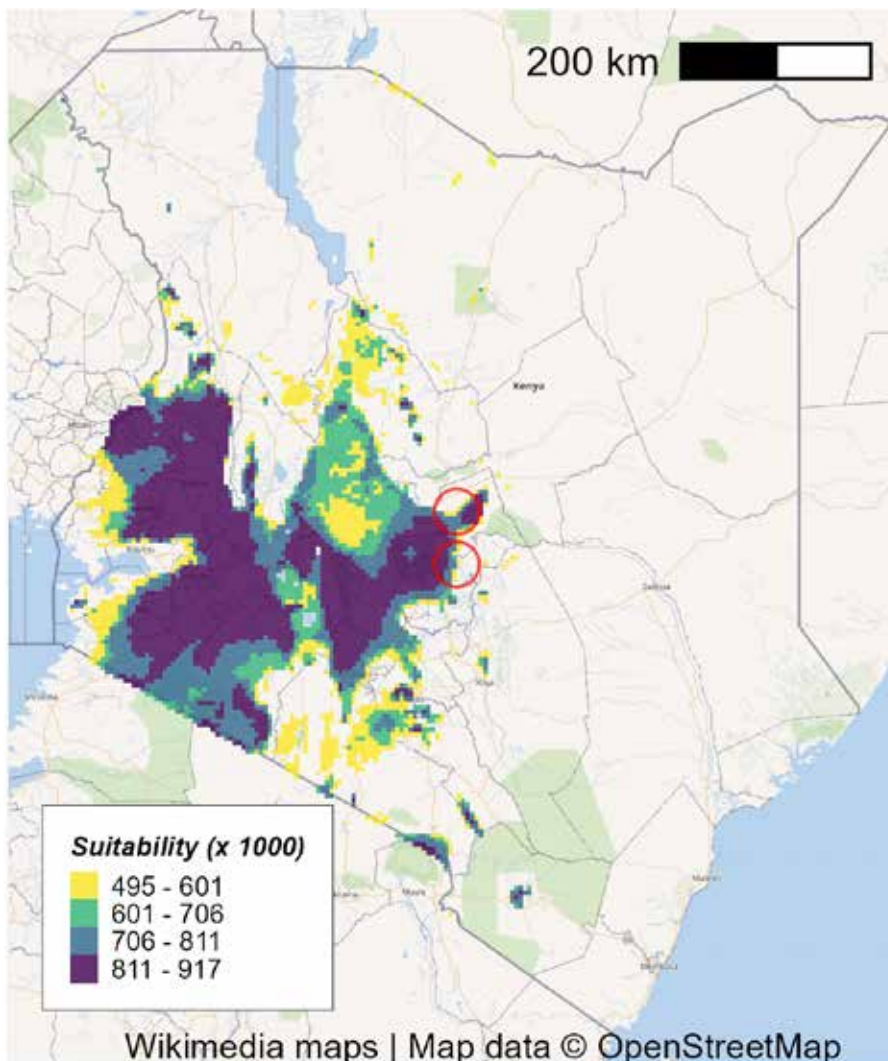
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16. *Myrianthus holstii* Engl.

URTICACEAE

Common name: Giant yellow mulberry

Local names: Mutuya (Kikuyu); Saounet (Kipsigis); Mutuja (Meru).



Description and ecology: A medium-sized, evergreen tree of the rainforest, growing up to 15 m or 20 m in height. **Bark:** Light grey/brown, smooth, discharging a watery sap when injured that turns black. **Leaves:** Large, palmate, with 5–7 leaflets, each elliptic and obovate, margin toothed, upper surface smooth and dark green, lower side grey/green, hairy with conspicuous veins, leaflets stalkless. **Flowers:** Dioecious species (i.e., male and female flowers on separate trees), male inflorescence green, female flowers small, round, with yellow heads on the stalk. **Fruit:** Compound or multiple, rough, roundish with pineapple or custard apple-shape, green, turning yellow when ripe, fleshy, 6 cm across, seeds embedded in pulp.

It is found only in Central Kenya around Mt Kenya, Nyambeni Hills and the Aberdares in highland moist forests, especially along forest edges and near watercourses, preferring moist valleys and riverbanks. Altitude: 900–2400 masl.

Uses: The fruit is edible, sweet and sour in taste and seeds are usually discarded. The timber is soft, used to make charcoal and as general fuelwood. Leaves are used as mulch and fodder for livestock. Its roots are used in the treatment of sore throat, while the bark extract is used to treat malaria. It is a good ornamental and shade tree and is used for soil conservation.



Myrianthus holstii – ripe and unripe fruit



Myrianthus holstii – tree



Myrianthus holstii – opened ripe fruit showing the white fruit pulp

Nutrient composition

No data on the nutrient composition of the fruit could be found in the literature. Research is needed to fully evaluate its nutritional potential.



Season: Flowers from July to August. Fruits from October to November.



Cultivation: It can be propagated by fresh seeds (seedlings) and produces root suckers. Seeds should be extracted from ripe fruit, cleaned and sown fresh. Seeds cannot be stored as they are recalcitrant. The seeds are also dispersed by animals such as monkeys and birds. Natural regeneration takes place around the base of trees in forests as well as on farmland. Protection and retention of trees on farms is common. Coppicing of the tree is the best management technique.



Pests and diseases: No information available.



Commercial/market value: Fresh fruit are collected from the tree and eaten as a snack. Several years ago, the fruit was sold across markets in Central Kenya, but today the tree has become rare. This species is one of the important high potential highland trees and should be domesticated. The leaves are locally traded as fodder.

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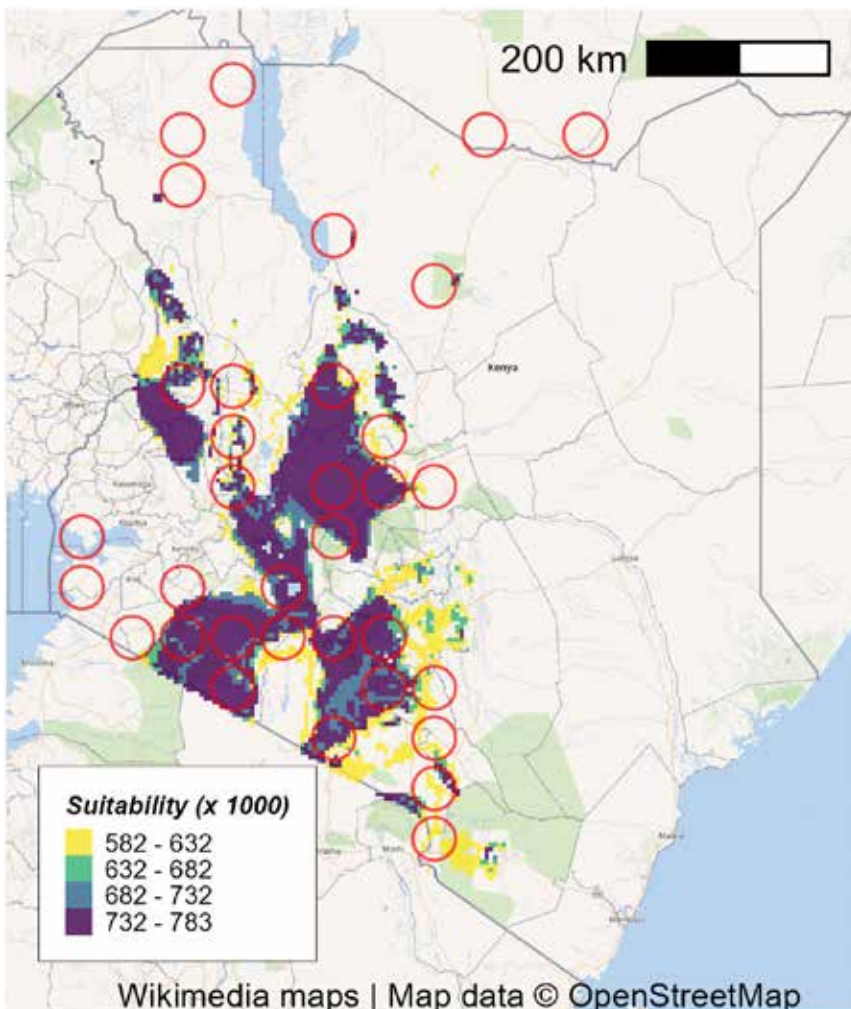
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17. *Pappea capensis* Eckl. & Zeyh.

SAPINDACEAE

Common name: Cape pappea, Jacket plum

Local names: Pika (Borana); Mba (Kamba); Ndirikumi (Kikuyu); Ngonyet (Kipsigis); Okuoro/Okworo/Omaange (Luo); Ol-timigomi/Orkisikong'u/Natua ekongu/Natwa ongo (Maasai); Kipiriokwa/Kibiriokwo/Piriak (Marakwet); Mubaa (Mbeere); Ntirikomi/Dilikoni (Meru); Puriokwo/Priokwo/Priak (Pokot); Loposeta/Lopisedi/Lgurugu/Lgurongui (Samburu); Asel/Adadak (Somali); Mubamba-ngoma (Swahili); Mndendele/Ndendele/Mkongori (Taita); Biriokwo (Tugen); Etolelh (Turkana).



Description and ecology: A leafy, semi-deciduous, slow-growing tree, usually grows up to 6 m high, occasionally up to 13 m high, with a short trunk branching low down to form a spreading, rounded crown. **Bark:** Pale to dark grey; smooth with horizontal markings, becomes dark brown, rough and fissured in older trees. **Leaves:** Oblong, in terminal clusters, dull dark green, stiff, margin smooth or sharply wavy, base rounded, unequal. **Flowers:** Small, yellow/green, in spikes up to 10–12 cm long, male flowers terminal, female at the base of each spike. **Fruit:** Small, round, furry green capsules,

about 1 cm across, in tight clusters, splitting on trees to reveal a bright orange/red jelly-like covering (the aril) around a shiny dark red/brown/black oval seed.

It is widely distributed in Kenya in the wetter and higher parts of the semi-arid zones including Makueni, Machakos, Thika, Kitui, Homa Bay, Baringo, Marsabit, Laikipia, Kajiado, Samburu, Loita and Magadi. Found in bushland and wooded or bushed grassland, also found in rocky hillsides and sandy lowlands. It grows on black clay, sandy soil and sloping rocky ground with clay or sand at an altitude of 1050–2400 masl.



Papea capensis – tree



Papea capensis – open fruit showing bright red, juicy and jelly-like arils



Pappea capensis – leaves and fruit

Uses: The bright red, jelly-like, translucent arils around the seeds are edible with sweet and sour pleasant taste and can be eaten raw or used to make jelly, vinegar and an alcoholic drink. Oil from the seeds can be used for soap and as a lubricant, including biodiesel. The red fruit is also a favourite with birds and other animals which in turn helps in dispersing its seeds. The wood is hard and tough, very strong and durable, with a twisted grain. It is a

source of excellent fuelwood, charcoal, timber and for making furniture, construction poles, beehives, tool handles, bows and kitchen/farm utensils. The leaves and fruits are eaten by wild animals (e.g., elephant, giraffe, kudu) and livestock (e.g., cows, goats). The species also serves as an ornamental or shade tree and is used in bee foraging. Seed oil is used as a treatment for ringworm. The bark of the tree is also used in traditional medicine.

Nutrient composition

Jacket plum, pulp, raw (*Pappea capensis*)

100 g edible portion on fresh weight basis (EP)

Component	Mean	n
Water (g)	89.0	1
Ash (g)	0.7	1
Calcium (mg)	11	1
Iron (mg)	0.6	1
Potassium (mg)	250	1
Magnesium (mg)	12	1
Phosphorus (mg)	15	1
Copper (mg)	0.28	1
Zinc (mg)	0.03	1

n, number of data points

Jacket plum contains almost 90% water. Its mineral levels are moderate to low. The nutritional information on its vitamin content and macro-nutrients is limited in the literature. More research is needed for better evaluation of its nutritional potential.



Season: Flowers in February to March in Narok, June in Makueni, Machakos, Elementaita, Taita Hills; in August in Homa Bay; and November and December in Baringo and Marsabit. Fruits in February in Laikipia, Tugen Hills; in August to September in Kajiado, Machakos, Kitui and Samburu; October in Taita Hills.



Cultivation: Propagated by seedlings and root suckers. Seed should be collected from the ripe fruit, and does not require any special treatment. The red flesh should be removed from the fruit and seeds sown immediately, e.g., in trays. Germination may take 6–10 weeks under ideal conditions. The seedlings are left in their trays/pots until they are 20–50 mm tall before planting out, taking care not to damage the young taproot.



Young trees respond well to organic and synthetic fertilizers. Saplings are slow growing, but growth rate increases as the tree matures. Tree coppices well.



Pests and diseases: The fruit is attacked by a small, bright-red soapberry bug (*Leptocoris hexophtalma*). Further information on pests and diseases is however not available.



Commercial/market value: Fruit is not sold in local markets; it is directly collected from the tree and eaten, particularly by children. It is common within its distribution area. The tree is suitable for agroforestry systems and should be domesticated because of its tasty fruit. It may also have a potential to serve as a biodiesel.

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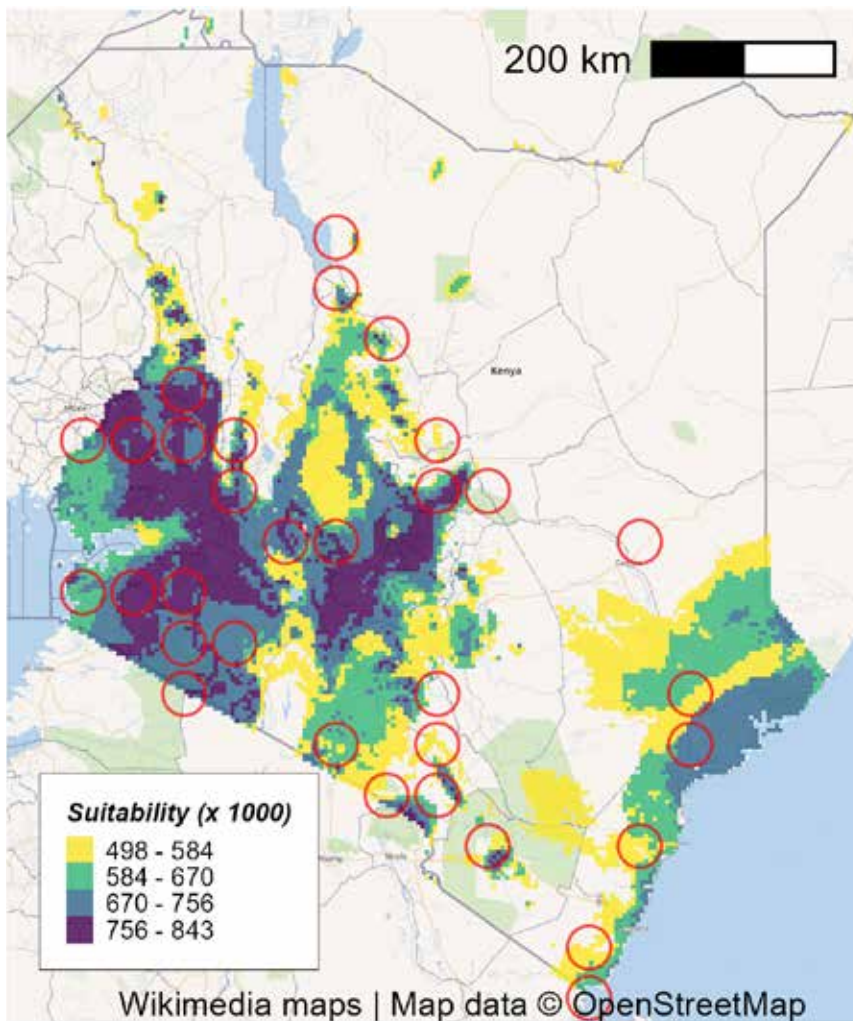
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18. *Phoenix reclinata* Jacq.

ARECACEAE (PALMAE)

Common name: African wild date palm; Dwarf date palm

Local names: Gonyooriya (Boni); Meti (Borana); Mchindu/Makindu (Digo); Makindu (Kamba, Swahili); Mkindu/Mkindwi/Kindwi (Giriama); Mukindu (Kamba); Mukindu (Kikuyu); Sosiyot (Kipsigis); Kumukhendu/Lushindu (Luhya); Othith (Luo); Oltukai (Maasai); Konchor (Orma); Mkindu (Pokomo); Lekawai (Samburu); Alol/Alool/Maleqa (Somali); Kigangachi (Taita); Mhongana (Taveta); Emusogot (Teso); Mukiindu (Tharaka); Nakadoki (Turkana).



Description and ecology: This is a beautiful, clump-forming palm, growing up to 15 m high, but may attain a height of 30 m in the forest (e.g., in the lower parts of Tana River). **Trunk:** Solitary, but mainly multiple in tufts; slim and slender and often bent over, 25 cm in diameter and covered with old leaf scars. **Leaves:** Bright shiny green, feathery, up to 2.7 m long, crown prominently downturned, leaflets narrow, up to 30 cm in length, stiff and sharp. **Flowers:** Dioecious species, inflorescences arising from among the leaf bases, male flowers cream/brown, up to 7 mm and female flowers green up to

2 mm. **Fruit:** Oval drupe, about 2.5 cm long, green when unripe, dark red/brown when ripe. The fruits are borne in large, pendant clusters and contain one seed each. Seed is obovoid, 10–15 mm × 5–9 mm, and deeply grooved along one side.

It is a widely distributed palm tree in Kenya (e.g., in Tana River Basin, Loita Forest, Nandi Hills, Kibwezi, Tsavo East/West National Park, Amboseli National Park) and grows very well in Nairobi. Often grows in dense clumps beside swamps, rivers and along forest edges at altitudes from sea level to 3000 masl.



Phoenix reclinata – a bunch of ripe fruit



Phoenix reclinata – palm tree



Phoenix reclinata – ripe fruit

Uses: Ripe fruits are sweet and edible and are used to make palm wine. Fruits are collected from the ground and eaten immediately as a refreshing snack. They are popular among children and livestock herders. Leaves are used in making baskets, mats, hats, brooms and for roof thatching. This palm is grown as an ornamental and is also used as fuelwood, for bee foraging, shade and riverbank

stabilization. Leaf rachis are used to clean the inside of milk gourds by the Maasai community. Palm roots are a great source of brown dye which is used by the Kikuyu people. The stems are used for construction of livestock enclosures, *bomas*/huts, bridges, walls and fencing. String can be made from the fibres of young, unexpanded leaves of immature palms.

Nutrient composition

African wild date palm, raw (<i>Phoenix reclinata</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean (min-max)	n
Energy ¹ kcal (kJ)	209 (884)	
Water (g)	43.4 (36.1-50.6)	2
Protein ² (g)	2.6	
Fat (g)	1.4 (0.7-2.1)	2
Carbohydrate, available ³ (g)	44.3	
Fibre, crude (g)	4.5	1
Ash (g)	3.9	1
Calcium (mg)	47 (44-51)	2
Iron (mg)	7.0	1
Potassium (mg)	1330	1
Magnesium (mg)	79	1
Phosphorus (mg)	34 (33-35)	2
Copper (mg)	0.33	1
Zinc (mg)	0.76	1
Thiamine (mg)	0.03	1
Riboflavin (mg)	0.02	1
Niacin (mg)	1.2	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

African wild date palm is low in water, but high in available carbohydrates and energy. It is a very good source of minerals, overall potassium, magnesium and iron. By consuming 100 g EP of the fruit, one can meet 38% of the daily recommended intake of potassium⁴ and 35% of magnesium.⁵ Vitamins are comparatively low.



Season: Flowers in October to November; immature fruits appear in January and ripen in March to May.



Cultivation: *Phoenix reclinata* can be propagated by seeds and suckers. Seeds can be collected from the wild or from cultivated trees. Seed treatment is

4 Conditional recommendation of daily potassium intake for adults (≥ 16 years): 3510 mg/d. www.who.int/nutrition/publications/guidelines/potassium_intake/en/

5 Recommended nutrient intake (RNI) of magnesium, average female and male, 19 to > 65 years: 224 mg/d. www.fao.org/nutrition/requirements/vitamins/en/



not necessary, but fruit pulp should be removed from seed and dried before storage. Germination is best using fresh seed and takes about 2 months. Seed can be stored for long periods if kept in dry, cool and insect-free places. There are about 900–5000 seeds/kg. This palm can be planted as an ornamental in homestead compounds. Fully grown trees are graceful, especially when pruned to a single stem. If plants are growing in groups, thinning is recommended. During leaf harvesting, some should be left on the tree so as not to kill the plant.



Pests and diseases: A variety of scale insects infest this palm. Larvae of the butterfly *Zophopetes dysmephila* feed on the leaves. *Phoenix reclinata* is susceptible to lethal yellowing disease, a phytoplasma disease that attacks several palm species.



Commercial/market value: Palm leaves are used in making mats, baskets, hats and for roof thatching, thus these items are sold in local markets. However, fruits are not marketed, but offer a certain potential. While this palm is over-exploited in northern and northeastern Kenya for its use in handicrafts, it is a common palm in most other areas of the country.

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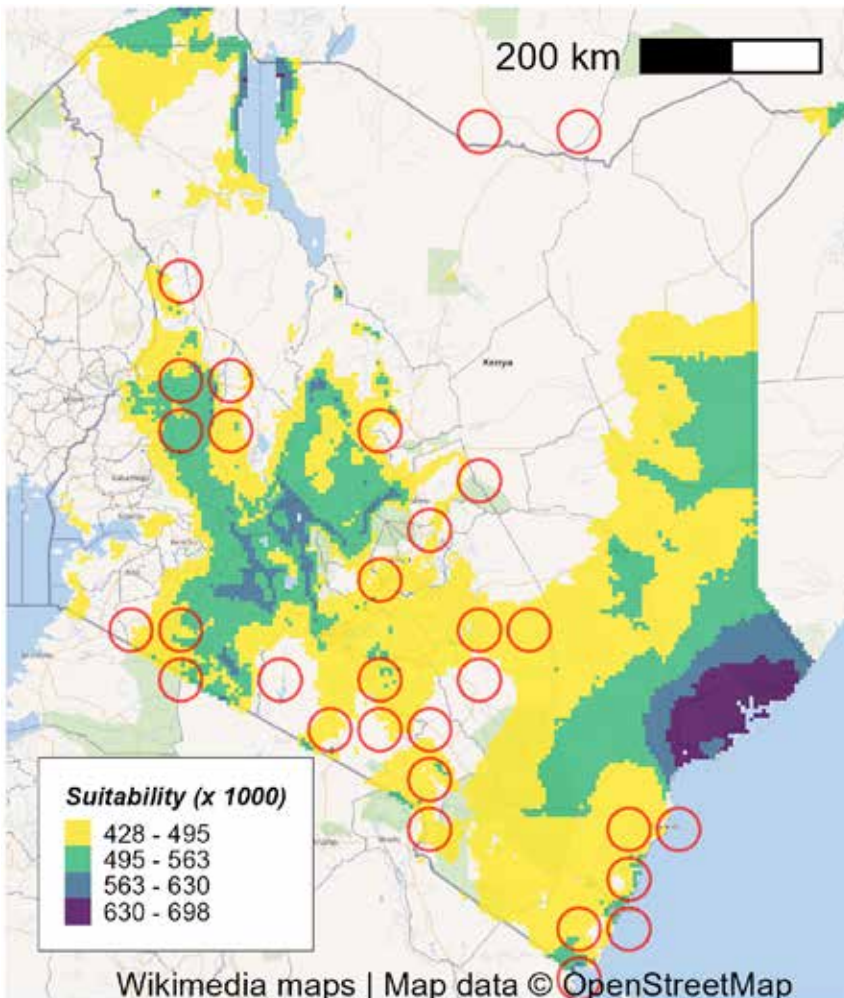
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19. *Sclerocarya birrea* subsp. *caffra* (Sond.) Kokwaro

ANACARDIACEAE

Common name: Marula

Local names: Didisa (Borana); Mng'ongo (Digo); Mufula/Mfula/Fula/Tulafula (Giriama); Lmang'wa/Imang'wa (Ilchamus); Mauw'a/Maua/Muuw'a/Mauw'a (Kamba); Ng'ong'o/Ong'ong'o (Luo); Olmang'uai/ilmang'ua (Maasai); Arol/Oroluo (Marakwet); Mura (Meru); Mukomothi (Mbeere); Oroluwo/Oroluo (Pokot); Mng'ongo/Morula/Mungango/Mongo (Swahili); Ekajikai (Teso), Tololokwo (Tugen); Ekajiket (Turkana).



Description and ecology: A medium-sized deciduous tree, growing up to 10–15 m high, with a thick bole and a rather dense, rounded crown. **Bark:** Grey/black and thick; finely fissured; scaling; inner bark is pink/red. **Leaves:** Pinnately compound; crowded at tips of branches; 3–18 pairs of leaflets; oval, to 10 cm; margin smooth or serrated; tip pointed or blunt. **Flowers:** Dioecious species (male and female flowers usually on different trees); pale green male flowers in spikes, hanging down; female flowers solitary, pinkish/red; borne on long stalks at the tip of branches. **Fruit:** Fleshy drupe; oval or nearly rounded; up to 3.5 cm across; light green when young, turning cream/yellow on ripening; spotted;

fruit skin tough, leathery, enclosing a sweet, juicy, white pulp which tastes a bit like mango. Each fruit encloses a single, hard stone that contains 2–3 large seeds inside, which are oily and edible.

Widely distributed species in dry areas of Kenya, e.g., Moyale, West Pokot (Lambwe Valley), Mbeere and Baringo; found in mixed deciduous woodland, wooded grassland, open bushland and rocky hillsides; also found in coastal and adjoining areas. Very common on sandy and loamy soils as well as dry, rocky riverbeds. It grows at altitudes of 0–1200 masl (subsp. *birrea* grows at 500–1600 masl).



Sclerocarya birrea – tree



Sclerocarya birrea – unripe fruit



Sclerocarya birrea – leafy branches



Sclerocarya birrea – ripe fruit

Uses: Ripe fruits are eaten raw; fruit skin is removed and the sweet, creamy pulp sucked; it is strongly scented and acidic. The fruit is frequently eaten as a snack, mostly by children. A popular, fermented alcoholic beverage known as marula beer is prepared from the ripe fruit. The fruit is also used to produce jam, jelly, juice, soft drinks, wine and liqueur (e.g., the well-known 'Amarula Cream Liqueur' from South Africa). The seeds, hidden in the stones of this fruit, make good snacks and are consumed raw or roasted. Oil extracted from the seeds is utilized as highly nutritious cooking oil; it is also used in natural therapies and in the manufacture of cosmetic products. The wood is soft and used for making bowls and cups, grain mortars, carvings, stools and beehives. The bark yields a dye and fibre for ropes. The bark has medicinal properties, and it also serves as a shade tree. The leaves and fruits are used for fodder (e.g., for cattle and goats), while the fallen fruit is usually eaten by a variety of wild animals including elephants and monkeys (which often behave drunkenly when

the fruits are already fermented). The gum that exudes from the tree is rich in tannin and is sometimes used in making ink by dissolving it in water and mixing it with soot.

Nutrient composition

Marula fruit pulp and skin, raw (<i>Sclerocarya birrea</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy ¹ kcal (kJ)	53 (223)		
Water (g)	86.1 ± 1.3	83-87.5	20
Protein ² (g)	0.7		
Fat (g)	0.8 ± 0.6	0.4-1.7	4
Carbohydrate, available ³ (g)	10.1		
Fibre, crude (g)	1.4	1.2-1.5	2
Ash (g)	1.0		1
Calcium (mg)	34 ± 6	20-43	20
Iron (mg)	3.4 ± 1.9	0.5-9.9	20
Potassium (mg)	325 ± 26	255-360	19
Magnesium (mg)	20 ± 3	14-25	19
Phosphorus (mg)	30 ± 7	12-38	20
Copper (mg)	0.15 ± 0.07	0.01-0.36	19
Zinc (mg)	0.30 ± 0.10	0.10-0.58	19
Thiamine (mg)	0.03		1
Riboflavin (mg)	0.02		1
Niacin (mg)	0.3		1
Vitamin C (mg)	168 ± 50	85-319	20

SD, standard deviation, calculated when the number of data points (n) ≥ 3;

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Marula fruit is an excellent source of vitamin C, with highest values over 300 mg/100 g EP. Vitamin C is a good antioxidant, protecting the body from radicals and improving the absorption of non-haem iron in the gut. Nevertheless, it is labile to heat and light. The fruits should therefore be consumed as fresh as

possible. *Sclerocarya birrea* fruits also contain high amounts of minerals. The values of micronutrients, overall iron and vitamin C, and zinc and copper vary greatly. The reasons include differences in genetics, post-harvest treatment of the fruits, maturity stage and geography.



Season: Flowers in June in Narok, June to July in Mbeere; fruits in February and July in Kajiado and Kitui, September in Mbeere and April to May in Kerio Valley, Baringo and Makueni.



Cultivation: Propagation of *Sclerocarya birrea* is by seedlings, truncheons (large woody cuttings) and grafting. Seed germination requires pre-sowing treatment to hasten the process because there is seed dormancy. Collect mature fruit and remove flesh, clean the stone and soak it for 24 hours in cold water before sowing. Germination is 40% after 6 weeks. Another method is to pre-treat stones by putting them in boiling water, removing the heat source and leaving them immersed for 24 hours; this gives a 85% germination success rate after 2 weeks.



Sclerocarya birrea seeds have orthodox seed storage behaviour, although viability is lost in a month in open storage. Seeds store well in air-dry storage at cool temperatures. There are about 400–450 seeds/kg. Young trees coppice easily and can be grafted to get the best varieties. Young trees are susceptible to fire damage.

Most existing *Sclerocarya birrea* trees have naturally established and, in the natural range, it is common to find the species regenerating on farmlands under mature female trees soon after the rains. However, natural regeneration is slow and growth rates among the seedlings are uneven. Furthermore, regenerating seedlings are rarely recruited to the sapling stage due to destruction by browsing animals and cultivation for agriculture. Today's *Sclerocarya birrea* populations are mainly those left growing in farmers' fields. There have been few attempts to date to propagate *Sclerocarya birrea* in

the nursery or to transplant seedlings into fields. Attempts to propagate from seed raise several key issues. Germination rates are low unless proper storage and pre-treatments are observed. The dioecious nature of *Sclerocarya birrea* means many seedlings raised will be male and unable to contribute directly to fruit supply on reaching maturity. By using grafting, female trees of superior quality can be raised for planting.



Pests and diseases: Psyllid mites are the major pest problem affecting both wild trees and nursery stock. Severe infections have been observed on wild trees, but the harvests do not seem to be significantly affected. Aphids, white flies and thrips can also become a problem in the nursery and may require spraying of insecticides. Fruits can be severely attacked by fruit flies, e.g., by *Bactrocera dorsalis* and *Ceratitidis cosyra*. Wood, if not treated, is susceptible to borer and termite attack and is liable to sap stain fungi and other more harmful fungal attacks. Powdery mildew can be prevalent under humid conditions and can quickly spread to all seedlings in a nursery house. Control is achieved by spraying with fungicides.



Commercial/market value: Marula fresh fruits or products are not commercialized and marketed in Kenya. However, elsewhere, there is high commercial interest in food and beverage products with *Sclerocarya birrea* as an ingredient, particularly in southern Africa. There is no doubt that the Kenyan marula fruit is of equivalent quality to the fruit marketed and processed in southern Africa. Thus, the species has high potential for future widespread commercialization by small-scale farmers and fruit processors in Kenya. There is high genetic variability of wild material

from which superior provenances or individuals can be selected for domestication and further improvement of this valuable species.

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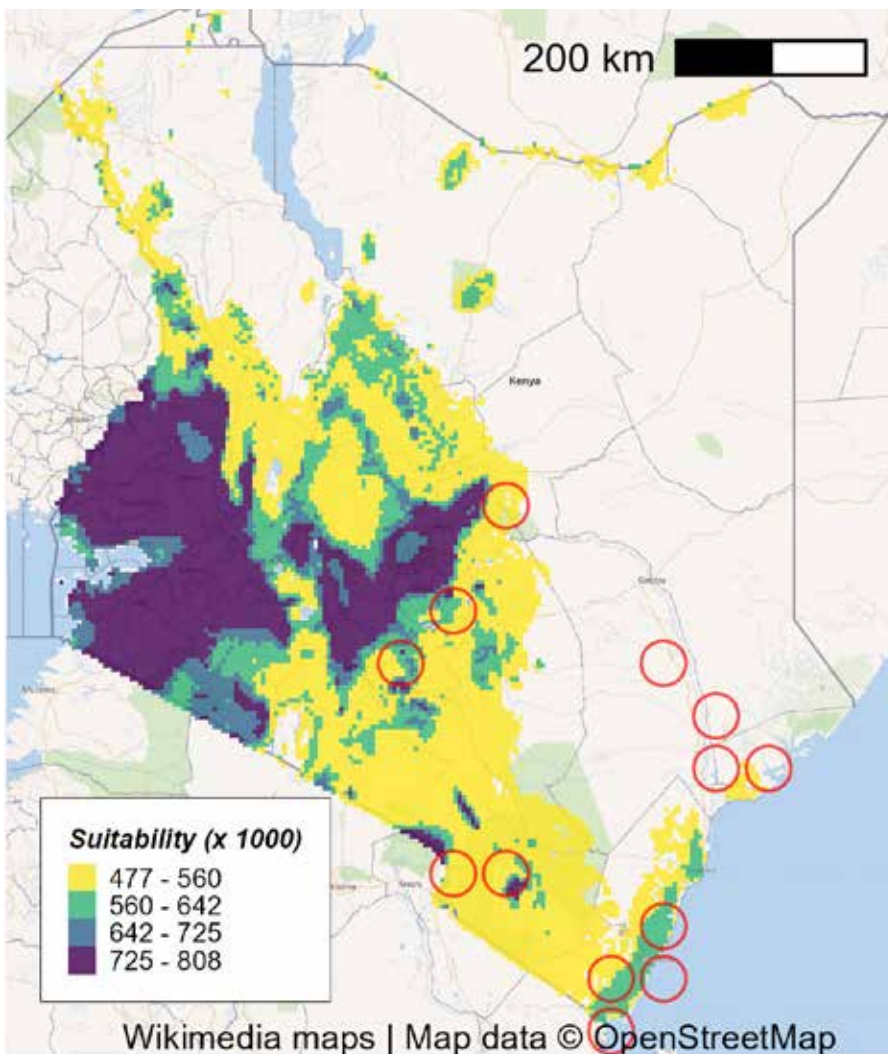
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20. *Sorindeia madagascariensis* Thouars ex DC.

ANACARDIACEAE

Common name: Sorindeia

Local names: Mkunguma (Digo); Msanzanza (Duruma); Nyambembe (Pokomo); Mtunguma/Mkunguma (Swahili); Mkunguruli (Taita); Mundaraha (Taveta).



Description and ecology: An evergreen tree that grows up to 20 m, or occasionally more. **Bark:** Grey/brown, flaking. **Leaves:** Compound leaf divided into up to 15 alternate leaflets, lower leaflets smaller, glabrous, usually asymmetrical base. **Flowers:** Dioecious species, flowers yellow with some pink near the base, small, nearly 5 mm; in long, loose, branched inflorescences, 20–80 cm long, arising from older wood and stem. **Fruit:** In large clusters, green, turning yellow/orange when ripe, oval and fleshy drupes, up to 1–2.5 cm long, each with one light brown and oval-shaped seed.

In Kenya it is found in riverine vegetation, especially along the lower Tana River, coastal forests, in areas with high ground water; also found in Taita Hills forests; usually grows on sandy, loamy soils, from 0–1500 masl.

Uses: The fleshy yellow/orange fruits are sweet and edible with a very pleasant flavour. It is viewed as one of the best indigenous fruits by the Pokomo and Taita people. Tree is used as fuelwood and for shade.



Sorindeia madagascariensis – ripe fruit in clusters



Sorindeia madagascariensis – leaves



Sorindeia madagascariensis – tree

Nutrient composition

Sorindeia, raw (<i>Sorindeia madagascariensis</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy¹ kcal (kJ)	75 (316)	
Water (g)	80.5	1
Protein² (g)	2.6	
Fat (g)	0.6	1
Carbohydrate, available³ (g)	14.2	
Fibre, crude (g)	1.2	1
Ash (g)	1.0	1
Calcium (mg)	255	1
Potassium (mg)	597	1
Magnesium (mg)	92	1
Vitamin C (mg)	107	1

n, number of data points (n)

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Fresh, ripe sorindeia fruit are rich in vitamin C. 100 g of the fruit meets twice the recommended daily intake of vitamin C.⁶ The vitamin is a good antioxidant, protecting the body from radicals and improving absorption of non-haem iron in the gut. The fruit is also a good source of potassium, calcium and magnesium.



Season: Flowers from July to August. Fruits from September to October.



Cultivation: *Sorindeia madagascariensis* is propagated by seeds. Seeds are collected and sown fresh to ensure good germination. Seeds should not be stored as they lose viability



quickly. Usually, fruits are collected from the wild or from trees that are retained on the farm during land preparation.

Pests and diseases: No information available.



Commercial/market value: The fruits are not sold in local markets. They are directly collected from the tree and eaten as a snack. It is popular among children. The tree is also suitable for agroforestry systems and should be domesticated and grown in homegardens mainly because of its tasty, nutritious fruit.

⁶ Calculations based on recommended nutrient intake (RNI) of vitamin C/day, adults, 19 to > 65 years: 45 mg/d www.fao.org/nutrition/requirements/vitamins/en/

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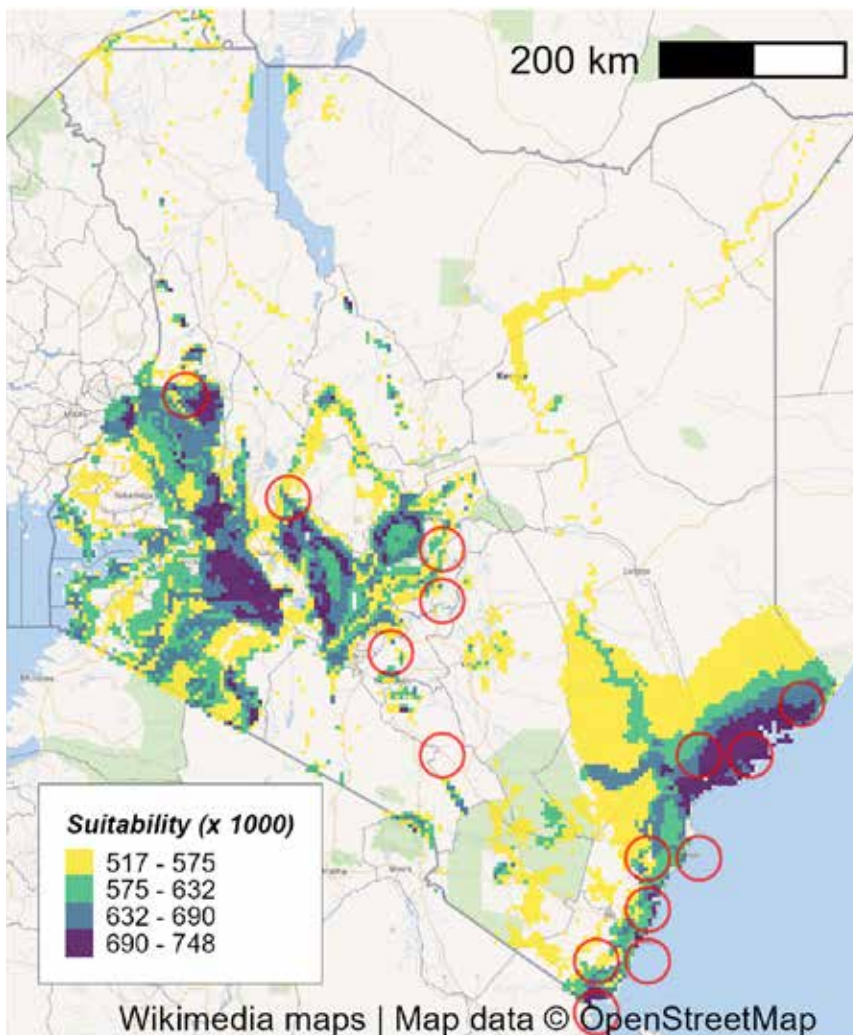
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21. *Strychnos spinosa* Lam.

LOGANIACEAE

Common name: Elephant orange, Monkey orange, Spiny monkey ball

Local names: Myae (Bajun); Mangula (Boni); Muhonga/Mursapungu (Digo); Mujaje (Giriama); Kiae/Kyae/Kimee/Mumee/Mamee (Kamba); Kumukhubwe (Luhya); Akwalakwala liech (Luo); Mwange/Mwange wan due/Mubage (Mbeere); Bungo (Pokomo); Kukuwol/Kukugho (Pokot); Mtonga (Swahili); Eturukurut (Teso).



Description and ecology: A semi-deciduous thorny tree, often multi-stemmed; usually growing up to 2–5 m, but can reach up to 9 m, with a rounded crown. **Bark:** Grey/brown, rough, with black tipped thorns, short and hooked, in pairs along the branches. **Leaves:** Opposite, shiny green, leathery, 3–5 veins from the base, oval to round, edge wavy, hairless. **Flowers:** Small, creamy green to white, in clusters at the end of the branches. **Fruit:** Round berries with a woody shell, green when young, turning yellow/brown when ripe, 7–12 cm across, conspicuous, remaining

on the tree for many months. Inside the fruit are tightly packed seeds surrounded by a fleshy, edible covering. Seeds are brown and hard in texture.

In Kenya it is found in the coastal zone and in a few inland areas such as Mbeere, Kitui, West Pokot and Baringo at altitudes of 0–1800 masl. It grows in a wide variety of dry woodland, savanna forests, riverine edges, bushland and wooded grassland. It mainly prefers sandy soils.



Strychnos spinosa – unripe fruit hanging on the tree



Strychnos spinosa – tree



Strychnos spinosa – ripe and unripe fruit



Strychnos spinosa – ripe fruit with white acidic pulp

Uses: The large, yellow ripe fruit contains edible flesh with a sweet acidic taste when eaten raw. The white pulp covering the seeds is sucked and the seeds discarded. Ripe fruit pulp can be used in making jams and juice. Unripe fruit is poisonous. The wood is hard

and can be used as fuelwood, charcoal, timber and for making furniture. The ripe fruit and leaves are used as fodder. It can be grown as an ornamental and shade tree. The roots and fruit of this tree are used in traditional medicine.

Nutrient composition

Monkey-orange, pulp, raw (*Strychnos spinosa*)

100 g edible portion on fresh weight basis (EP)

Component	Mean \pm SD	min-max	n
Energy ¹ kcal (kJ)	62 (261)		
Water (g)	81.6 \pm 5.2	77.9-89.2	4
Protein ² (g)	2.1		
Fat (g)	0.2	0.1	1
Carbohydrate, available ³ (g)	11.7		
Fibre, total dietary (g)	2.6		1
Ash (g)	1.9 \pm 1.9	0.3-4.6	4
Calcium (mg)	31 \pm 16	14-56	6
Iron (mg)	0.8 \pm 1.0	0.1-3.0	7
Potassium (mg)	596 \pm 388	328-1370	6
Magnesium (mg)	29 \pm 15	10-49	7
Phosphorus (mg)	24 \pm 19	12-66	7

Monkey-orange, pulp, raw (<i>Strychnos spinosa</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Copper (mg)	0.12 ± 0.19	0.02-0.46	5
Zinc (mg)	0.20 ± 0.08	0.12-0.29	6
Thiamine (mg)	0.23		1
Riboflavin (mg)	0.10		1
Niacin (mg)	1.4		1
Vitamin C (mg)	49	10 - 88	2

SD, standard deviation, calculated when the number of data points (n) ≥ 3;

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Strychnos spinosa fruit provides good values of vitamin C, as well as potassium, magnesium, zinc and copper. The values of most minerals vary greatly. This is largely due to differences in ripening stages, geographical regions as well as post-harvest handling. Next to vitamin C and minerals, the fruit has high levels of vitamins from the B-complex, such as thiamine, riboflavin and niacin. These vitamins are important coenzymes in the metabolism of amino acids and carbohydrates in the body.



Season: Flowers from April to May and November to December. Fruits in August in Kitui and Kwale; in November to December/January in Kilifi and Lamu; in Bungoma fruits in May to July and from January to February.



Cultivation: It is propagated from the seeds and produces root suckers. The seed has a hard coat but germinates well after treatment. Collected seeds are immersed in hot water, or the seed coat is burnt before sowing. Seed storage behaviour is orthodox, thus suitable for long-term storage. There are about 1800 seeds/kg. It grows relatively fast from seed and does well in cultivation. *S.*



spinosa can be best managed by pruning and coppicing. Roots suckers can be induced or encouraged by root pruning or injuring the roots. Naturally regenerated trees are left by farmers on farms when clearing land for cultivation of field crops. Mature trees bear abundant fruits, i.e., 300 to 400 fruits per tree per year.

Pests and diseases: No significant damage by any pest organisms has been documented. The tough outer shell of the fruit makes them resistant to fungi and fruit flies.



Commercial/market value: Not locally marketed in Kenya. The ripe fruit is rarely sold in local markets in Mombasa or Kilifi. Monkey oranges are an important indigenous African resource that supports farmers in times of crop failure and are a supplemental food in rural areas. In this way, promotion of monkey orange trees could potentially foster sustainable development in rural, sub-Saharan African communities. Monkey oranges have all the characteristics of a successful crop – high productivity, high

prices, extended shelf life, resistant to pests, delicious flavour and are in high demand. Their tough, outer shells protect them from being easily damaged during transportation and storage. They have an exceptional ability to remain edible in tropical heat for months after fruit maturity. Monkey oranges could be used to produce juices and fruit leather (dried fruit pulp) commercially. This fruit tree has even been introduced to Israel for potential commercial crop development.

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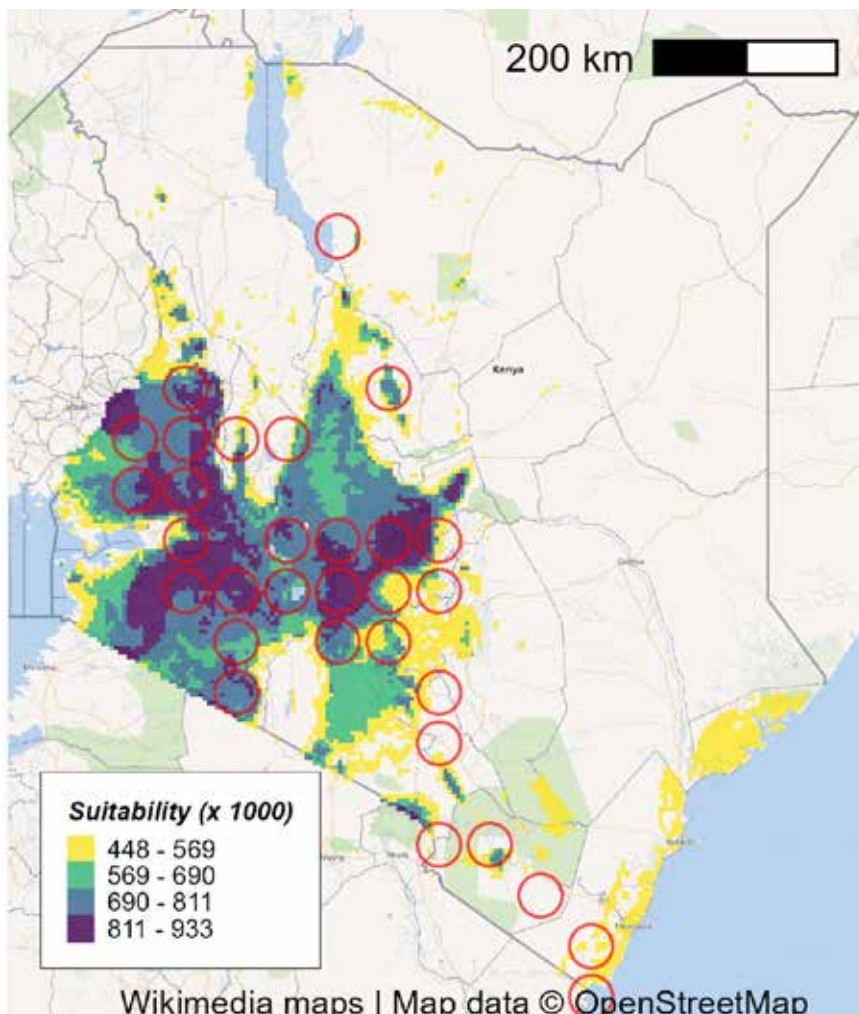
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22. *Syzygium guineense* (Willd.) DC.

MYRTACEAE

Common name: Water berry, Water pear, Guinea water berry

Local names: Kada (Borana); Muziahi/Muziyahe (Digo); Kivuena/Muvueni (Kamba); Mukoe/Ngoe (Kikuyu); Lamaiyat (Kipsigis); Kumusitole/Busitole/Omusitole/Obusitole (Luhya); Oleragai, Olairagai (Maasai); Lemaiyua (Marakwet); Muriru/Mukui (Mbeere); Muriru (Meru); Limaiyua/Lamayuet (Nandi); Lamaiyua/Lomaiwo (Pokot); Lamulii/Lairakai/Leperei (Samburu); Mzuari/Mzambarau (Swahili); Mkongo/Msu (Taita); Mase (Taveta); Lomoiwo/Lamaek/Lamaywet (Tugen).



Description and ecology: A densely leafy forest tree with a broad fluted trunk, rounded crown and drooping branches; usually growing 10–15 m in height, although it can reach 25 m or more along riverbanks. **Bark:** Smooth, light brown to grey when young, black and rough flaking in patches with age, red watery sap comes out if cut. **Leaves:** Dark green when mature, while young leaves purple/red, in opposite pairs, long tip, shape variable – some are rounded and some pointed (elliptic), shiny and smooth on both surfaces, with a short, grooved petiole. **Flowers:** Small, white, in dense showy heads, sweet fragrance attracts many insects. **Fruit:** Oval berries, purple/black and shiny when ripe, up to 3 cm long,

fruit in big bunches of 20–30. Seeds (1 per fruit) are 1.3–1.4 cm in diameter, yellow/brown and rounded.

The tree has a wide distribution in Kenya; it is mainly found in the Kikuyu escarpment, Karura Forest, Kakamega Forest, Mt Kulal, Nguruman, Kibwezi, Chogoria, Embu, Tambach, Kitale, Nyeri, Bungoma and Kwale in both high-altitude and riverine forests. It usually grows in moist conditions with a high-water table, sometimes even in water, and is usually found along streams and on rocky ground in high rainfall savannah. It grows at altitudes from sea level to 2100 masl.



Syzygium guineense – tree



Syzygium guineense – leaves



Syzygium guineense – bunches of ripe fruit

Uses: The ripe fruit of *S. guineense* is sweet, pleasantly flavoured and edible. The fruit pulp and skin are sucked, and the seed discarded. Fruit can be made into a sweet drink. Fruit pulp may also be made into jams, jellies, juice and puddings. Fruit is eaten by birds and monkeys. The wood is red, hard, strong and used as timber, for poles, posts, tool handles, as fuelwood and charcoal. Leaves serve as fodder. Bark can be used in the preparation of dyes and tannin. Flowers provide good bee forage. The bark and roots are used in traditional medicine to cure certain diseases. This handsome evergreen tree is preserved in gardens for its deep shade.

Syzygium cordatum Hochst. ex Krauss (Common names: Water berry tree, Red berry; Swahili:

Msambarau) is another related species to *S. guineense*. It is a medium-sized, evergreen tree 8–15 m high. In Kenya, it is found in Saiwa Swamp, Chepareria (West Pokot), Mbeere, in Bungoma along the river, in the swamps of Amboseli National Park, Nairobi and Thika. It thrives near water, along watercourses, in riverine thickets and forests along permanent streams, rivers or in swampy areas; at altitudes of 100–2500 masl. Its fruit is fleshy, oval to 1.5 cm long, purple when ripe, one seeded. The ripe fruit of *S. cordatum* is edible. The pulp is slightly acidic in flavour, can be eaten raw especially by children, and made into an alcoholic drink. Good quality jam and jelly can be produced from the ripe fruit. The fruit is also eaten by monkeys, bushbabies and birds.



Syzygium cordatum – unripe fruit and leaves



Syzygium cordatum – ripe and unripe fruit

Nutrient composition

Water berry, raw (<i>Syzygium guineense</i>) 100 g edible portion on fresh weight basis (EP)			
Component	Mean \pm SD	min-max	n
Energy ¹ kcal (kJ)	68 (288)		
Water (g)	81.9 \pm 1.9	80.2-84.0	4
Protein ² (g)	1.3		
Fat (g)	0.7 \pm 0.1	0.6-0.8	3
Carbohydrate, available ³ (g)	13.2		
Fibre, crude (g)	1.9	1.8-2.0	2
Ash (g)	1.0	0.7-1.4	2
Calcium (mg)	64	61-67	2
Iron (mg)	1.6	0.8-2.3	2
Potassium (mg)	163		1
Magnesium (mg)	34	24-44	2
Phosphorus (mg)	41		1
Vitamin C (mg)	12		1

SD, standard deviation, calculated when the number of data points (n) \geq 3;

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Water berry is a good source of calcium, magnesium and phosphorus; potassium is comparatively low. With 11.9 mg/100 g EP, its vitamin C content is moderate. Data on other vitamins are scarce in the literature and hence no further evaluation on the micronutrient content was possible.



Season: *S. guineense* flowers from March to June and fruits from May to July whereas *Syzygium cordatum* flowers from March to May and fruits in April to July.



Cultivation: *Syzygium* species can be propagated by direct sowing at the site (best method) or seedlings (sow seeds in pots). Seed needs no pre-



sowing treatment but removing flesh and washing in water before sowing enhances germination. Germination rates are good and uniform. Rates of 80–90% are attained after 20 to 50 days. The species regenerates adequately in its natural habitats by seed. Fruit is perishable hence should be picked up from the ground soon after falling in order to obtain fresh seeds. They may also be collected by shaking the branches with hooks. After collection, the seeds should be sown out immediately as they will lose viability if dried (i.e., they are recalcitrant); if this is not possible, fruit can be stored for a few days in moist sawdust and open containers in well ventilated rooms. On

average, there are 2400 to 3700 seeds/kg.

S. guineense is planted on cleared sites, tolerates pollarding and is able to coppice. The species is sensitive to crown competition and is a strong light demander.

Syzygium cordatum seeds are also recalcitrant in nature, i.e., they cannot be stored and should not be dried. There are about 400–450 seeds/kg. Trees can be managed by lopping, pollarding, pruning and by coppicing. Pollarding is practised to produce close, rounded heads of young branches. *Syzygium cordatum* is a fairly fast-growing tree.



Pests and diseases: In *S. guineense*, fruit flies produce a wormy appearance on fruit. Leaf-eating caterpillars are also found and may be controlled by insecticides. Vervet monkeys eat buds and flowers. With regard to *S. cordatum*, larvae of different butterflies (*Charaxes protoctea* ssp. *azota*, *C. druceanus*, *Deudorix dinochares*, *D. diocles* and *D. antalus*) feed on the leaves.



Commercial/market value: The fruits of *S. guineense* are not yet sold in any market in Kenya, although it has potential to be sold fresh or processed, like fruits of the other *Syzygium* species. Fruits are, so far, directly collected from the tree and eaten as a snack, especially by children. Both species are suitable for domestication and should be grown in farms and homegardens because of their tasty, nutritious fruit.

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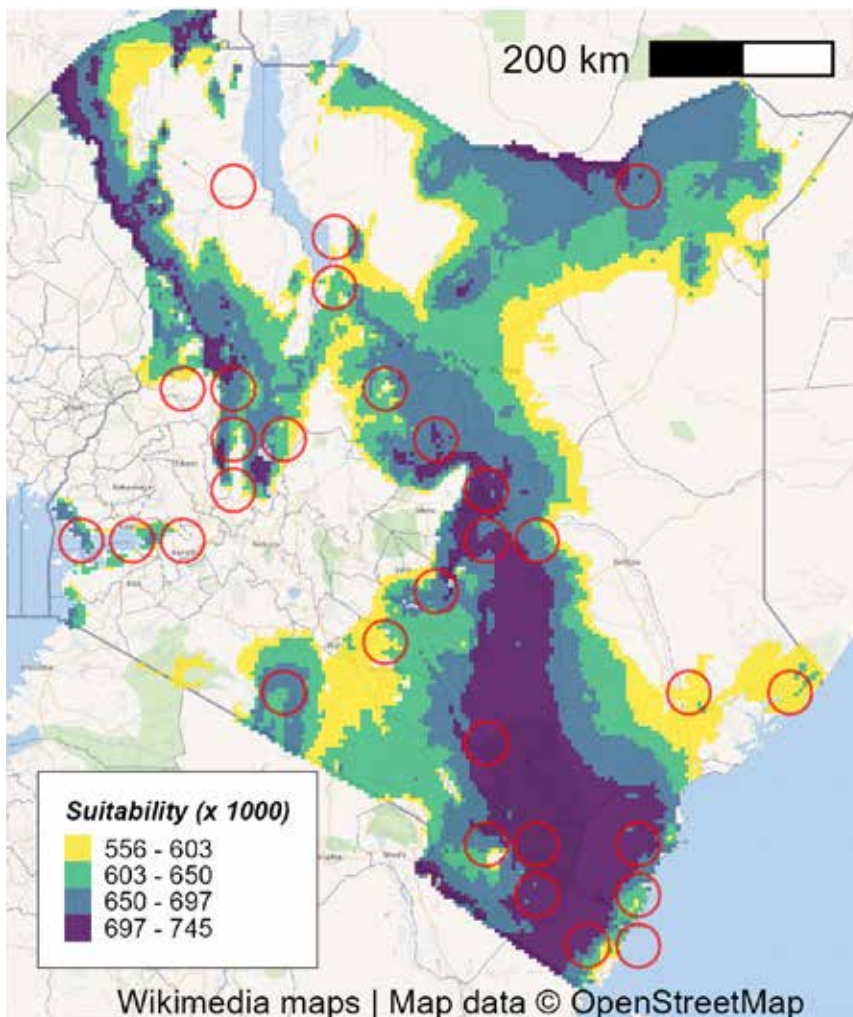
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23. *Tamarindus indica* L.

LEGUMINOSAE (CAESALPINIACEAE)

Common name: Tamarind

Local names: Ukwaja (Bajun); Mukai (Boni); Roka/Roqa (Borana, Orma); Mkwadzu/Mkwaju (Digo); Muthithi (Embu, Mbeere, Meru, Tharaka); Mkwaju/Kwaju (Giriama); Kikwasu/Kithumula/Nthumula/Nzumula/ Ngwasu (Kamba); Lamaiyet/Lemecwhet (Kipsigis); Kumukhuwa (Luhya); Ochwaa/Chwaa (Luo); Oloisijoi (Maasai); Aron/Oron (Marakwet); Limaiyua/Lamayuet (Nandi); Mkwayu (Pokomo); Arol/Oron (Pokot); Rogei (Samburu); Roge/Roqhe/Hamaar/Hamar/Raqee (Somali); Mkwaju/Ukwaju/Msisi (Swahili); Mkwachu (Taita); Mase/Muzumura (Taveta); Epeduru (Teso); Arwe/Aryek (Tugen); Epeduru (Turkana).



Description and ecology: A large tree, growing up to 30 m high, with an extensive, dense crown and drooping branches with short bole that measures about 1 m in diameter. It is either evergreen or deciduous in dry areas. **Bark:** Rough; grey-brown, flaking longitudinally. **Leaves:** Compound, on hairy stalks, up to 15 cm long, dull green, leaflets in 9–20 pairs, opposite, round at the tip and base, veins prominent, young leaves red. **Flowers:** Small, orange/yellow (petals yellow with red veins), in small bunches, flower buds red. **Fruit:** Green when unripe, pale brown when ripe, sausage-shaped pods, hairy, about 3–10 cm long, split when mature to reveal sticky brown pulp surrounding hard, shiny, dark red/brown 1–6 seeds.

It is commonly distributed in the drier parts of the coast (Malindi, Kilifi, Tana River, Watamu, Mombasa, Lamu) and in the dry northern, northeastern and southern parts of Kenya, e.g., Turkana, Lodwar, Migori, Baringo, Kitui, Kibwezi, Makueni, Ukambani, Tsavo East and Tsavo West National Parks, Garissa, Wajir and Mandera, usually along rivers and streams. It is commonly found growing in wooded grassland and bushland, also in open forest and riverine areas. In more humid semi-arid areas, this species is not restricted to riverine conditions. Commonly found on light clay, sandy and well-drained alluvial soils at altitudes from 0–1500 masl.

Uses: The edible fruit pulp is sour, has a very acidic taste and can be eaten raw; it is popularly used to flavour tea (among the Digo), curries and rice (coast); the pulp makes an excellent chutney and a pleasant refreshing drink. The pulp is dissolved in water and the solution used to prepare porridge, or added to stews or eaten with dried termites (Turkana); fruit pulp also used in preparing beer in Turkana. Young red leaves are chewed by Maasai, Luo–Migori or cooked as a vegetable (Boni). Hard seeds are fried and eaten. In some countries, the pulp is used in the preparation of jams, juices and sweets (South Africa and the Indian subcontinent). The dark brown heartwood is hard, tough and well grained; it is used in boatbuilding (dhows at the coast) and for making furniture, yokes and tool handles; it is also used to make stools, headrests (Turkana), pestles, mortars (Somali), poles, posts, carts and walking sticks and used for fuelwood and for making charcoal. Overripe fruit is used to clean copper and brass. The leaves serve as fodder for livestock including camels and goats. The tree is ideal for shade in hot areas, and is a very good medicinal plant (fruit, roots, bark and leaves). The leaves make a good mulch and the soil under trees is very fertile, it helps in soil conservation and enhances soil fertility.



Tamarindus indica – unripe fruit (left) and ripe (right) fruit pulp and fresh tamarind juice made of the pulp



Tamarindus indica – tree



Tamarindus indica – fruit and young leaves



Tamarindus indica – ripe fruit pulp made into delicious chutney served with traditional dishes in Kenya's coastal region



Ripe and unripe tamarind fruit made into spicy chutneys

Nutrient composition

Tamarind, pulp, ripe, raw (<i>Tamarindus indica</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy¹ kcal (kJ)	277 (1170)	
Water (g)	26.9	1
Protein² (g)	3.6	
Fat (g)	0.8	1
Carbohydrate, available³ (g)	61.3	
Fibre, total dietary (g)	5.1	1
Ash (g)	2.3	1
Calcium (mg)	192	1
Iron (mg)	3.1	1
Potassium (mg)	933	1
Magnesium (mg)	66	1
Phosphorus (mg)	87	1
Copper (mg)	0.42	1
Zinc (mg)	0.10	1
Vitamin A⁴ (mcg)	1	
β-carotene equivalents⁵ (mcg)	7	1
Thiamine (mg)	0.26	1
Riboflavin (mg)	0.14	1
Vitamin B6 (mg)	0.07	1
Niacin (mg)	1.0	1
Folate (mcg)	15	1
Vitamin C (mg)	11 (3-15)	2

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Tamarind fruit pulp dehydrates to a sticky, brown paste during the ripening process. When fully ripe, the fruit contains only around 30% water, but 60% available carbohydrates, out of which the majority is total sugars. Due to the low water content, ripe tamarind has a high concentration of minerals and is a good source of iron, potassium and calcium. Vitamins from the B-complex are also present, while vitamins A and C levels are low.



Season: Flowers in April to May and in September to November. Fruits in July to August and January to February.



Cultivation: Tamarind can be propagated using seeds or by grafting (cleft/whip grafting), shield and patch budding, stem cuttings and air layering or marcotting. If one intends to use seeds for propagation, then seed pre-treatment is required to speed up germination. This pre-treatment involves soaking seeds for 12 hours in cold water or nicking the seed. The germination rate is about 90% after pre-treatment. Seeds can be stored for long periods but are susceptible to attack by weevils. There are about 350–1000 seeds/kg. Seedlings should grow to at least 80 cm before being transplanted to their final location at the beginning of the rainy season. Good mother trees with superior characteristics should be chosen for vegetative propagation, e.g., grafting or marcotting.



T. indica is a slow growing but long-lived tree. When establishing a pure plantation, the final spacing should be at least 13 x 13 m to allow for intercropping. The distance can be reduced with vegetatively propagated plants (spacing of 8–10 m), as they do not attain the same size as seeded trees. Vegetative propagation is also beneficial as the smaller trees produced are easier to harvest and bear



fruit from the fourth year. The pod yield at this time is 40 kg/tree but when it reaches 10 years of age, it can yield 100 kg/tree. The tree may remain productive until it reaches an age of 50–60 years, yielding up to 150 kg/tree or over 2 tonnes/ha a year. Pollarding, coppicing and pruning are recommended management strategies.

Pests and diseases: Several species of scale insects and mealybugs attack tamarind trees. Pest attack is very serious in fruits and seeds, e.g., by numerous species of fruit and seed borer beetles as well as by seed weevils and grain borers. Control methods at producer level are lacking and heavy post-harvest losses are reported. Destruction of the pulp by insects and mould fungi during storage is also a big problem.



Commercial/market value: In Kenya, much of the tamarind trade is local. However, some of the fruit is exported to Yemen, Zanzibar and Somalia. Most of the market outlets in Kenya are in Kitui, Tharaka, Mwingi, Kibwezi, Siaya, Lodwar, West Pokot, Baringo, Marimanti and Mwingi. Grade 2 (seedless) tamarind pulp appears to be preferred domestically and internationally compared to grade 3 (seeded) tamarind pulp, thus farmers are able to obtain more money when they process their fruits into grade 2 tamarind pulp. Whole tamarind fruits of 'sweet' varieties are imported to Kenya from Thailand and sold at high prices in some supermarkets in Nairobi. Growing improved tamarind varieties in Kenya and processing the fruits into more high-quality products should be considered.

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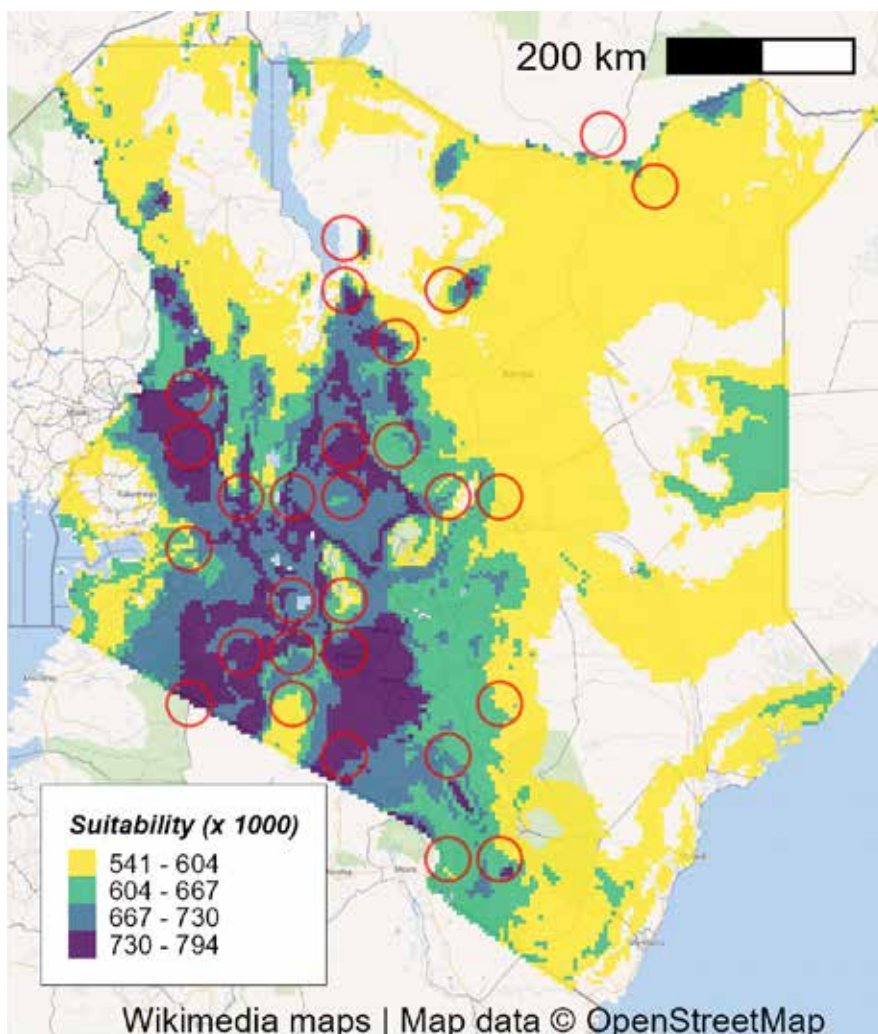
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24. *Vangueria madagascariensis* J.F. Gmel.

RUBIACEAE

Common name: Common wild medlar

Local names: Buriri (Borana-Moyale); Kikomoa/Mukomoa/Ngomoa (Kamba); Mubiru/Mbiru (Kikuyu), Kimolwet/Kimolonik (Kipsigis); Omokomoni/Enkomoni/Chinkomoni (Kisii); Kumukhasi/Kumukomosi (Luhya-Bukusu); Mukhomoli (Luhya-Maragoli); Apindi/Anyuka (Luo); Olgumi (Maasai); Komolwo/Komol (Marakwet); Mubiru (Mbeere, Meru); Komolwo (Pokot); Irigormosso (Rendille); Lkormosiyoi/Lkoromosien (Samburu); Mviru (Swahili); Mdaria (Taveta); Komolwo, Komolik (Tugen).



Description and ecology: A multi-stemmed deciduous shrub that grows up to 4 m high, rarely a small tree up to 6–8 m. **Bark:** Smooth, pale to dark grey, becomes scaly when old. **Leaves:** Large, shiny green, opposite, with or without hairs, older leaves are hairless, crowded at the end of branches, broadly oval to 20 cm, usually smaller, with wavy margin and clear veins below. **Flowers:** Small, up to 8 mm long, green/yellow, borne on a branched inflorescence. **Fruit:** Rounded, up to 4.5 cm across, unripe fruit shiny green, turning brown when ripe, often in bunches of a few, containing 4–5 hard, brown seeds, up to 1.5 cm long. The dry fruit is grooved like a pumpkin.

In Kenya, *Vangueria madagascariensis* is widely distributed in riverine bushland, bushland and bushed grassland, evergreen forests and forest margins; it sometimes grows on rocky outcrops and termite mounds. It grows naturally in riverine-lowland forests and in *Brachystegia-Combretum* woodland. The species is fire-sensitive; it is found in Kitui, Kiambu, Narok, Baringo, Narok, Marsabit, Nyambeni Hills, Mbeere, Taita, West Pokot, Mwala, Machakos and Uasin Gishu; from 0–2400 masl; on sandy, red clay or sandy clay soils.



Vangueria madagascariensis – ripe and unripe fruit



Vangueria madagascariensis – multi-stemmed shrub



Vangueria madagascariensis – ripe open fruit with edible dry pulp and seeds

Uses: The fruit pulp of *V. madagascariensis* is sweet, with a slight acidic taste; the hard skin is removed, the pulp sucked, and seeds discarded. Wood used as fuelwood, for making tool handles, carvings, for construction and poles (centre pole for building huts by the Kamba community). Fruit is eaten by elephants. Tree is used as medicine (roots and bark), and for shade, as ornamental and bee forage.

Vangueria infausta subsp. *rotundata* (Robyns) Verdc. (Common names: False medlar, Wild medlar,

African medlar; Swahili: 'Mviru'; Meru: 'Mubiru') is another common species that belongs to the family Rubiaceae. It is a deciduous, multi-stemmed, bushy, and hairy shrub, or less often a small tree, rarely exceeding 5–6 m; with a short trunk and hanging branchlets. It is widely distributed in Kenya in a variety of habitats such as bushland, especially along streams, dry forests, forest fringes, woodland, grassland with scattered trees and rocky bushland. It is found along the southeastern slopes of Mt Elgon and in Kibwezi, Machakos, Embu and Nairobi. This species does well in open and partially shaded areas, especially under acacias; it grows at 0–2450 masl; it prefers well-drained soils but can be found in waterlogged areas during the rainy season. Fruits are rounded, glossy, about 4 cm across, hanging below the leaves, green when young, and brown when ripe. Ripe fruit of *V. infausta* enclose brown edible pulp and about 4 seeds; ripe fruit are much relished. Fruit pulp is sucked, and the skin and seeds discarded. Dry fruit may be stored for over a year without losing the sweet acidic taste. Ripe fruits are fermented and made into a local brew. To soften outer tough skin, soak the fruit in water overnight. Pulp is added to milk or water to make a special porridge for children (among the Maasai).



Vangueria infausta – ripe open fruit with edible dry pulp and seeds



Vangueria infausta – dry ripe fruit



Vangueria infausta – multi-stemmed shrub

Nutrient composition

Wild medlar, pulp, raw (<i>Vangueria infausta</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean	min-max	n
Energy ¹ kcal (kJ)	114 (438)		
Water (g)	69.0	64.4-73.5	2
Protein ² (g)	1.5		
Fat (g)	0.4	0.1-0.7	2
Carbohydrate, available ³ (g)	24.3		
Fibre, crude (g)	3.7	2.7-4.7	2
Ash (g)	1.2	0.9-1.4	2
Calcium (mg)	14	3-25	2
Iron (mg)	4.3	1.1-7.5	2
Potassium (mg)	502	483-521	2
Magnesium (mg)	44	39-48	2

Wild medlar, pulp, raw (*Vangueria infausta*)*100 g edible portion on fresh weight basis (EP)*

Component	Mean	min-max	n
Phosphorus (mg)	29	22-37	2
Zinc (mg)	0.24		1
Thiamine (mg)	0.04		1
Riboflavin (mg)	0.03		1
Niacin (mg)	0.6		1
Vitamin C (mg)	5		1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

There is a lack of food composition data on *Vangueria madagascariensis*. Hence the table presents values on *Vangueria infausta*. The fruit is a good source of minerals, particularly potassium, magnesium and iron. It also contains moderate values of the B-vitamins thiamine, riboflavin and niacin, but is not a good source of vitamin C.



Season: *V. madagascariensis* flowers in January to February and fruits in April to May in Kitui, Kiambu, Nairobi and Narok. It flowers in May and June and fruits in August and September in Baringo, West Pokot, Embu and Meru. *V. infausta* flowers are usually produced in April to May in central and eastern Kenya and in August to October in the western parts of the country, while fruits are available from August to October and January to February.



Cultivation: *V. madagascariensis* can be propagated from seed. Seed germination is difficult because of its hard coat. The ripe fruit is persistent and must be picked directly from the tree. Seeds should be sown immediately after collection. They germinate well



but sporadically (taking up to 6 weeks); nicking the seed or soaking it in cold water overnight may hasten germination. Seeds can retain viability for a year if they are dried properly. There are 500–600 seeds/kg.

V. infausta can be propagated by seed, from cuttings and by root suckers. The seeds are taken out of the pulp, dried and beaten to weaken the hard seed coat before planting. Soaking overnight in cold water may speed up germination. Seeds germinate in 3 to 4 weeks. Germination rate is good (usually 80% or more). Transfer seedlings to nursery bags when they reach the 3–leaf stage and keep them for at least a year before planting them into the field. Cuttings can be made from the present year's growth, but they must be treated with a root-stimulating hormone powder.

Coppicing, pruning and pollarding are suitable management practices for *Vangueria* species. The species is mostly found semi-cultivated on farms. Since it is a light demander, the planting area

should be cleared of other vegetation. Weed around the young tree regularly until it is well established.



Pests and diseases: Fruit-eating birds feast on the abundant ripe fruit, sometimes leaving only the fruit skin on the tree. Small gall-like growths that may appear on the leaf surfaces are caused by a species of fungus.



Commercial/market value: In Kenya this fruit has not yet been commercialized although there is a great potential to do so as it is highly nutritious. Priority should be given to the exploration, collection and promotion of both production and value-addition technology of these species. For example, a strong alcoholic drink or brandy can be distilled from the fruit, or it can be fermented to make beer and vinegar. If mixed with a little water and sugar, it produces an acceptable substitute for applesauce. The fruit juice can also be used for flavouring (e.g., for porridge) by squeezing it out in water and discarding the seed and skins.

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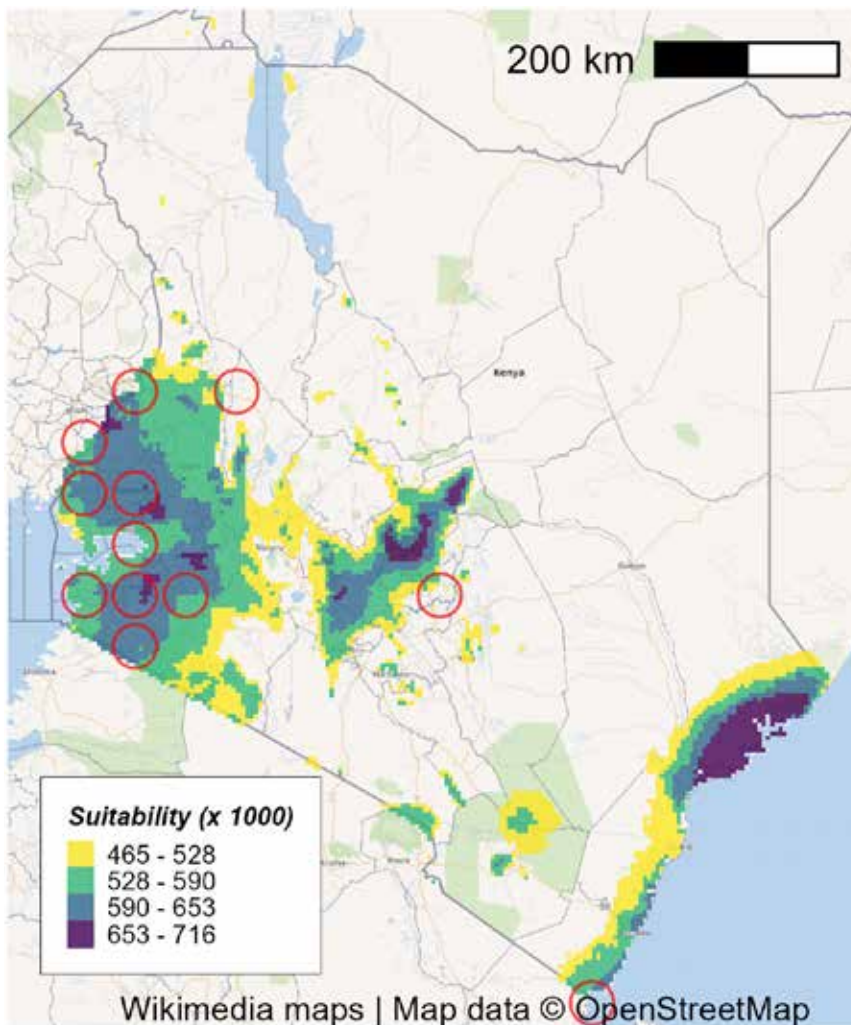
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25. *Vitex doniana* Sweet

LAMIACEAE

Common name: Black plum, Vitex, African oak

Local names: Muhuru (Kikuyu); Mulkelwet (Kipsigis); Mutahuru (Kisii); Kumufutu/Chifutu (Luhya- Bukusu); Muholu/Kumufuu/Omufuu (Luhya); Oyuelo/Jwelu (Luo); Muburu (Mbeere); Tirkirwa (Pokot); Mfuu/Mfudu (Swahili); Ewelo/Ekarukwei (Teso).



Description and ecology: A semi-deciduous forest tree, growing 4–14 m, with a rounded crown and a clear bole. **Bark:** Pale brown or grey/white, with long fissures and scales. **Leaves:** Compound, 5-leaf, digitate (finger-like), opposite, leathery, shiny, terminal leaflet to 15 cm long, lower leaflets smaller, stalked, tip rounded or sharp. **Flowers:** Cream to white with one hairy mauve lobe, scented, in long-stalked bunches up to 9 cm. **Fruit:** Hard drupe,

marked with white dots, oblong, up to 3 cm, green, black when ripe, up to 4-seeded.

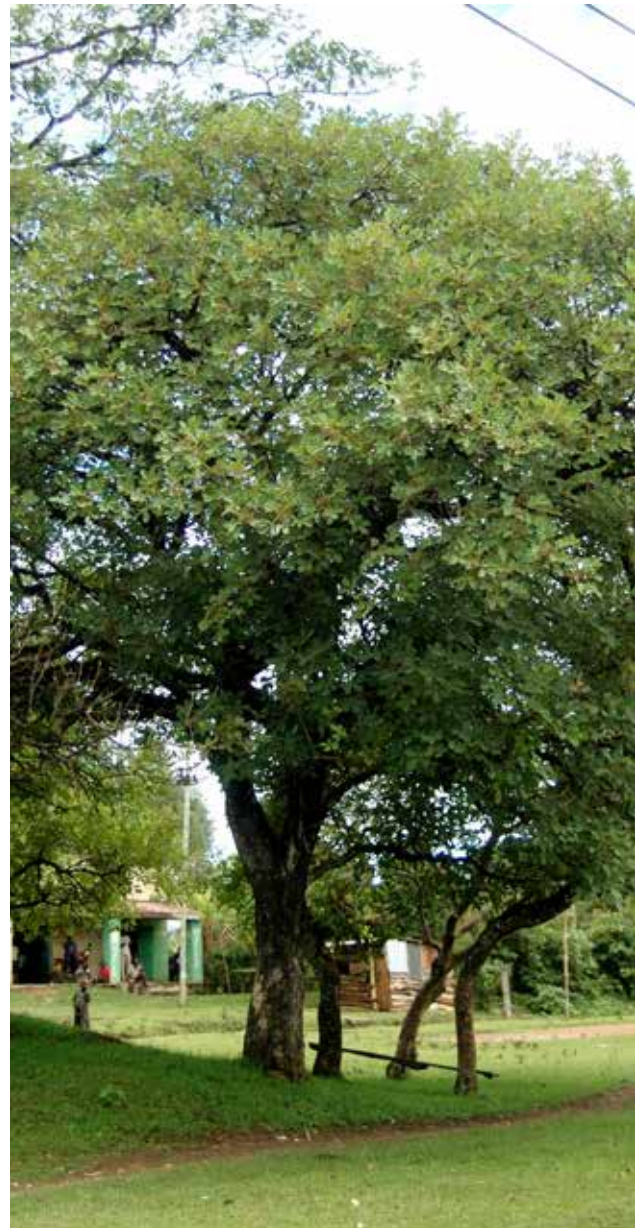
The tree is commonly found in the western region of Kenya. It is also found in central parts of the country, but is rare around the south coast. It is a tree of wooded grassland, often in coastal woodlands and forest edges. It occurs on a variety of soils, but usually on alluvial soils; mostly growing at altitudes from 1200–1950 masl.



Vitex doniana – leaves



Vitex doniana – ripe and unripe fruit and leaves



Vitex doniana – tree

Uses: The ripe black fruit pulp of *V. doniana* is edible; it has a sweet taste and is frequently eaten as a snack. The seeds are roasted and used to make a coffee-like drink. Fruit pulp can be used in making jams and wine. Syrup made from the fruit pulp can be used instead of other syrups as a nutritive sweetener. The wood is yellow/white, termite resistant, with an even grain, easy to work and reasonably durable; it is used for fuelwood, charcoal, poles, construction and making furniture, dhow ribs and small canoes and hanging beehives. Leaves, fruits and seeds serve as fodder for livestock; the ripe fruit is eaten by monkeys. The tree is used for bee forage, shade, mulch and to mark boundaries.

Vitex payos (Lour.) Merr. (common name: Black plum, Chocolate berry; Swahili: 'Mfudu', 'Mfuku') is another

edible fruit species of the Genus *Vitex*. It is a small, deciduous tree that grows up to 8 m high, with a low, sparsely branched and rounded crown and square branchlets. In Kenya, it grows in hot, low and semi-arid areas, in the more arid zones found near rock outcrops, in wooded grasslands, or acacia woodlands in Kitui, Embu, Machakos, Makueni, Kilifi and Kwale (at 0–1600 masl); often on sandy soils, less often on red soils or rocky ones. Fruit is oblong, 3 cm long, first green, marked with white dots, chocolate brown or black when ripe, with edible sweet, starchy black pulp around a single hard seed. The black pulp of the fruit is eaten raw. It is often used to make jam. The fruit juice can be used to produce a beverage; the boiled fruit is the basis for an alcoholic liqueur and wine. The seeds inside the fruit stone are also edible.



Vitex payos – ripe and unripe fruit



Vitex payos – unripe fruit hanging on the tree



Vitex payos – tree

Nutrient composition

Black plum, pulp, raw (<i>Vitex doniana</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean	n
Energy ¹ kcal (kJ)	112 (476)	
Water (g)	70.1	1
Protein ² (g)	0.4	
Fat (g)	0.3	1
Carbohydrate, available ³ (g)	26.3	
Fibre, crude (g)	1.4	1
Ash (g)	1.5	1
Calcium (mg)	21	1
Iron (mg)	1.3	1
Potassium (mg)	637	1
Magnesium (mg)	17	1
Phosphorus (mg)	77	1
Thiamine (mg)	0.14	1
Riboflavin (mg)	0.02	1
Niacin (mg)	0.4	1
Vitamin C (mg)	0-20	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Black plum contains good amounts of potassium and phosphorus, and moderate values for calcium, magnesium and iron. Vitamin C ranges from 0 to 19.6 mg/100 g EP. This can be due to differences in post-harvest handling, storage conditions or ripening stages. Vitamin C is labile to heat and light, thus its content decreases easily.



Season: *V. doniana* flowers in May to June and fruits in July to August in Kakamega and Homa Bay. Whereas in Bungoma it flowers from September to October and fruits from December to February. *V. payos* flowers in November



to December in Machakos, Makueni and Embu and in March and September or October in Kwale and Kilifi. This species fruits in April to June in Kitui, Machakos, Makueni and Embu.

Cultivation: *Vitex* species can easily be propagated from seed by direct sowing at site and by root suckers. Collected seeds need treatment before sowing. For treatment, remove the fleshy part of the fruit and immerse the stone in warm (not very hot) water; allow cooling and soaking for 24 hours. This species has an



orthodox seed storage behaviour; moist storage of seeds at 3–5°C for up to one year is possible. However, fresh seeds produce better results. There are about 1000–1100 seeds/kg. Several seedlings may germinate from one fruit. For natural regeneration, forest fires may help break the seed coat before germination.

V. doniana has a medium growth rate. Pruning is a suitable management practice to get a clear bole. A single tree can yield much fruit.



Pests and diseases: Some *Vitex* species are attacked by the fungus *Armillaria mellea* that results in a black resin on the stems of some trees. This is not a threat to the establishment of the species; however, it can be controlled by uprooting the affected trees during the first thinning operation. Various animals may damage the trunk, exposing it to drying and fungi.



Commercial/market value: *V. doniana* is one of the most widespread and useful *Vitex* species in East Africa. The fruit is not sold in local markets in Kenya. The sweet ripe black fruit is usually collected from the wild and eaten raw as a snack. This species is not protected or cultivated by local farmers. It is one of the underutilized fruit species which can be domesticated, cultivated and/or improved and processed. In Tanzania, fruits are sold in local markets in Songea, Iringa, Tabora and Kigoma.

V. payos fruit, the “real” chocolate berries, are very popular in parts of southern and eastern Africa, e.g., in Malawi, Mozambique and Tanzania. Since 1990, Zimbabwean entrepreneurs have been manufacturing jam from the fruit and selling it in city markets. In Kenya, fruits

are sold in Kitui, Mutomo and Mbeere (Ishiara). In order to increase farmers’ income, this fruit species should be domesticated and cultivated at farm level. Appropriate processing technologies need to be developed to add value to the products.

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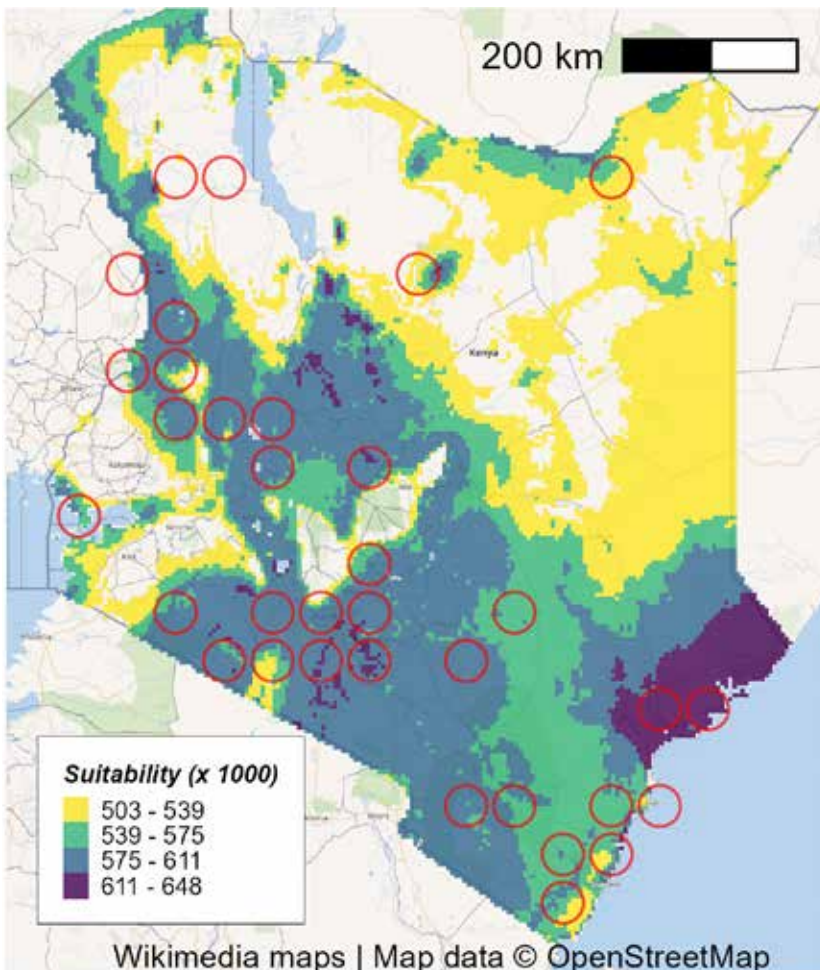
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26. *Ximenia americana* L.

OLACACEAE

Common name: Wild plum, Sour plum, False sandalwood

Local names: Mchunda-kula (Bajun); Uda/Odda/Dabobes (Borana); Mtundukula (Digo); Mtundukula/Tundukula (Giriama); Lama (Ilchamus); Mutula/Ndula (Kamba); Mutura/Mutuura (Kikuyu, Mbeere); Muruli (Luhya); Kumutuli (Luhya-Bukusu); Olemo/Olemb ochok (Luo); Ol-amai/Engamai (Maasai); Kinyat/Kunyotwo (Marakwet); Muthoroma/Ndoroma (Meru); Huda hudo (Orma); Kinyotwo/Kinyat (Pokot); Lamai (Samburu); Murcud/Mandurcet (Somali); Mtundukula/Mpingi (Swahili); Mtundukula/Ndudukula (Taita); Olimu/Elamai (Teso); Muroroma (Tharaka); Elamai (Turkana).



Description and ecology: A spreading, usually scrambling spiny shrub, or small tree, up to 4–6 m high, but commonly less than 4 m high, often armed with thin and straight spines up to 1 cm long, with branches usually arching down. **Bark:** Grey, grey/brown or black, smooth in young trees, rough and fissured with age. **Leaves:** Simple, alternate, often in tufts on short shoots, oblong, to 6 cm long, densely hairy when young, blue/green in colour, tip round or notched. **Flowers:** Dioecious species, flowers small, 0.5–1 cm long, solitary or in clusters, in axils of spines, white/green, sweet scented. **Fruit:** Oval, shiny drupe, thin skinned, 2.5–3 cm long; light green turning yellow, orange or red on ripening. Each fruit contains one seed. Seeds are about 1.5 cm x 1.0 cm in diameter.

It is widely distributed in Kenya; it is mostly a solitary tree dispersed in diverse habitats from scattered thorn bush in semi-arid zones, rocky/stony hilly areas, savanna bushland, woodlands, wooded grassland and coastal bushland. In Kenya it is found in the lower parts of the Eastern region (Kibwezi, Kitui, Machakos), along the coast (Kilifi and Malindi), Kajiado, Baringo, Bungoma, West Pokot, Nyanza, the Rift Valley and in southern Turkana; at altitudes of 0–2000 masl. *X. americana* is drought-resistant. It

is found on many kinds of soils – usually poor and dry, including clays, clay loams, loamy sands, sandy clay loams and sands.

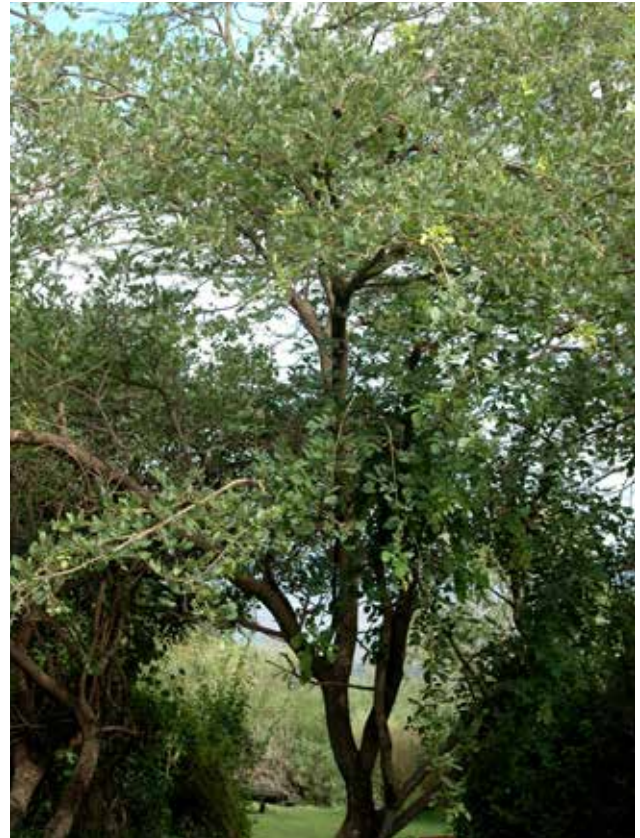
Uses: The sweet but slightly acidic fruit pulp is edible. Ripe orange/red fruit are collected and eaten fresh. The thin outer skin is removed, the fruit pulp sucked, and seed discarded. The fruit pulp is sweet but tart and very tasty when fully ripe. It is eaten as a snack. The fruit can also be used to make juice, jams and jellies. Kernel oil can be used as vegetable butter and as a substitute for ghee. Young leaves are said to be edible after thorough cooking. In South Africa, the fruit has been used to make some kind of beer. Its wood is hard and of good quality, and is used to make poles, rafters, tool handles and utensils; also used for fuelwood and charcoal. The heartwood contains an essential oil used for fumigation. Its bark and roots are a source of dye. Trees are also used for bee forage. The flowers have an essential oil that could be a good substitute for orange blossom. Leaves and fruit are eaten by livestock. The seed oil is smeared on wood and metal and the inside of honey drums as a preservative; roasted seed oil is used in tanning leather. Seed oil is used to treat dry and cracked skin on the feet. The tree also provides ornamental shade and is grown as a live fence.



Ximenia americana – branches with ripe and unripe fruit



Ximenia americana – ripe fruit



Ximenia americana – tree

Nutrient composition

Wild plum, raw (<i>Ximenia americana</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy ¹ kcal (kJ)	135 (572)	
Water (g)	64.8	1
Protein ² (g)	2.8	
Fat (g)	0.8	1
Carbohydrate, available ³ (g)	28.5	
Fibre, crude (g)	1.2	1
Ash (g)	1.9	1
Calcium (mg)	8	1
Iron (mg)	1.3	1
Potassium (mg)	718	1
Magnesium (mg)	31	1
Phosphorus (mg)	34	1
Copper (mg)	0.28	1

Wild plum, raw (*Ximenia americana*)*100 g edible portion on fresh weight basis (EP)*

Component	Mean	n
Zinc (mg)	0.68	1
Vitamin C (mg)	84 (70 – 98)	2

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Wild plum is rich in vitamin C. 100 g EP of the fruit can meet almost twice the recommended daily intake of vitamin C⁷. Moreover, *Ximenia americana* contains high levels of potassium, while calcium is extremely low. Potassium serves as electrolytes in the body and is crucial for maintaining total body fluid volume and normal functioning of cells. *Ximenia americana* contains considerable amounts of bioactive compounds such as overall flavonoids and anthocyanins, which have antioxidant capacity. More research on that is however needed.



Season: Flowers from October to February and fruits from December to February in Bungoma. Fruits in July to August at the coast but sometimes fruit can be collected in December as well.



Cultivation: *X. americana* is propagated through seeds and cuttings. Seeds collected from the wild should be sown fresh to ensure good germination. Germination rate is 50–60%. Pre-treatment of the seed is not necessary. Seed storage behaviour is recalcitrant, and therefore seeds cannot be stored for long periods. There are about 1400 seeds/kg. Plants are sometimes semi-parasitic, i.e., able to take water and nutrients from other plants through the roots, but they



are not dependent upon this for survival. Seedling plants can commence fruiting when they are 3–4 years old. Plants can flower and fruit on several occasions each year. It is a dioecious species, i.e., both male and female trees need to be grown for fruit harvest.

X. americana is a slow-growing species. Coppicing and pruning are recommended management practices. Regeneration in natural forests is very sparse, so partial protection of its natural habitat could promote natural regeneration. Regular trimming is necessary if the tree is to be grown as a live fence.



Pests and diseases: *X. americana* are susceptible to attack by caterpillars, beetles and blight diseases, but detailed information is lacking.

Commercial/market value: The fruit is a very important food in arid zones, but is not sold in markets in Kenya. This is an underutilized fruit tree with high potential in lowland areas and should therefore be promoted for domestication and cultivation.

⁷ Calculations based on recommended nutrient intake (RNI) for vitamin C, adults (19 to > 65 years): 45 mg/d; (3) RNI for folate, adults (19 to > 65 years): 400 mcg/day. www.fao.org/nutrition/requirements/vitamins/en/

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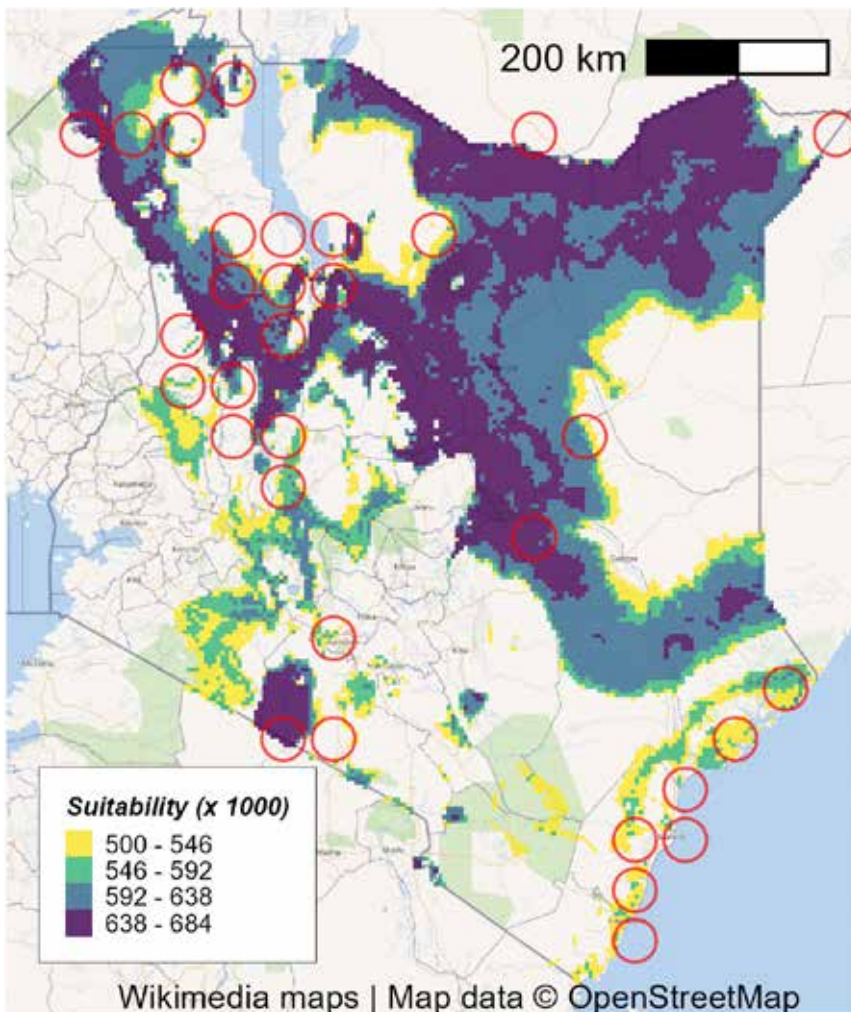
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27. *Ziziphus mauritiana* Lam.

RHAMNACEAE

Common name: Indian plum, Jujube, Chinese plum

Local names: Kurkurrah/Quaqura (Borana); Mukunazi (Digo); Mukunazi/Kunazi (Giriama); Lmampai/Imampai (Ilchamus); Olongo (Luo); Oloilalei (Maasai); Tilomwo/Tilam (Marakwet); Tilomwo/Tlomwo/Tilam (Pokot); Gab (Rendille); Ilerendei (Samburu); Goob/Gob/Gup (Somali); Mkunazi/Mukhalita (Swahili); Esilang (Teso); Tilomwo/Chepkomonit (Tugen); Ekalale/Ngakalalio (Turkana).



Description and ecology: A thick-branched, spiny shrub or tree, reaching 7–10 m in height, with drooping angular branches and a rounded crown. Branchlets are zigzag and hairy when young. **Spines:** Brown, in pairs, one straight, the other curved. **Bark:** Silver/grey in young trees, dark brown and fissured when old. **Leaves:** Alternate along the stem, oval; small, hairless above, hairy beneath, soft, shiny yellow/green above and white below, 3 veins arise from the base, leaf base rounded and equal-sided. **Flowers:** Small, green/yellow, star-shaped, clustered in leaf axils; on hairy stalks; sweet-scented. **Fruit:** A drupe, rounded, up to 1–2 cm in diameter, unripe fruit is green, turning cream/yellow to shiny red/brown when ripe. The fruit consists of a large, hard, round-

or oval-shaped stone, 6–8 mm long, surrounded by a white fleshy pulp.

Z. mauritiana is widespread in the arid and semi-arid areas of Kenya including Kibwezi, Baringo, Turkana, Samburu, Kajiado, West Pokot and Lodwar, but is also found in humid areas of the coast in Kilifi, Malindi, Lamu, Mombasa, Kwale, and in riverine vegetation in dry areas, flood plains, dry bushland; it is often found in disturbed areas or cultivated land and is widely naturalized in the tropics. It grows in open areas in sandy to black cotton soils, prefers well-drained sandy loams and alluvial soils, at 0–1600 masl, usually in areas with an annual rainfall of 300–500 mm. It is known for its ability to withstand adverse conditions such as salinity, drought and waterlogging.



Ziziphus mauritiana – tree



Ziziphus mauritiana – fruit packed and sold along the roadside in Kilifi



Ziziphus mauritiana – dried fruit sold in the local market in Makueni



Ziziphus mauritiana – fruit hanging on the branches

Uses: The fruit is a very important food in arid and semi-arid areas. The sweet fruits are collected and eaten fresh as a snack. The dry creamy fruit pulp is eaten directly or made into a thirst-quenching drink and a potent alcoholic spirit. The fruit can also be dried, stored and eaten during famine periods. Among the Turkana and Pokot, large amounts of fruit may be collected, dried, pounded and sieved. The fine powder can be used as emergency food during the drought seasons. The young leaves are cooked as a vegetable. The leaves and fruit make good fodder for goats and camels. The wood is hard, heavy, termite-resistant, and used at the coast for making beds and dhow ribs; also used for poles, bows and arrows, making furniture, walking sticks, stools, as carving

material and for fuelwood and charcoal. The thorny shrub is ideal as a live hedge and for fencing; it also serves as a shade tree and windbreak and is valuable as bee forage, for its role in soil conservation and for the resin, gum, tannin and dyes it yields. The tree is excellent in soil erosion control, especially along riverbanks.

Ziziphus mucronata Willd. is a closely related species, commonly known as Buffalo thorn; in Swahili it's known as 'Mkunazi'. A scrambling shrub or small tree that grows up to 7–8 m high, with drooping, tangled branches, and strong, sharp thorns. It is widespread in the drier parts of Kenya, e.g., widely distributed from the coast to Nyanza region, as well as in the north along dry riverbeds, in bushland, woodland and

wooded grassland, at 0–1950 masl. Fruit appears in stalked bunches, each up to 2 cm across, rounded, green, turning glossy, dark red when ripe. Dark red/brown fruit contains creamy pulp which is edible. The pulp is dry with a sweet, slightly bitter taste. Each fruit

encloses a large stone with very hard seeds. The fruits are used by local communities to make porridge or beer if properly fermented. The seeds can be ground and used as a coffee substitute.



Ziziphus mucronata – ripe semi dried fruit, fruit pulp and seeds



Ziziphus mucronata – tree



Ziziphus mucronata – leaves and ripe fruit

Nutrient composition

Jujube pulp, raw (<i>Ziziphus mauritiana</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy¹ kcal (kJ)	78 (331)		
Water (g)	79.5 ± 5.2	75.9-88.6	5
Protein² (g)	1.6		
Fat (g)	0.4 ± 0.2	0.3-0.7	5
Carbohydrate, available³ (g)	16.3		
Fibre, crude (g)	1.4 ± 0.3	1.1-1.7	5
Ash (g)	0.7 ± 0.1	0.7-0.9	5
Calcium (mg)	42 ± 14	23-57	5
Iron (mg)	0.7 ± 0.2	0.4-1.0	5
Potassium (mg)	425 ± 101	256-514	5
Magnesium (mg)	20 ± 2	19-22	5
Phosphorus (mg)	25 ± 7	19-35	5
Copper (mg)	0.2 ± 0.1	0.01-0.2	5
Zinc (mg)	0.1 ± 0.1	0.03-0.1	5
Vitamin A⁴ (mcg)	17		
β-carotene equivalents⁵ (mcg)	102		1
Thiamine (mg)	0.03		1
Riboflavin (mg)	0.10		1
Niacin (mg)	0.8		1
Vitamin C (mg)	35 ± 8	27- 44	4

SD, standard deviation, calculated when the number of data points (n) ≥ 3;

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A activity expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Jujube is a nutritious fruit containing high levels of minerals. In addition, vitamins from the B-complex are well represented. The fruit is a source of vitamin C and contains some β-carotene.



Season: *Z. mauritiana* flowers in January in Garissa, May in Mandera, Turkana and Marsabit, August in West Pokot, Turkana and Marsabit and November in Kwale. It fruits in September to October in Turkana, Marsabit and

Lamu and March to April in Kilifi and Mombasa. *Z. mucronata* flowers from February to April and fruit can be collected from May to August.



Cultivation: *Ziziphus* species can be propagated by seeds, grafting and cuttings or using root suckers. Germination rates are low unless seeds are either soaked in cold water, or the hardcover of the stone is carefully cracked prior to sowing. Seeds are orthodox; thus viability can be maintained for 2 years in hermetic air-dry storage at 5°C. The germination rate increases during the first year of storage. The cleaned stones can even be kept for 5 years in sealed containers, although during this period the viability drops from 95% to 30%. *Z. mauritiana* has 2000–3300 seeds/kg. Due to its difficulty in germination by seeds, *Z. mauritiana* is grown through tissue culture technology for mass propagation, mainly for its fruit and as an ornamental in Kuwait, India and Mali. Grafting of improved varieties is also common, e.g., in India. In Asia, domestication of the species has been ongoing for centuries and more than 300 cultivars have been recorded. Asian cultivars typically have large juicy fruits, whereas those of African origin are much smaller in diameter and less juicy.

Z. mauritiana is a fast-growing species. Under favourable conditions, its height increment on loose soil is 75 cm in a year and 1.2 m in 2 years; growth is slower in the third season, when under similar growth conditions plants are thick and bushy, and up to 1.5 m high. Growth is however often poor under natural conditions; it grows 5–8 cm high after the first season and 17–35 cm after the second season. *Z. mauritiana* coppices well and grows vigorously from stumps and root suckers. Coppicing, lopping,

pollarding and pruning are the best management techniques for this tree. Fruiting starts after 3–5 years and is usually very abundant.

Z. mucronata is very adaptable, growing in all types of soil and tolerating intense heat and cold equally well. Under good conditions it will reach a height of 4–6 m in 4–5 years. Trees can be planted as scattered groups of 10–20 individuals to act initially as fodder trees and later for shade and its fruits. Young trees must be protected from browsing cattle. Trees can be managed through lopping, pollarding and coppicing, but sometimes it is very difficult to handle due to its many hooked spines. Uncracked seeds can be stored for a year. There are 700–1100 seeds/kg.



Pests and diseases: Many pest species attack the leaves and fruits of *Ziziphus* species. Fruit flies including *Carpomyia vesuviana* and *C. incompleta* are the main pests that attack the fruit; control is possible with insecticides. Lesser pests include caterpillars. A leaf-eating caterpillar and the green slug caterpillar attack the foliage. A mite forms scale-like galls on twigs retarding growth and reducing the fruit crop. Powdery mildew causes defoliation and fruit drop.



Commercial/market value: In dry areas, *Ziziphus* species have great value in providing subsistence food during drought or famine. *Ziziphus* fruit is not commercialized in Kenya. However, fruits are locally sold in most major centres in northern Kenya and in the coastal region, especially in Lamu, Kilifi, Malindi, Mombasa and Lodwar or along roadsides by children. It is a very important underutilized fruit species with great potential due to its nutritional value. It should therefore be given priority in

order to increase farmers' income. This species should be domesticated and cultivated at farm level. Introduction of improved large-fruited varieties could enhance adoption by farmers in Kenya.

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PART TWO: EXOTIC FRUIT TREES AND SHRUBS



Eriobotrya japonica (Loquat)



Artocarpus heterophyllus (Jackfruit)



Annona squamosa (Custard apple)



Persea americana (Avocado)



Mangifera indica (Mango)



Carica papaya (Papaya)



Citrus paradisi (Grapefruit)



Citrus aurantiifolia (Lime)

28. *Annona squamosa* L.

ANNONACEAE

(Native to Central and South America)

Common names: Custard apple, Sugar apple, Sweetsop

Local names: Mtopetope/Mtomoko (Swahili); Matomoko (Taita).

Description and ecology: A small, semi-deciduous tree, 3–6 m tall, with a short bole, up to 20 cm in diameter. Branches spread widely and the tips bend over or touch the ground. **Bark:** Grey with an interlaced pattern of shallow fissures. **Leaves:** Alternate, thin, dull green, long, narrow and oval, up to 7–16 cm long, a few hairs below. The tree may shed its leaves during drought. **Flowers:** Yellow/green, about 2 cm across when open, with 3 fleshy petals, solitary or in groups of 2–4, each on a stalk. **Fruit:** Round to heart-shaped, compound, fleshy; 5–10 cm across, surface green/yellow with a powdery bloom, with a scaly appearance. Fleshy fruit contains a creamy-white pulp, which is aromatic with a very sugary taste; pulp surrounds the smooth, oblong, shiny, dark brown/black seeds, up to 1.3 to 1.6 cm long.

In Kenya, this small open-crowned tree grows very well in lowlands from coastal areas up to 1200 masl, with a minimum amount of rainfall. It also does well around Lake Victoria. The tree grows best in full sunshine and can withstand long periods of drought. It does not tolerate very acidic, salty soil or waterlogged areas.



Annona squamosa – tree



Annona squamosa – fruit and leaves



Annona cherimola – fruit and leaves



Annona squamosa – opened fruit showing the creamy-white pulp



Annona cherimola – opened fruit showing the white pulp

Uses: The fruit is edible; its creamy white pulp is very sweet with pleasant flavour that tastes like custard. Fruits are normally eaten fresh. The pulp can be used as flavouring in ice cream. After removing the seeds, the pulp can be passed through a strainer or homogenized to make a delicious and refreshing drink. Heat-extracted oil from the seeds has been used against agricultural pests. Wood is used as fuelwood; trees are ornamental and can also serve as windbreaks.

Annona cherimola Mill. (which is native to Ecuador and Peru), known as cherimoya, custard apple or sugar apple or 'mtomoko'/'mstafeli' (Swahili) is a small, shrubby, semi-deciduous tree, 3–10 m high, often branched from the base. Trees grow rather

vigorously when young, but the growth rate declines as they get older. The fruit is conical or heart-shaped, 10–20 cm long and up to 10 cm in width. The skin, thin or thick, may be smooth with fingerprint-like markings or covered with conical or rounded protuberances. The fruit is easily broken or cut open, exposing the snow-white, creamy, juicy flesh, which has a pleasant aroma and delicious, sub-acidic flavour; fruit contains numerous hard, brown/black, bean-like, glossy seeds, 1.25–2 cm long. The white pulp of the ripe cherimoya is commonly eaten by hand or by scooping the flesh with a spoon from the cut-open fruit. In Mexico, sometimes people add a few drops of lime juice to it. Occasionally it is de-seeded and added to fruit salads or used for making fresh juice or ice cream.

Nutrient composition

100 g edible portion on fresh weight basis (EP)	Sugar apple, pulp, raw		Cherimoya, pulp, raw	
	<i>(Annona squamosa)</i>		<i>(Annona cherimola)</i>	
Component	Mean	n	Mean	n
Energy ¹ kcal (kJ)	96 (405)		78 (327)	
Water (g)	73.3	1	79.4	1
Protein ² (g)	1.8		1.6	
Fat (g)	0.3	1	0.7	1
Carbohydrate, available ³ (g)	19.3		14.7	
Fibre, total dietary (g)	4.4	1	3.0	1
Ash (g)	0.8	1	0.6	1
Calcium (mg)	28	1	10	1
Iron (mg)	0.8	1	0.3	1
Potassium (mg)	264	1	287	1
Magnesium (mg)	21	1	17	1
Phosphorus (mg)	34	1	26	1
Copper (mg)	0.09	1	0.07	1
Zinc (mg)	0.10	1	0.16	1
Vitamin A (RE) ⁴ (mcg)	1		1	
β-carotene equivalents ⁵ (mcg)	3	1	5	1
Thiamine (mg)	0.11	1	0.10	1
Riboflavin (mg)	0.13	1	0.13	1

100 g edible portion on fresh weight basis (EP)	Sugar apple, pulp, raw (<i>Annona squamosa</i>)		Cherimoya, pulp, raw (<i>Annona cherimola</i>)	
	Mean	n	Mean	n
Vitamin B6 (mg)	0.20	1	0.26	1
Niacin (mg)	0.9	1	0.6	1
Folate (mcg)	14	1	23	1
Vitamin C (mg)	36	1	13	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β -carotene + 1/12 α -carotene + 1/12 β -cryptoxanthin

⁵ β -carotene equivalents = β -carotene + 1/2 α -carotene + 1/2 β -cryptoxanthin

Annona squamosa and *Annona cherimola* are nutritious fruits. They provide high levels of vitamins from the B-complex (thiamine, riboflavin, niacin, vitamin B₆, folate), which are important coenzymes in the body and play a central role in the metabolism of amino acids and carbohydrates. Moreover, the fruits are both sources of dietary fibre. While *Annona squamosa* seems to be a better source of vitamin C, *Annona cherimola* is slightly superior in folate. Vitamin A and β -carotene values are low in both species.



layering, inarching and marcotting are also practised. Seed storage behaviour is orthodox. If kept dry, seeds retain their viability for several years. There is no loss in viability in 6 months of hermetic storage at -20°C and at 1.5% MC. However, loss in viability occurs if seeds are stored at room temperature.

Annona squamosa trees are planted 5–6 m apart or 10–12 m apart when grown with mango trees. This slow-growing tree must be protected from browsing animals. If well looked after, it will start producing fruit after about 2 years. Regular watering and weeding are required for good fruit production. The soil needs to be fertilized generously for better fruit yield. A commercial fertilizer containing 3% nitrogen, 10% phosphoric acid and 10% potash is recommended.

Annona cherimola tree is traditionally grown from seed, which takes 2–4 weeks to germinate. Grafting is recommended for best fruit production. This is done to speed up growth rate by using *Annona squamosa* as a root stock. When the seedlings are 7.5–10 cm high, they are



Season: *Annona squamosa* flowers in January to February and fruits in April to May. *Annona cherimola* flowers throughout the year and fruit harvesting is mainly from April to December.



Cultivation: *Annona squamosa* is propagated by seeds and vegetatively. Seeds are planted, with no pre-treatment, in rich soil and covered to a depth of not more than 2 cm, then sparingly watered. They germinate in 2–4 weeks and the seedlings are ready for planting out after 6 months. Budding is done at the beginning of the growing season when the sap flows freely. Cleft grafting is the method more commonly used. Air

transplanted to pots or the nursery plot with 50 cm between rows. When 12–24 months old and dormant, they are budded or grafted and then allowed to grow to 0.9–1.2 m high before setting out in the field. Large seedlings and old trees can be top worked by cleft grafting. It is necessary to protect the trunk of topped trees to avoid sunburn.



Pests and diseases: *Annona* fruits left to ripen on the tree are eaten by birds and bats. The most common pests of *A. squamosa* are mealybugs (*Planococcus* spp.), fruit flies (*Dacus* spp.), spotting bugs (*Amblypelta* spp.) and scales (*Parasaissetia* spp.). All these can be controlled in an integrated pest management program. Another serious pest is a eurytomid wasp whose larvae bore into the fruits. The major root rot disease is bacterial wilt (*Pseudomonas solanacearum*). The major fruit diseases are black canker (*Phomopsis* spp.), diplodia rot (*Botryodiplodia* spp.) and purple blotch (*Phytophthora* spp.). The incidence of these fruit diseases increases under moist or wet conditions.

Regarding *Annona cherimola*, caterpillars may defoliate the tree. A scale insect, *Conchaspis angraeci*, attacks the trunk and branches. Additional pests include fruit flies (*Anastrepha* spp.), leaf miners (*Leucoptera* spp.) and seed borers (*Bephrata maculicollis*). The latter pest deposits eggs on the surface of the developing fruits; the larvae invade the fruit and consume the seeds, causing premature and defective ripening and rendering the fruits susceptible to fungal diseases. The tree may succumb to root rot in clay soils or where there is too much moisture and insufficient drainage. Sooty mould can occur on leaves and fruits where aphids and other insects have



deposited honeydew. Stored seeds for planting are subject to attack by weevils. To avoid damping off of young seedlings, seeds should be dusted with fungicides.

Commercial/market value: *Annona* fruits are mainly traded within its country of production in local or urban markets, or sent to factories for processing. It is much appreciated in Kenya due to its tasty, sweet fruit and is readily available during fruit season in local markets, major supermarkets and green grocery shops countrywide. However, in 2017 only 1200 t of custard apples was produced. *Annona* production suffers from insufficient financial support in the following areas: research, transport, roads, and extension services. Post-harvest losses are generally high because of its short shelf life. The processed pulp can be of low quality and often fails to meet international standards. There is a lack of information on the international market. *Annonas* may be cultivated for specific purposes as well as for income generation.

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29. *Artocarpus heterophyllus* Lam.

MORACEAE

(Native to South and Southeast Asia)

Common name: Jackfruit

Local names: Mfenesi (Digo, Giriama, Swahili); Efenesi (Teso).

Description and ecology: A medium-sized, evergreen tree with thick branches, grows up to 25 m tall; with a short, cylindrical and straight bole, up to 1 m in diameter in old trees, branches less than 2 m from the ground. **Bark:** Grey and smooth on the branches, rough on the trunk. **Leaves:** Glossy, oval, 15 cm long and 10 cm wide. **Flowers:** Male and female are separate, very small, arranged in large inflorescences (about 10 x 5 cm), female flowers have a strong smell. Inflorescences are borne on trunks or on thick and large branches and this is where the fruit develops. **Fruit:** Yellow/green, multiple fruit, with a spiky, thick skin, massive and irregular, up to 20 kg in weight and 1 m length, with 100-500 creamy white edible seeds up to 5 cm long, each coated with a firm yellowish aril (the 'fruit pulp').

In Kenya, it is widely cultivated along the coast. It requires well-drained, deep and highly fertile soils. This species does not tolerate shallow soil, coral rag, drought or waterlogging.

Uses: Jackfruit is the largest tree-borne fruit in the world. The ripe fruit pulp which is aromatic and very

sweet, is usually eaten fresh, but is definitely an acquired taste. It is also used to make chutney, jam, jelly and paste, or preserved as candy by drying or mixing with sugar, honey or syrup in Thailand and the Philippines. The pulp is also used to flavour ice cream and beverages, or is reduced to a concentrate or powder and used for preparing drinks. Unripe fruits are used as vegetables in Uganda or made into pickles in Thailand. The large seeds are eaten after being boiled or roasted and have a chestnut flavour. They are dried and salted as table nuts, or ground to make a flour that is blended with wheat flour for baking. The male spikes are used as a salad or pickle. The ripe fruit pulp can be fermented and distilled to produce an alcoholic beverage. The wood is used for fuelwood, charcoal, as timber for making carts and doors, and for making furniture. The trees can be used for shade and fodder (cropped leaves and fruit residues, overripe and fallen fruits). *A. heterophyllus* can be planted to control floods and soil erosion on farms.



Artocarpus heterophyllus – whole ripe fruit and separated arils sold in supermarkets or by street traders



Artocarpus heterophyllus – opened ripe fruit showing the fruit pulp (yellowish arils) and cut seeds



Artocarpus heterophyllus – unripe fruit hanging on the tree



Artocarpus heterophyllus – tree

Nutrient composition

Jackfruit, ripe pulp, raw (<i>Artocarpus heterophyllus</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy¹ kcal (kJ)	91 (384)		
Water (g)	75.9 ± 3.5	73.5-81.0	4
Protein² (g)	1.6		
Fat (g)	0.5	0.3-0.6	2
Carbohydrate, available³ (g)	18.9		
Fibre, total dietary (g)	2.2	1.5-2.8	2
Ash (g)	0.9		1
Calcium (mg)	25	24-26	2
Iron (mg)	0.4	0.2-0.6	2
Potassium (mg)	386	324-448	2
Magnesium (mg)	27	25-29	2
Phosphorus (mg)	28	21-34	2
Copper (mg)	0.14	0.08-0.20	2
Zinc (mg)	0.6		1
Vitamin A (RE)⁴ (mcg)	8		
β-carotene equivalents⁵ (mcg)	46	26-67	2
Vitamin E (mg)	0.53		1
Thiamine (mg)	0.08	0.05-0.11	2
Riboflavin (mg)	0.08	0.06-0.10	2
Vitamin B6 (mg)	0.33		1
Niacin (mg)	0.7	0.5-0.9	2
Folate (mcg)	24		1
Vitamin C (mg)	14		1

SD, standard deviation, calculated when the number of data points (n) ≥ 3

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Ripe jackfruit pulp has a sweet taste, which is reflected in the value of available carbohydrates. As much as 85% of the available carbohydrates in jackfruit are sugar, primarily glucose and fructose. The fruit pulp contains moderate values of B-vitamins, including folate, but provides lower vitamin C values compared to other fruits.



Season: Flowers from April to May and October to November. Fruits August to September and February to March.



Cultivation: *A. heterophyllus* is usually propagated by seed through direct sowing on site, or by transplanting wild seedlings. Direct sowing at the site is better than raising seedlings in a nursery. This is because the taproot grows quite fast and may be injured when potted seedlings are transplanted. Vegetative propagation (i.e., bud grafting, air layering, root cuttings) is preferred. No treatment is required before sowing seeds. Seeds are hand-picked individually from the fruit flesh and washed. Germination from fresh, cleaned seed begins after about 10 days and is completed within 35–40 days. Sprinkle ash around young seedlings and newly sown seeds to keep insects away. Seeds should not be dried or stored as they are recalcitrant. In some countries in Asia, jackfruit is commonly grafted or budded for propagation of good clones. Jackfruit seedlings can be used as a rootstock. Seed viability can be maintained for a few months in moist, dark storage at 15°C. There are about 430 seeds/kg.



Young trees require shade in the nursery and initially after planting in the field. They must also be protected from livestock since they are palatable. Once established, full sunlight is required for good production. For good fruit yield, space trees 10–12 m apart. Jackfruit normally starts to fruit about 8 years after

planting if trees are raised from seeds. Grafted trees may produce fruit earlier. Flowering can be induced by making a cut in the bark of branches or the stem. One or 2 months later a flower stalk may emerge at the point where the slight wound was made. Not much pruning is required. Some thinning of the shoots may be feasible on young trees. Remove dead or diseased branches from time to time.



Pests and diseases: Several fungi including *Colletotrichum lagenarium*, *Phomopsis artocarpina* and *Septoria artocarpina* attack different parts of the tree and cause leaf spots. Fungicide is sprayed to protect trees from these diseases. The well-known pink disease, a girdling canker on branches caused by *Corticium salmonicolor* is a prominent disease of jackfruit. Borers are the major pest. Caterpillars of *Diaphania caesalis*, the jackfruit shoot borer, tunnel into buds, young shoots and fruit. Removal of affected parts breaks the life cycle since the caterpillar pupates in the tunnel. Bark borers, i.e., caterpillars of *Indarbela tetraonis* and larvae of the beetle *Batocera rufomaculata*, can be controlled by fumigating the holes. The brown bud weevil, *Ochyromera artocarpina* is a specific jackfruit pest that can be controlled by destroying affected fruits and buds. Other pests include numerous sucking insects such as mealybugs, aphids, white flies and thrips as well as leaf-webber caterpillars.



Commercial/market value:

Jackfruit is marketed locally in Kenya, but it has great potential in the international market. It is grown all over the Eastern Africa region especially in Uganda. In the wetter parts of Kenya, the tree is mainly grown around homesteads as a shade, for fruits or as support for climbing crops

such as yams and passion fruits. It has not yet been commercialized in Kenya.

Fresh jackfruit is not only in high demand in Asian countries, e.g., in India, Bangladesh and Malaysia, but also in Brazil. There are established jackfruit industries in Sri Lanka and Vietnam, where the fruit is processed into products such as flour, noodles and ice cream. Dried jackfruit chips and sweet canned jackfruit are produced by various manufacturers. Unripe fruit pulp is also canned and sold as a vegetable for export; recently there has been a growing demand for the pulp as a meat substitute for vegans in Europe and the US. This could be an interesting potential market for Kenyan jackfruit if production was promoted.

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30. *Carica papaya* L.

CARICACEAE

(Native to Tropical America)

Common name: Papaya, Pawpaw, Tree melon

Local names: Mpapai (Swahili)

Description and ecology: A tree-like herb, grows up to 2–10 m in height, usually unbranched. Trunk contains soft, fibrous spongy tissue, about 20 cm across, narrowing to a crown of leaves at the top.

Bark: Pale-grey, smooth, well-marked with leaf scars.

Leaves: Large, up to 60 cm across, deeply palmately lobed, with hollow stalks up to 60 cm long, swollen at the base. **Flowers:** Male and female flowers are on separate plants (dioecious species). Male plants have abundant creamy-yellow flowers in clusters on drooping stalks, each flower about 2 cm long, tubular, scented. Female plants are larger than males, with a few flowers in the axils of the leaves, each flower with 5 thick waxy petals, cream, about 5 cm long, fragrant, with prominent sticky stigma (occasionally male and female flowers grow together on one plant, which is preferred in plantations). **Fruit:** Oblong to spherical, 7–50 cm long and 15 cm across, borne on a short stalk, thin skin of green, yellow or orange colour. Fruit

flesh is yellow or orange, and encloses numerous seeds in a central cavity; seeds are rounded, blackish, about 0.6 cm in diameter, each enclosed in a gelatinous membrane (aril).

In Kenya papaya is cultivated from sea level to over 2000 masl, in areas with evenly warm climatic conditions and good soil moisture.

Uses: Ripe papaya is a favourite breakfast and dessert fruit that is available all year-round. The fruit is usually eaten raw with a twist of lemon. It can be used to make fruit salads, refreshing drinks, jam, jelly, marmalade and candies. It is a versatile fruit and can be preserved, dried and cooked in pies. The young unripe fruit is used for pickles, while its tender leaves are cooked as vegetables. Meat can be tenderized by wrapping it in papaya leaves or by chopping young fruit into pieces and mixing them with meat.



Carica papaya – plant with fruit



Carica papaya – ripe fruit, whole and cut, showing flesh and seeds



Carica papaya – immature fruit of 'Solo' variety that is the most common variety grown in Kenya



Carica papaya – almost ripe fruit of the local variety 'mountain papaya'



Carica papaya – plants on a farm full of fruit

Nutrient composition

Papaya, pulp, raw (<i>Carica papaya</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy ¹ kcal (kJ)	36 (152)	
Water (g)	89.8	1
Protein ² (g)	0.5	
Fat (g)	0.1	1
Carbohydrate, available ³ (g)	7.3	
Fibre, total dietary (g)	1.9	1
Ash (g)	0.4	1
Calcium (mg)	20	1
Iron (mg)	0.7	1
Potassium (mg)	210	1
Magnesium (mg)	19	1
Phosphorus (mg)	15	1
Copper (mg)	0.02	1

Papaya, pulp, raw (<i>Carica papaya</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean	n
Zinc (mg)	0.12	1
Vitamin A (RE) ⁴ (mcg)	161	
β-carotene equivalents ⁵ (mcg)	966	1
Thiamine (mg)	0.03	1
Riboflavin (mg)	0.03	1
Vitamin B6 (mg)	0.02	1
Niacin (mg)	0.4	1
Folate (mcg)	25	1
Vitamin C (mg)	58	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Papaya fruits are good sources of vitamin C and A. A small fruit (157 g) can meet twice the recommended daily intake of vitamin C⁸ and over 40% of vitamin A⁹. While vitamin A is indispensable for the visual cycle and for the functioning of cells, vitamin C protects the body from radicals and improves the absorption of non-haem iron in the gut.



Season: Flowers and fruits throughout the year depending on the different *C. papaya* cultivars.



Cultivation: *C. papaya* is usually grown from seed by raising seedlings in the nursery, which germinates in 2–4 weeks under favourable conditions. After



2 weeks, the seedlings are moved into full sunlight and a week later transferred to pots. Direct sowing in bottomless pots eliminates some transplanting problems. Seedlings are planted out in the field 6–8 weeks later at a density of 1000–2000 plants/ha with a recommended spacing of 2.5–3 x 2–3 m, or 4.5 x 2 m where machinery is used. Direct sowing of seeds in the desired field is a simpler method but seeds should be protected from pests such as ants. Since there is no reliable method of determining sex in dioecious papaya cultivars until the first flowering occurs, at least 4–5 seedlings should be planted per planting hole in such cases

8 Calculations based on recommended nutrient intake (RNI) for vitamin C, adults (19 to > 65 years): 45 mg/d. www.fao.org/nutrition/requirements/vitamins/en/

9 Calculations based on recommended safe intake/day for Vitamin A (retinol equivalents) average female & male: 19 to > 65 years: 575 mcg/day. www.fao.org/nutrition/requirements/vitamins/en/

and the male ones later thinned. Today, several hermaphrodite cultivars such as 'Solo' or 'Sunrise' are grown to avoid raising numerous male plants with no fruit production. Vegetative propagation is possible but is rarely practised because of the scarcity of scion material from mother plants. For vegetative propagation, the top of the plant is broken off to induce the development of shoots, which can then be used for cleft grafting or making cuttings. Seeds have orthodox storage behaviour; viability can be maintained for up to 3 years in hermetic air-dry storage at 12°C. There are 300–700 seeds in each fruit and approximately 20,000 seeds/kg.

Weeds must be controlled, especially during the initial stages of establishment. Herbicides, hand weeding, mulching and use of cover crops are some of the practical methods used in the control of weeds. Even though it is fairly resistant to drought, *C. papaya* requires a constant water supply. It is very responsive to fertilizers, and yield can be significantly improved through proper fertilization. Control of soil pH is also very important. Fruit production begins within a year of planting and is continuous thereafter. *C. papaya* produces 30–150 fruits/year. As the fruit is formed in the leaf axils, plants must be kept growing continuously for maximum yield. Mature plants may be rejuvenated by cutting them back to 30 cm above the ground.



Pests and diseases: The major pests of papaya are fruit flies and mites. Red spider mites puncture plant tissue with their proboscis to suck the sap. Fruit flies lay eggs in ripening fruits, while maggots cause the fruits to rot. Nematodes infest plant roots, which then develop knots and swells. Common bacterial pathogens are

Erwinia spp. that cause cankers and black rot; *Pseudomonas* spp. cause bacterial leaf spot and wilt. Several fungi can attack papaya including black spots on fruits and leaves caused by *Cercospora papayae* and powdery mildew caused by *Oidium caricae-papayae* under humid, poorly ventilated conditions. Birds and fruit bats feast on ripe fruits. The most important virus disease is the papaya ringspot virus that causes symptoms on leaves and fruits and is a severe problem in some papaya-producing regions. Control measures in nurseries and plantations, although costly, are often essential. In general, they include sterilizing the soil in nurseries, introducing disease-free soil in older plantation sites, using disease-free and resistant planting material, following regular chemical spraying programmes, and practising plantation hygiene and crop rotation.



Commercial/market value: Papaya is cultivated both on a small and large scale and is strongly recommended as a homegarden tree for all parts of Kenya. In 2017, production of papaya was 136,000 t from an area of 9900 ha. The fruits are sold extensively locally and only very few are exported. Different cultivars are available in Kenya, including 'Solo' and the 'mountain papaya'. Papaya fruits are highly nutritious, and its fresh consumption and processing should be promoted. However, in Kenya the full potential of papaya is not yet being exploited as there is limited knowledge of farmers about its production and value-addition technologies.

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31. *Casimiroa edulis* La Llave

RUTACEAE

(Native to Central America)

Common name: Mexican apple, Golden apple, White sapote, Mexican sapote, Casimiroa

Local names: No local names known

Description and ecology: A medium-sized, evergreen tree, up to 12 m tall, much-branched with a short trunk, with leafy, hanging branches. **Bark:** Smooth, pale brown. **Leaves:** Compound, alternate, with 3–5 lobes, each long, oval, shortly stalked to the centre, shiny green surface. **Flowers:** Green/white/yellow, small, in loose heads beside leaves, with 5 petals. **Fruit:** Green, rounded when young, turning green/yellow when ripe, about 10 cm in diameter, with soft skin encloses white pulp, with around 2–6 large, whitish seeds. Seeds oval and wedged, 18–23 mm long.

In Kenya, it grows in warm areas, especially along the coast, and central and eastern regions, at 0–2400 masl.

Uses: Fleshy, sweet and juicy fruit are usually eaten fresh or used in fruit salads, preserves and sauces. Fruits are also used for flavouring of dairy products such as milkshakes. Trees are used as ornaments, windbreaks and for bee forage. The wood is yellow,

fine-grained, compact, moderately dense, heavy, medium/strong and resistant, but not durable. It is occasionally used in carpentry and for making domestic furniture; it is also used as fuelwood.



Casimiroa edulis – tree



Casimiroa edulis – ripe fruit, whole and cut, showing the white fruit flesh

Nutrient composition

White sapote, fruit, raw (<i>Casimiroa edulis</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean	n
Energy ¹ kcal (kJ)	83 (353)	
Water (g)	78.3	1
Protein ² (g)	0.1	1
Fat (g)	0.03	1
Carbohydrate, available ³ (g)	20.1	
Fibre ⁴ (g)	0.9	1
Ash (g)	0.5	1
Calcium (mg)	10	1
Iron (mg)	0.3	1
Phosphorus (mg)	20	1
Thiamine (mg)	0.04	1
Riboflavin (mg)	0.04	1
Niacin (mg)	0.5	1
Vitamin C (mg)	38	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Protein, method unknown

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Fibre, method unknown, assumed crude fibre

White sapote is nutritious in terms of its mineral and vitamin content. It contains good values of minerals such as phosphorus, but shows comparatively low values of iron and calcium. It is a good source of vitamin C; niacin, thiamine and riboflavin values are rather low. The fruit may contain even more beneficial components, such as vitamin A, folate or zinc and copper, but its nutritional information in the literature is limited.



Season: Flowers in January and February and fruits mature from June to October.



Cultivation: White sapotes are commonly grown from seeds (seedlings). Seeds should be slightly but not completely dried. Sow within 3 weeks after harvest as viability declines rapidly. Seeds germinate after 3–4 weeks in warm conditions, preferably at a temperature of about 30°C. Grafting or budding is strongly recommended as the species is highly variable and there are clear benefits to using improved cultivars. When using whip grafting, wrap or cover the scion to prevent dehydration. Cleft grafts and slot grafts are made on larger rootstocks and when top working mature trees. Grafted trees bear fruit after 3–4 years, while seedlings take 6–7 years. For budding, use last season's growth of budwood that has hardened off. Older wood that has fruited gives poorer results.

Plant seedlings at a distance of 8 m x 4 m, later thinning to 8 m x 8 m apart. Water young trees to encourage growth. The trees produce 2–3 flushes of shoot growth per year. Cultivars differ markedly in their growth habits. The tree is a prolific fruiter and branches with heavy foliage.

Therefore, during the fruiting season, you must provide support to the branches. Regular, light pruning (4–6 times per year) is required for the more vigorous types during the first 2 years to obtain adequate branching without delaying fruiting too much. White sapote is fairly drought-resistant. The fruits must be handled during harvest with care even when they are unripe as they bruise very easily; any bruised skin will quickly blacken and the pulp beneath it may turn bitter. Mature fruits must be clipped from the branches, leaving a short piece of stem attached to the fruit.



Pests and diseases: The white sapote has few pests and diseases. However, the fruits of some cultivars are attacked by fruit flies. Brown scale insects may suck sap from the fruit, thus reducing its size and quality.



Commercial/market value:

Casimiroa is one of the most productive fruit trees in Kenya. There are several cultivars grown in the country; in some, the fruit turns from green to yellow during ripening while others may show no change in colour and remain green even when ripe. Fruit comes in different shapes and sizes. *Casimiroa* is an underutilized fruit in Kenya and was only produced on an area of 53 ha and a volume of 260 t in 2017. The fruit is highly nutritious and should be promoted for cultivation at homestead and farm level to ensure that the local population is able to access a balanced fruit diet. Introduction of improved cultivars with lower seed proportion and less bitterness of fruit pulp could help in raising the potential of this

species.

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32. *Citrus sinensis* (L.) Osbeck

RUTACEAE

(Native to southern China, Vietnam)

Common names: Orange, Sweet orange

Local names: Mchungwa (Swahili)

Description and ecology: A shrub or small tree, growing 4–6 m in height, but can sometimes reach up to 10 m, with dense foliage and rather thin spines beside the leaves. The twigs are angled when young. **Bark:** Grey/brown, branches green/brown, armed with spines. **Leaves:** Simple, alternate, oval to 8–15 cm long, 2–8 cm across, dark green, entire edge, with stalk narrowly winged, with a line or joint within the leaf blade, pleasantly aromatic when crushed. **Flowers:** White, with 5 petals, 2–3 cm across, in clusters of 1–6, sweet-scented, attractive to bees, white flower buds. **Fruit:** A hesperidium (i.e., a special form of a berry as in all citrus fruits), variable in colour, shape and sizes, rounded, smooth, green to orange/yellow when ripe, 4–12 cm across. The pulp (endocarp) is of yellow/orange/red colour and consists of tightly packed membranous juice sacs enclosed in 10 to 14 wedge-shaped compartments which are readily separated as individual segments. Juicy pulp surrounding the seeds with a sweet and sour taste. In each segment there may be 2–4 irregular shaped seeds, white externally and internally, although some types of oranges are seedless. The sweet orange differs physically from the sour orange in having a solid centre.

There are two types of oranges grown in Kenya: ‘common type’ and ‘navel type’. Common types include “Hamlin”, “Parson Brown”, “Trovia” and others. Navel types are “Washington navel”, “Australian navel”, “frost Washington navel”, and others.

Oranges are the most important and widely grown citrus fruit in Kenya, usually cultivated from coastal areas to semi-arid, lowland areas, which include Kitui, Mwala, Mombasa and Kilifi. This species does not grow well in very wet areas or at high altitudes. However, farmers in Kenya grow oranges even at higher altitudes in Thika, Nairobi and in Limuru, up to 2100 masl.

Further Citrus species: Several other *Citrus* species are cultivated in Kenya.

- *Citrus paradisi* Macfad., common name grapefruit (‘mbalungi’ in Swahili)
- *Citrus reticulata* Blanco, common name tangerine (‘mchenza’ in Swahili)
- *Citrus limon* (L.) Osbeck, common name lemon (‘mlimao’ in Swahili)
- *Citrus aurantiifolia* (Christm.) Swingle, common name lime (‘mdimu’ in Swahili)



Citrus sinensis – tree



Citrus sinensis – fruit hanging on tree



Citrus sinensis – whole and cut fruit of an imported seedless variety



Citrus sinensis – local green fruits of a seedless variety hanging on the tree



Citrus sinensis – whole and cut fruits of the Washington navel variety



Citrus aurantiifolia – ripe fruit hanging on the tree



Citrus aurantiifolia – whole and cut fruit



Citrus limon – whole and cut fruit

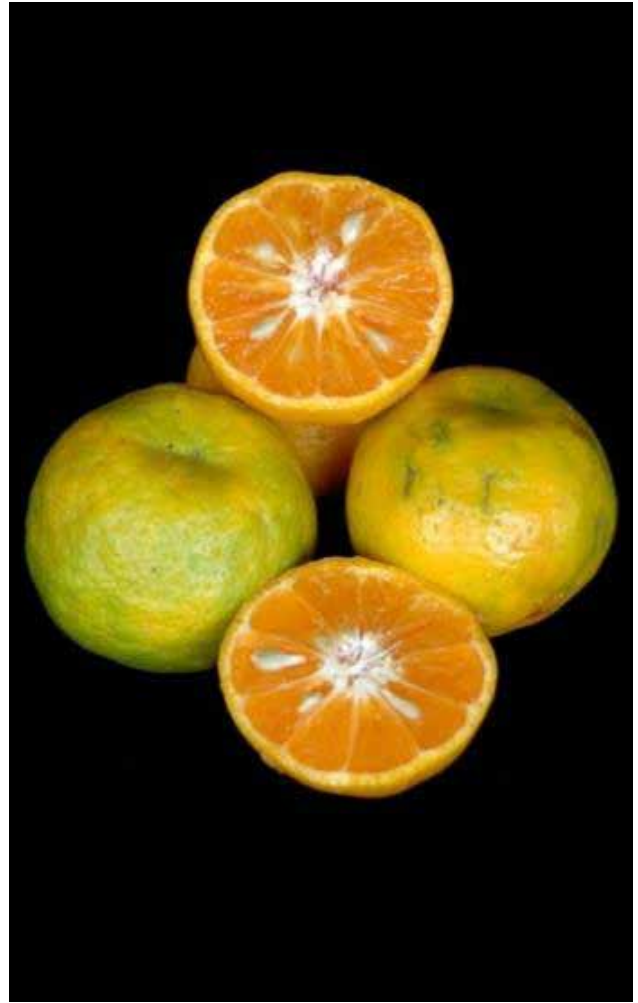


Citrus paradisi – cut fruit of different varieties



Citrus reticulata – fruit hanging on the tree

Uses: Oranges and all other citrus fruits are juicy and used for fresh consumption or to make jams, jellies, marmalades and juice, lemonades or iced lemon tea. They can also be used in confectionaries like pies, cakes, pastry dough and marinades. Juice can be concentrated or frozen for later use. The outermost part of the fruit rind is grated to produce lemon or orange zest, which also has many culinary uses for its flavour-rich oil glands. The inner, white part of the rind can be used to produce pectin. Lemon/lime pickles are favourite side dishes in the Middle East, India,



Citrus reticulata – whole and cut fruit

Morocco and among Kenyan Indians. Lemon, orange and grapefruit oils are used in aromatherapy for body and head massages worldwide. Peels, leaves and flowers contain essential oils that may be used in the manufacture of cosmetics and in medicinal applications. The wood of all citrus trees is used as fuelwood and for boards and panelling. Sweet-scented flowers of all citrus species attract bees and are excellent sources of bee forage. Citrus trees are also grown as ornamental and shade trees.

Nutrient composition

100 g edible portion on fresh weight basis (EP)	Orange, raw	Lemons, raw	Grapefruit (pink, red), raw	Tangerines, raw	Limes, raw
Component	<i>(Citrus sinensis)</i>	<i>(C. limon)</i>	<i>(C. paradisi)</i>	<i>(C. reticulata)</i>	<i>(C. aurantiifolia)</i>
Energy ¹ kcal (kJ)	47 (199)	30 (164)	34 (142)	56 (235)	41 (173)
Water (g)	86.8	88.9	90.9	85.2	88.3
Protein ² (g)	0.9	1.1	0.6	0.8	0.7
Fat (g)	0.1	0.3	0.1	0.3	0.2
Carbohydrate, available ³ (g)	9.3	6.6	7.0	11.6	7.7
Fibre, total dietary (g)	2.4	2.8	1.1	1.8	2.8
Ash (g)	0.4	0.3	0.3	0.4	0.3
Calcium (mg)	40	26	12	37	33
Iron (mg)	0.1	0.6	0.1	0.2	0.6
Potassium (mg)	181	138	139	166	102
Magnesium (mg)	10	8	8	12	6
Phosphorus (mg)	14	16	8	20	18
Copper (mg)	0.05	0.04	0.05	0.04	0.06
Zinc (mg)	0.07	0.06	0.07	0.07	0.11
Vitamin A (RE) ⁴ (mcg)	22	2	93	68	5
β-carotene equivalents ⁵ (mcg)	135	14	557	409	30
α-tocopherol (mg)	0.18	0.15	0.13	0.20	0.22
Thiamine (mg)	0.09	0.04	0.04	0.06	0.03
Riboflavin (mg)	0.04	0.02	0.02	0.04	0.02
Vitamin B6 (mg)	0.06	0.08	0.04	0.08	0.04
Niacin (mg)	0.3	0.1	0.3	0.4	0.2
Folate (mcg)	30	11	10	16	8
Vitamin C (mg)	53	53	34	27	29

n, number of data points are all 1/species

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Orange and other citrus fruits are well known for their vitamin C content. While one orange (medium size 100 g pulp) clearly meets the recommended daily intake¹⁰ of vitamin C, tangerines and limes provide 60–65%. All citrus species are good sources of minerals and dietary fibre. Oranges show the highest folate content, whereas grapefruit are richest in vitamin A. The vitamin A content is reflected in the colour of the grapefruit pulp, it is lowest/absent in white and highest in pink and red ones.



Season: In Kenya, orange and other citrus species flower and fruit throughout the year, depending on the variety and cultivar.



Cultivation: *Citrus sinensis* and other citrus species are propagated by seedlings, budding and grafting. Budding is done onto rootstock of other citrus species, for example on lemon or on special rootstock cultivars. Rootstock easily grows from seeds. For seedling propagation, seeds are cleaned after removal from the fruit and slowly dried, then stored in a refrigerator. Storage behaviour is intermediate and seeds lose viability from 81% to 20% after 6 months of storage. There are about 3500 seeds/kg. Grafting/budding with scions of improved cultivars is required to obtain high-quality fruits.



Seedlings should never be planted out deeper than they were in the nursery. Young trees are planted at a spacing of 3–5 m squares, but a spacing of up to 1.3 m can be used, depending on the climate and cultivar. Irrigation is necessary if rainfall is not adequate. If soil lacks nutrients, fertilizer containing nitrogen, phosphorus, potash, magnesium, calcium, zinc, manganese and iron

should be added. Pruning is practised to encourage branching and to keep the tree low for easy harvesting of the fruit. Any growth below the budding/grafting point should be removed. Pruning, sanitation, introduction of resistant varieties and spraying are used to control pests and diseases. Weeds are controlled mechanically or by using chemicals. A windbreak should be provided to protect trees. Trees aged 3–4 years produce 2.5–5 t/ha of fruit, while 8–12-year-old trees produce 20–40 t/ha. Single trees may live up to 100 years, but the economic life of an orchard seldom exceeds 30 years.



Pests and diseases: Several pests and diseases affect orange and other *Citrus* trees. *Tristeza* is a severe viral disease that triggers yellowing and wilting of leaves, twig die-back and subsequent death of trees. Other virus diseases such as leaf-mottle-yellow disease and the bacterial disease citrus greening, caused by *Liberibacter* spp. also cause the death of trees. The latter disease is spread by the African citrus psyllid and causes huge problems in citrus-growing areas in Kenya's highlands. There are also several disease-causing fungi that can severely affect *Citrus* trees including: *Alternaria* spp. (causing rots and leaf spots), *Botrytis* spp. (causing fruit mould and gummosis), *Colletotrichum* spp. (causing anthracnose), *Diaporthe citri* (causing stem-end rot), *Elsinoe fawcettii* (causing scab), *Glomerella cingulate* (causing anthracnose), *Penicillium digitatum*, *P. italicum*, *Psorosis* spp. (causing fruit mould) and *Phytophthora* species (causing root rot).

¹⁰ Calculations based on recommended nutrient intake (RNI) of vitamin C, adults (19 to >65 years): 45 mg Vitamin C/day. www.fao.org/nutrition/requirements/vitamins/en/

Pests include termites and nematodes of several species, but mainly sucking and biting insects such as aphids (*Toxoptera* spp.), psyllids (*Trioza erytreae*), citrus black flies (*Aleurocanthus woglumi*), scale insects (e.g., *Aonidiella aurantia*, *Parlatoria* spp. or *Coccus viridis*), fruit flies (e.g., *Ceratitis capitata* or *Bactocera* spp.), caterpillars of the blossom moth (*Cryptoblastes plagiroleuca*) or the common fruit-piercing moth (*Eudocima phalonia*), and the citrus rust mite (*Phyllocoptruta oleivora*).



Commercial/market value: All mentioned citrus species are widely cultivated in Kenya as commercial plantations and produce good quality fruits. Over the years, the area under citrus and production volumes have been relatively stable. In 2017, about 90,000 t of oranges, 11,000 t of lemons and 13,000 t of tangerines were produced. Citrus fruits are readily available in the local markets, supermarkets, big grocery stores and even along the roadsides. The climate in Kenya allows sweet oranges, tangerines, grapefruits, lemons and limes to be produced throughout the year. However, introduction and cultivation of improved cultivars could further increase the potential of citrus fruits in the country.

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33. *Cyphomandra betacea* (Cav.) Sendtn.

SOLANACEAE

(Native to South America)

Common name: Tree tomato, Tamarillo

Local name: Mgogwe/Matunda damu (Swahili).

Description and ecology: A woody, evergreen shrub or small tree that grows up to 3 m high, with characteristic umbrella-like branching. **Bark:** Young stems shiny, rounded leaf scars on older stems. **Leaves:** Alternate, large, rather heart shaped, softly hairy, on long stalk, drooping in when it is too hot. **Flowers:** In groups, hanging from older stems, fragrant, each flower 5-lobed, white/pink with a darker stripe. **Fruit:** In clusters, shiny, globose or egg-shaped berries, up to 7–10 cm long, abundant, on long stems. Fruit skin colour may be solid deep-purple, blood-red, orange/yellow, or red-and-yellow, and may have faint, dark, longitudinal stripes. Flesh colour around the black seeds varies from orange/red to orange/yellow or cream/yellow. The seeds are distinctly bitter; they are thin, nearly flat, circular, and larger and harder than those of the true tomato.

In Kenya, it is found at 0–1400 masl, growing on sandy soils as well as on well-drained, rich, deep soils, as these trees cannot tolerate waterlogging.

Uses: Tamarillos are usually eaten fresh by scooping out the entire fruit, discarding the exocarp (skin) and outer layer of the mesocarp (fruit flesh). The refreshing, raw pulp is juicy and has a sub-acidic, sometimes tart taste. The unripe fruit can be used for chutney, curry and sambal (hot, chilli-based condiment). Properly ripened fruit is also processed and used for stews, stuffing, jellies, jams, desserts and ice cream topping, and to make smoothies. Squeezed fruit yields a refreshing and tasty juice; sugar may be added. Tree blossoms provide bee forage. The leaves of the tamarillo have been used as a dye.



Cyphomandra betacea – trees with unripe fruit



Cyphomandra betacea – whole and cut ripe fruit



Cyphomandra betacea – unripe fruit hanging on tree

Nutrient composition

Tamarillo, raw (<i>Cyphomandra betacea</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy¹ kcal (kJ)	39 (162)		
Water (g)	87.9 ± 2.2	86.0-92.0	6
Protein² (g)	2.2		
Fat (g)	0.3 ± 0.3	0.1-0.7	6
Carbohydrate, available³ (g)	4.7		
Fibre, total dietary (g)	4.1		1
Ash (g)	0.8 ± 0.1	0.7-0.9	5
Calcium (mg)	15 ± 7	9-25	5
Iron (mg)	0.5 ± 0.2	0.2-0.5	5
Potassium (mg)	373 ± 53	300-440	5
Magnesium (mg)	18 ± 3	14-22	5
Copper (mg)	0.13 ± 0.07	0.05-0.20	5
Zinc (mg)	0.17 ± 0.04	0.1-0.20	5
Vitamin A (RE)⁴ (mcg)	153		
β-carotene equivalents⁵ (mcg)	920		1
α-tocopherol (mg)	1.86		1
Thiamine (mg)	0.06		1
Riboflavin (mg)	0.03		1
Vitamin B6 (mg)	0.19		1
Niacin (mg)	0.3		1
Vitamin C (mg)	19 ± 4	16-23	3

SD, standard deviation, calculated when the number of data points (n) ≥ 3

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Tamarillos are very high in water, low in energy and low in fat, but comparatively high in dietary fibre and protein. They are a source of minerals and contain high values of vitamins A and E. The high vitamin E value (which is comparable to that found in walnuts), may derive from the seeds, rather than the pulp of the fruits. The vitamins from the B-complex are contained in moderate concentrations.



Season: Flowers and fruits throughout the year.



Cultivation: Seeds for propagation should be selected from a range of trees with good and healthy fruits to maintain their genetic diversity. However, seedlings are not always true-to-type. Seeds from ripe fruits are washed, dried in the shade and placed in a freezer for 24 hours. Chilling is claimed to result in virtually 100% germination in 4–6 days. Seedbeds should be prepared with manure or compost and lightly shaded. Propagation from cuttings is an alternative, but freedom from virus infections should be ensured. Plant seedlings out directly from the seedbed to the orchard or transplant into pots. Potted seedlings survive better. Seeds have orthodox storage behaviour; no loss in viability after 42 months of hermetic storage at -20°C with 5.5% MC. However, reduction in seed viability occurs after 8–10 months of storage at room temperature. There are about 100,000 seeds/kg.



Seedlings once transplanted grow vigorously and may reach a height of 1.5–1.8 m before lateral branches emerge. The plants grow continuously and easily shed old leaves. *Cyphomandra betacea* is a fast-growing tree on good sites. Orchards need to be well drained; often the trees are planted on hills or ridges. Because of the shallow root system, deep cultivation around the stems should be avoided, but mulching is beneficial. Young seedlings

are cut back to a height of about 1 m to encourage branching, and each year the plants are pruned at the beginning of the crop cycle. This annual pruning consists of cutting back and thinning out the branches that have fruited to rejuvenate the bearing wood and to limit tree spread. Coppicing can also be practised. The plants must be protected from wind because of their shallow root system and fragile branches. Plants respond well to nitrogen fertilizer, particularly after the first fruit has set. Irrigation during the dry season is important to sustain growth and to improve fruit size and yield. Yields per tree average around 20 kg of fruit/year, and commercial yields are about 15–17 t/ha. Trees are short-lived; 12 years is the recorded lifespan of an orchard.



Pests and diseases: In general, tree tomato is easy to cultivate and relatively resistant to pests. Red spider mites puncture the plant tissue to suck the sap. Aphids are one of the most common pests; they may transmit virus diseases such as cucumber mosaic virus and tamarillo mosaic virus. *Phytophthora* blight (caused by *P. palmivora* and *P. infestans*) is a fungal disease that affects tree tomato plants, particularly during the rainy season. Additional fungal diseases include anthracnose (caused by *Colletotrichum* spp.), which hardens and deforms the skin of the fruit, powdery mildew (caused by *Oidium* spp.), and verticillium wilt, a soil-borne fungus that also infects tomato, potato and eggplant.



Commercial/market value: Large-scale commercial production and organized marketing occurs in New Zealand. However, international trade in fruit and preserves is still limited. Tree tomato is an emerging commercial crop in Kenya due to increasing demand in urban centres. A total of 10,000 t was

produced in 2017 on an area of 900 ha, while in 2012 only 3300 t was produced in about half of that area. In Kenya, cultivars with red fruits are often chosen for fresh fruit markets because they look attractive, but they have a stronger, more acidic flavour than yellow ones. Yellow fruit is also preferred for processing as it has a milder flavour and can be canned, since the juice of the red fruit is too abrasive. The tree tomato fruit stores well and is suitable for export to long distance markets.

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34. *Eriobotrya japonica* (Thunb.) Lindl.

ROSACEAE

(Native to China and Japan)

Common name: Loquat, Japanese plum, Japanese medlar

Local names: Kitunda (Kamba), Minoria/Murungati haru/Muburuti (Kikuyu); Ekeragwati (Kisii); Lqogat (Luhya); Musabibu (Luo).

Description and ecology: A dense, evergreen shrub or small tree up to 7 m, branching close to the ground. **Bark:** Grey and rough, young stems hairy. **Leaves:** Dark green, stalkless, shiny above, woolly hairs below, about 35 cm long, the tip pointed, edge prickly, toothed, young leaves paler, foliage in upward-pointing tufts. **Flowers:** Cream/white, fragrant, in pyramidal heads at the end of branches, each flower 2 cm across, flower buds covered with golden-brown hairs. **Fruits:** In loose clusters, golden/yellow, egg-shaped, usually 2–5 cm long. Fruit pulp is yellow/orange, succulent, sweet to sub-acidic or acidic flavour. There may be 3–5 seeds, dark-brown or light-brown, angular to ellipsoid, about 1.5 cm long.

It is commonly grown in the central and western regions of Kenya, and in Nairobi. It also does well in the Kenyan highlands. It grows at 1500–2400 masl, and is drought-resistant once established. However, it prefers moderate to heavy rainfall.

Uses: Peeled or unpeeled fruits are eaten fresh or may be mixed with other fruits like banana, mango and orange in fruit salads. Fruit pulp can be processed into jam, jelly, syrup and fresh juice. Fruits are also used in desserts or as pie filling, or are chopped and cooked as a sauce. Loquats can also

be used to make a light fruit wine. Trees serve as shade, ornamental and windbreaks. Leaves can be used for fodder and mulching. The wood is used to make fuelwood, charcoal, poles and carvings.



Eriobotrya japonica – ripe and unripe fruit on the tree



Eriobotrya japonica – branches with leaves and fruit



Eriobotrya japonica – tree

Nutrient composition

Loquat, pulp, raw (<i>Eriobotrya japonica</i>)		
100 g edible portion on fresh weight basis (EP)		
Component	Mean (min-max)	n
Energy ¹ kcal (kJ)	48 (202)	
Water (g)	86.9	1
Protein ² (g)	0.4	
Fat (g)	0.2	1
Carbohydrate, available ³ (g)	10.2	
Fibre, total dietary (g)	1.7	1
Ash (g)	0.5	1
Calcium (mg)	16	1
Iron (mg)	0.3	1
Potassium (mg)	266	1
Magnesium (mg)	13	1
Phosphorus (mg)	27	1
Copper (mg)	0.04	1
Zinc (mg)	0.05	1
Vitamin A (RE) ⁴ (mcg)	182	
β-carotene equivalents ⁵ (mcg)	1090	
Thiamine (mg)	0.02	1
Riboflavin (mg)	0.02	1

Loquat, pulp, raw (<i>Eriobotrya japonica</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean (min-max)	n
Niacin (mg)	0.2	1
Folate (mcg)	14	1
Vitamin C (mg)	1	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β -carotene + 1/12 α -carotene + 1/12 β -cryptoxanthin

⁵ β -carotene equivalents = β -carotene + 1/2 α -carotene + 1/2 β -cryptoxanthin

Loquat fruits are an excellent source of vitamin A, due to their high content in vitamin A-active carotenoids, β -carotene and β -cryptoxanthin. They also provide moderate values of minerals, but are low in vitamin C.



Season: Flowers from April to May. Fruit picking season is from the end of July to September.



Cultivation: *E. japonica* is propagated by seed, air layering, T-budding or side grafting. Propagation is generally by direct sowing of seed, as pre-treatment is not necessary for germination. In many countries *E. japonica* is still propagated by seed, but in regions where commercial cultivation of this fruit has received serious attention, budding and grafting have replaced this method as seedlings are not true-to-type. There are several superior cultivars and they should be budded or cleft-grafted. It is recommended to have several different loquat varieties in the orchard for optimal fruit set as some cultivars are self-incompatible. The seeds should be sown fresh and not dried. Seed nature is recalcitrant. Fresh seeds germinate well and fast. There are about 400–600 seeds/kg.



Eriobotrya japonica is fairly fast growing. Plant spacing should either be 3.5 x 7 m or 6 x 6 m. For good productivity, manuring and interplanting with a nitrogen-fixing leguminous crop are recommended. Manuring should be carried out every 2 years at the rate of 40–50 kg/tree, or 12–40 t/ha. After planting out, the tip of the seedling is pruned to 60–75 cm above the ground level to promote the growth of 3–5 branches. Trees are also pruned immediately after harvesting to limit the number of fruits for the next season and even out production. Grafted trees, when available, remain smaller but make stronger growth and produce fruit faster. Where insulation is strong the fruit clusters are bagged to prevent sunburn of the fruit skin.



Pests and diseases: Pests include leaf-eating chafer beetles and grey weevils, which attack the margins of the leaves. Scale insects, aphids, red spider mites and thrips (*Heliothrips* spp.) suck the sap from plant leaves. White flies and mealybugs also damage young fruits and leaves. Different aphid species suck sap from twigs and shoots and sooty

mould develops on the honeydew which they excrete. Fruit flies of different species can be a serious problem as they damage the fruits. Birds are also serious pests of loquat fruit. Important diseases include fireblight (caused by the bacterium *Erwinia amylovora*) and loquat scab (caused by the fungus *Fusicladium eriobotryae*). Flowers are also attacked by powdery mildew and anthracnose.



Commercial/market value: In Kenya loquat is only cultivated on a small-scale mainly for home consumption. In 2017, only 780 t were produced although the reported area under loquat increased from only 90 ha in 2012 to 190 ha in 2017. Fresh loquat fruits are sometimes sold in local markets in the central region and in some parts of Nairobi. Superior cultivars should be promoted and cultivated commercially for export as well as for local markets. This important fruit species should be cultivated in homegardens to improve the nutrition of local communities.

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35. *Mangifera indica* L.

ANACARDIACEAE

(Native to northern India and Burma)

Common name: Mango

Local names: Maembe/Muembe (Kamba); Mwiembe (Kikuyu); Rieembe (Kisii), Liembe (Luhya); Maembe/Mawembe (Luo); Amba (Somali); Mwembe (Swahili, Tharaka).

Description and ecology: A densely leaved evergreen tree, with a rounded crown, usually 10–15 m tall but occasionally reaching 25 m. **Bark:** Dark brown, cracking with age. **Leaves:** Dark green, crowded at the ends of branches, simple, up to 30 cm long, leathery, smell of turpentine when crushed, soft when young and copper-coloured. **Flowers:** Numerous, small, in pink/brown pyramidal heads. **Fruit:** A drupe with great variation in the form, size, colour and quality of the fruits. Fruit shape is nearly round, oval, ovoid/oblong or somewhat kidney-shaped, with leathery, waxy, smooth, fairly thick, aromatic skin. Fruit colour varies from light or dark

green to clear yellow, yellow/orange, yellow/red/pink or blushed with bright or dark red/orange/red/yellow when ripe; fruit flesh yellow to orange in colour, juicy and aromatic, sometimes fibrous with a large woody stone containing the seed.

It is the most abundant and widespread fruit tree growing in Kenya from sea level to 1800 masl. It is naturalized at the coast and along the banks of the lower part of Tana River where old trees with stems measuring over 2.5 m in diameter can be found. It is also found in Kitui, Embu, Kangundo, Mwala, Machakos, Nyanza, Thika, Murang'a and Nairobi.



Mangifera indica – unripe fruit of the cultivar 'Apple' hanging on the tree



Mangifera indica – young tree



Mangifera indica – unripe fruit of the cultivar 'Ngowe' hanging on the tree

Mango is sometimes dubbed “the king of fruits” and is one of the most popular, nutritionally rich fruits in the tropics with a unique flavour, fragrance and taste, as well as health-promoting qualities. Over a dozen improved varieties are commonly available in Kenya, in addition to numerous locally grown, traditional cultivars. Each variety differs in fruit size, shape, colour, quality, taste or ripening time and ecological requirements.

Some varieties have fibrous fruits while others contain little or no fibre. The latter are now increasingly being grown for local and export markets especially at the coast and in the eastern region of the country. Mangos grow well in areas which receive low rainfall (500–1000 mm per annum) and where temperature ranges from 24°C to 30°C at altitudes from 0–1800 masl., and in well-drained soils. In low altitudes the varieties Apple, Boribo, Dodo, Batawi, Ngowe and Alphonso are well adapted. The varieties suitable for medium altitudes include the Floridan cultivars Haden, Kent, Sabine, van Dyke and Tommy Atkins; local cultivars, Apple and Ngowe, can also be grown.



Mangifera indica – ripe fruit of the cultivar 'Apple'



Mangifera indica – unripe fruit of a small local variety on tree



Mangifera indica – unripe fruit of the cultivar 'Kent' hanging on the tree



Mangifera indica – ripe fruit of the cultivar 'Tommy Atkins'



Unripe mangoes made into delicious, sweet or spicy snacks (partly treated with food colouring) at the Kenyan coast



Refreshing natural mango juice served in most restaurants in Kenya

Uses: Ripe mango fruit has a delicious, very sweet and aromatic flesh. The majority of mango production in Kenya is consumed fresh; about 3–5% of production is processed to make products such as jam, jelly, syrup, nectars, concentrates, dried/candied fruit and fresh juice. Mango juice with ice cubes is a popular, delicious drink and can be blended with milk to make a mango milkshake. Unripe mangoes are used in flavouring food and made into chutneys and

pickles, especially among the Asian community. In India, the kernels are important as a famine food, but the astringency has to be removed by boiling, roasting and soaking them for a long time. Wood is used as fuelwood, for making carvings, for timber (soft wood) and boatbuilding (canoes); the leaves and seeds are sometimes used as fodder for goats. The trees can also be planted for shade or used as ornamentals. The flowers make good bee forage.

Nutrient composition

Mango, pulp, raw (<i>Mangifera indica</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean	n
Energy ¹ kcal (kJ)	65 (274)	
Water (g)	82.7	1
Protein ² (g)	0.5	
Fat (g)	0.2	1
Carbohydrate, available ³ (g)	14.2	
Fibre, total dietary (g)	2.1	1
Ash (g)	0.3	1
Calcium (mg)	17	1
Iron (mg)	0.7	1
Potassium (mg)	180	1

Mango, pulp, raw (<i>Mangifera indica</i>) <i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Magnesium (mg)	9	1
Phosphorus (mg)	18	1
Copper (mg)	0.06	1
Zinc (mg)	0.11	1
Vitamin A (RE)⁴ (mcg)	227	
β-carotene equivalents⁵ (mcg)	708-2020	2
Vitamin E (mg)	1.05	1
Thiamine (mg)	0.03	1
Riboflavin (mg)	0.03	1
Vitamin B6 (mg)	0.11	1
Niacin (mg)	0.4	1
Folate (mcg)	25	1
Vitamin C (mg)	37	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Mangos are a very good source of vitamins A and C. The content of vitamin A, based on their active components (β-carotene equivalents) can vary greatly among the different cultivars. Generally, the more intense the yellow or orange pulp colour of mango, the higher the vitamin A content. Mangos also provide moderate values of folate and other B-vitamins.



Season: Flowers in September in Kibwezi, Machakos, Embu and Kitui, and fruit mature in December to February; fruits in November to December in Nyanza and in December to January in the coastal and lower Tana regions. However, different varieties of mangos



from different areas are available most of the year.

Cultivation: Mangos can be propagated from seed and through grafting using scion and rootstock. No treatment is necessary for germination of seeds. However, nicking the hard, fibrous kernel enhances seed germination. Nicking must be done on the side away from the points where the first shoot and root will develop. Separate the kernel from pulp and clean it before storage or sowing. Seed storage behaviour is recalcitrant; there is complete loss in viability within 7 days in open storage at 30°C. Seed viability can be maintained for

up to 120 days with partially dried seeds stored at 15°C. Seeds are damaged by chilling to temperatures below 3–6°C. Fresh seeds germinate at temperatures between 5°C and 40°C, with germination being most rapid between 25°C and 40°C. The germination rate of fresh seeds is generally over 80%, with the normal rate ranging from 60% to 90%. There are 40–50 seeds/kg.

Mango cultivars are either monoembryonic (i.e., one seedling emerges per seed) or polyembryonic (i.e., several seedlings emerge from one seed; all of them apart from one seedling are clones of the mother tree). Most of the local Kenyan cultivars are polyembryonic and do not need grafting as they produce true-to-type seedlings. However, most of the improved cultivars from Florida are monoembryonic and can only be propagated vegetatively, e.g., by grafting. For any successful grafting process, ensure that the stock and scion are compatible, healthy and properly handled during the whole process. Different types of grafting methods can be used, e.g., whip and tongue grafting, top-wedge grafting and side-wedge grafting. Top working of older mango trees is also possible. Mango seedlings start to bear fruit within 4–7 years, while grafted trees may bear a few fruits within their second year in the field.

To establish a mango orchard, the planting holes should be 0.6 x 0.6 m wide and one should mix the topsoil with manure. The best spacing between the trees should be 8 m x 8 m. Formative pruning of young trees is necessary by cutting the main shoot at 1 m height so that about 4 horizontal shoots will arise to form the frame of the tree. Depending on the cultivar and growth pattern, selective pruning of branches may be required

later to open the canopy and encourage growth of lateral branches. Mango is a fairly fast-growing tree, but it can be adversely affected by fire. Due to its thick canopy, heavy shade and high water demand, densely planted mature trees do not support undergrowth, including any food crops. However, intercropping is possible between young and single trees. Weed control and fertilizer application are necessary for good and constant fruit yields. Irrigation is usually not required once the young trees are established.



Pests and diseases: While local mango varieties grown in homegardens are usually quite healthy, commercial orchards of local and improved varieties need a lot of pest and disease control. Different types of fruit flies, including the indigenous species *Ceratitis capitata* and *C. cosyra*, plus invasive species, *Bactrocera invadens* from Asia, are known to attack ripening mango fruits in almost all mango-producing areas in Kenya. As fruit flies are quarantine pests and cause huge losses, control is very important, e.g., by using traps and baits, applying orchard hygiene or regularly spraying chemical or biological insecticides. Another important mango pest is the mango weevil *Sternonchetus mangiferae*. Its larvae feed on the seed of mango fruits and damage the pulp when boring out of the seed to pupate. In addition, this species is a quarantine pest, therefore control is necessary, e.g., by applying orchard hygiene or pesticides. Other pests of mango include mealybugs (*Rastrococcus* spp.), mango white scales, thrips and gall midges that cause ‘pimples’ on the leaves.

The most important fungal diseases are anthracnose, caused by *Colletotrichum gloeosporioides* and resulting in brown-black spots on leaves and fruits, and

powdery mildew that results in white powdery fungal growth on leaves, flowers and young fruits caused mainly by *Oidium mangiferae*. Orchard hygiene and frequent application of fungicides help to control these diseases. Other important diseases include fungal infections such as scab (caused by *Elsinoe mangiferae*) and flower malformation (caused by *Fusarium subglutinans*), plus the Bacterial black spot on leaves and fruits (caused by *Xanthomonas campestris*).



Commercial/market value: The production of mango fruits in Kenya has increased significantly in the past decade and reached about 700,000 t in 2017. From 2012 to 2017, the area under mango increased from 41,400 to 50,600 ha. From the total production, most fruits were used for home consumption and sold in local markets, while only about 3-5% of the production was processed and 1.3% exported in 2017. Export is restricted to neighbouring countries and the Middle East due to the frequent occurrence of quarantine pests that resulted in a ban of Kenyan mangos in the EU (European Union). To target promising export markets, farmers must comply with the standards required by the *GLOBALGAP Control Points and Compliance Criteria*, which is required for all fruits and vegetables destined for the EU market. Processing of mangos in Kenya can help to address the huge post-harvest losses; this includes juice, jam and pickles or chutney from mango, as well as dried or candied mango.

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36. *Persea americana* Mill.

LAURACEAE

(Native to Central and South America)

Common name: Avocado pear, alligator pear, aguacate

Local names: Ikoloviu (Kamba); Mukorobea/Maguna ngui (Kikuyu); Avakado (Luo), Mwembe mafuta (Swahili).

Description and ecology: A densely leafy evergreen tree, up to 10 m or more with a straight trunk. **Bark:** Grey/brown. **Leaves:** alternate, large, oval, to 20 cm long, shiny, dark green above, veins very clear, young leaves bright green, but also orange/pink in some cultivars. **Flowers:** Pale yellow, very small (5–8 mm in diameter), in large terminal heads, only 1 in 5000 producing fruit. **Fruit:** Round to pear shaped, large berry, about 20 cm long, hanging on long stalks. One big central seed surrounded by a thick layer of yellow/green flesh. The outer, leathery skin varies in colour from green to purple or black. The single seed is oblate, round, conical or ovoid, 5–6 cm long, hard and heavy, ivory in colour but enclosed in 2 brown, thin, papery seed coats often adhering to the flesh cavity, while the seed slips out readily.

There are three botanical races of avocado that originated in Mexico, Guatemala and the West Indies; each of these has distinctive characteristics. Fruits of the Guatemalan race are roundish and have thick, hard skins that are often rough. The fruits, for example of the cultivars Hass and Reed, mature late, have a high oil content and store well; cultivars grow best at 1000–2000 masl. Cultivars of the West Indian race have fruits that are usually large with a large seed and have a pale green, smooth skin when ripe, sometimes with a reddish blush. The flesh has low oil content and is mild to watery in flavour; it has a poor shelf life. This race includes the early maturing

varieties such as Hardy and Simmonds. The West Indian race is suitable for cultivation in the lowlands and is usually found between sea level and 1000 masl. The Mexican race is cold-tolerant, hardy and has fruits that are relatively small with a thin and smooth skin. The fruit often has a high oil content and does not store well (short shelf life); crushed leaves have a typical anise-like smell. The cultivars of this race include Puebla and Teague. The Mexican race grows best at 1500–2500 masl. In Kenya all the three races and their hybrids are grown at more or less the same altitude. Avocado grows successfully in a wide range of soil types, e.g., deep, fertile, well-aerated, particularly sandy or alluvial loams with neutral or slightly acid pH values (pH 5–7). Avocado does not tolerate waterlogged or poorly drained soils.

Uses: Flesh of the ripe fruit is edible and generally served raw. Avocado has a delicate nutty flavour and butter-like taste. It is now a common fruit used in fruit salads, green salads and desserts, and is often eaten as a snack. Avocado dip is an uncooked savoury dish mixed with herbs and/or spices and with vegetables such as tomatoes (called guacamole), served with Tortilla chips or with long sticks of carrots, cucumber etc. as a starter in restaurants and at home. Avocados are frequently used for milkshakes and occasionally added to ice cream and sandwich spreads. In Kenya avocado is often eaten at breakfast time. Ripe pulp is also used in hair conditioning, for skin scrubs and

in the manufacture of creams, while pure oil is used for head massage. The edible oil pressed from the fruit pulp is also commercially used for cosmetics. The wood is used as timber and fuelwood, and the species is good for bee foraging.



Persea americana – young tree in flower



Persea americana – bunches of unripe fruit hanging on the tree



Persea americana – young grafted avocado trees intercropped with vegetables



Persea americana – ripe fruit of different varieties grown in Kenya



Persea americana – ripe cut fruit of a cultivar with green-yellow fruit pulp



Persea americana – whole and cut ripe fruit of a cultivar with cream/white fruit pulp

Nutrient composition

Avocado pulp, raw (<i>Persea americana</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy¹ kcal (kJ)	154 (633)	
Water (g)	76.5	1
Protein² (g)	1.7	
Fat (g)	14.7	1
Carbohydrate, available³ (g)	1.3	
Fibre, total dietary (g)	4.7	1
Ash (g)	1.1	1
Calcium (mg)	15	1
Iron (mg)	0.8	1
Potassium (mg)	492	1
Magnesium (mg)	32	1
Phosphorus (mg)	46	1
Copper (mg)	0.23	1
Zinc (mg)	0.51	1
Vitamin A (RE)⁴ (mcg)	11	
β-carotene equivalents⁵ (mcg)	68	1
Vitamin E (mg)	1.60	1
Thiamine (mg)	0.06	1
Riboflavin (mg)	0.15	1
Niacin (mg)	1.8	1
Vitamin C (mg)	10	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Avocado is a caloric, energy-rich fruit that is rich in good fat. The fat consists mostly of monounsaturated fatty acids (70%), which have a positive impact on the blood lipid profile and consequently lower the risk of heart disease. The fruit is also a good mineral source, particularly of potassium, phosphorus, copper and zinc. Avocado contains excellent values of the fat-soluble vitamin E (comparable to that found in walnuts), an antioxidant that protects body cells from oxidative damage.



Season: Avocado fruit is available throughout the year, but harvest time depends on the cultivar. The main harvest season is from March to September. The number of fruits which set and mature is small in relation to the number of flowers produced. Cultivars differ in productivity and in regularity of bearing; some produce a large crop only every other year.



Cultivation: Trees grown from seed are of uncertain quality because the cultivars are not 'true-to-type'. Seedlings are therefore not recommended as commercial planting material although they can be used as a rootstock for grafting. The most popular improved varieties for export are Fuerte and Hass. There are different types of grafting methods used including whip and tongue grafting, top-wedge or cleft grafting and side-wedge grafting. Top working on older trees is also possible. Seeds for rootstocks should be sown directly at the desired site, no pre-treatment is required. Use fresh and healthy seeds for best results. The seeds are recalcitrant and are only viable for 2–3 weeks after removal of the fruits. There are about 15 seeds/kg.

The planting hole should be 0.6 m x 0.6 m wide but the spacing between trees differs with varieties; Fuerte cultivar should be planted on a spacing of 9 m x 9 m; while



Hass cultivar should be planted on a spacing of 8 m x 8 m. During the first few years after planting, formative pruning is needed to encourage lateral growth and the desired branching. Suckers from the rootstock must be removed. In later years, pruning is mainly undertaken to improve the shape of the crown and to influence the size, quality and quantity of the fruit. It includes removal of undesired shoots inside the canopy, pruning of broken or diseased branches and shortening of those touching the ground. Frequent weed control and soil management as well as fertilizer application are necessary for good development of trees and constant yields. Irrigation is not required in most avocado-growing areas of Kenya.

Pests and diseases: Only a few pests attack avocado trees and fruits, including scale insects and thrips. However, avocado trees are vulnerable to some fungal diseases. Most important is the avocado root rot caused by *Phytophthora cinnamomi* that results in loss and wilting of leaves, die back of branches and finally in death of the tree. In areas subject to flooding and in poorly drained soils, trees are likely to be infected by this fungus that is difficult to control. Another important fungal disease is anthracnose caused by *Colletotrichum gloeosporioides* that results in black spots on the fruits. Anthracnose can be controlled by orchard hygiene and application of fungicides.



Commercial/market value: Avocado is mostly sold locally, but about 16% of the total harvest was exported in 2017, mainly to Europe and the Middle East. In Kenya, most of the avocado is produced by small-scale farmers, who sell their produce to the fresh market or to avocado oil processors. In 2017, the total harvest in Kenya was about 287,000 t and the

area under avocado increased from 11,000 ha in 2012 to 15,000 ha in 2017. The major part of production is recorded from March to September and smaller volumes are available from October to February. The main export cultivars are Fuerte and Hass.

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37. *Psidium guajava* L.

MYRTACEAE

(Native to Central and South America)

Common name: Guava

Local names: Kivela (Kamba); Mubera (Kikuyu); Lipera (Luhya); Mapera (Luo); Zeitun (Somali); Mpera (Swahili).

Description and ecology: A small, evergreen tree that grows up to 8 m, branching irregularly. **Bark:** Smooth, pale brown, later peeling and flaking. Young shoots are 4-sided. **Leaves:** Large, dull green, oval, up to 15 cm long, in opposite pairs. **Flowers:** White, about 2.5 cm across, 1–3 together beside leaves, with many stamens. **Fruit:** Rounded, ovoid or pear-shaped berry, up to 10 cm long, tip with remains of the calyx, skin colour green, yellow or whitish, rarely red, depending on the variety. Fruit pulp is white, yellow, light or dark-pink, or near-red; juicy, acidic, sub-acid, or sweet and flavourful. The sweet flesh surrounds many hard, yellowish, angular seeds, though some rare types have soft, chewable seeds. Seedless varieties also exist.

Guava is naturalized in Kenya. It has spread extensively in the humid parts of the western region. However, it does not seem to establish and colonize natural ecosystems successfully; it is a vigorous colonizer of disturbed ground, fallows and roadside areas. It also grows in semi-arid parts of Kenya including Kitui, Machakos and Mbeere; it is also

common in Nairobi and the coastal areas. Grows from 0–2000 masl on many soil types, including those with high water tables and slight salinity. Guava is relatively drought-tolerant, but yield is highest under sufficient water supply.



Psidium guajava – ripe fruit on tree



Psidium guajava – tree



Psidium guajava – ripe whole and cut fruit of a cultivar with red pulp



Psidium guajava – fruit being sold in a local open-air market



Psidium guajava – ready-to-eat fruit slices of a cultivar with white pulp

Uses: The whole fruit is edible, including those that have not fully matured with their crispy and sour tasting fruit flesh; ripe fruits have a pleasant aroma and an acid to sweet taste, with the best fruit being both sweet and mildly acidic. In addition to raw consumption, guavas are used to make jam, jelly, juice, nectar, ice cream, yoghurt and canned products. Wine making from the fruit has been commercialized in Southern Africa. Guava paste or fruit leather (or guava cheese as it is known in the West Indies) is made by slowly drying the pulp mixed with sugar; it is eaten as a sweetmeat. In some Asian countries such as Indonesia, the leaves are sometimes used in cooking. Several parts of the guava trees are used as traditional medicine. The tree also has other uses such as live fencing, fuelwood, charcoal, posts, tool handles, shade, ornamental and soil conservation. Leaves are fodder for goats and camels. The flowers secrete nectar in excess all day, thus attracting bees which also collect juice from the damaged fruits.

Nutrient composition

Guava, pulp, raw (<i>Psidium guajava</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy¹ kcal (kJ)	57 (238)	
Water (g)	82.9	1
Protein² (g)	1.0	
Fat (g)	0.4	1
Carbohydrate, available³ (g)	9.5	
Fibre, total dietary (g)	5.6	1
Ash (g)	0.6	1
Calcium (mg)	23	1
Iron (mg)	0.7	1
Potassium (mg)	270	1
Magnesium (mg)	13	1
Phosphorus (mg)	32	1
Copper (mg)	0.06	1
Zinc (mg)	0.32	1
Vitamin A (RE)⁴ (mcg)	70	
β-carotene equivalents⁵ (mcg)	419	3
α-tocopherol (mg)	0.32	1
Thiamine (mg)	0.05	1
Riboflavin (mg)	0.04	1
Vitamin B6 (mg)	0.14	1
Niacin (mg)	1.2	1
Folate (mcg)	7	1
Vitamin C (mg)	261	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

Fresh guava fruit is very rich in vitamin C. Consuming only one fruit (estimated 50 g pulp) is essential to meet the recommended daily intake¹¹ of vitamin C (45 mg/d). Vitamin C is a good antioxidant; it protects the body from radicals and improves absorption of non-haem iron in the gut. The fruit also contains some vitamin A and good levels of B vitamins such as niacin and vitamin B₆. In addition, it is a source of dietary fibre, a component which positively influences the gastrointestinal tract and is inversely related to cardiovascular diseases and type 2 diabetes.



Season: Flowers from February to March and fruit mature from May to June in Machakos, Makueni, and Ukambani. In Mombasa, Nairobi and Kisumu it flowers from May to June and fruits from July to August. A second crop may be available in some regions in November/December.



Cultivation: Guavas can be propagated by seed, root suckers, cuttings, air layering and grafting. About 70% of seedlings retain the general characteristics of the parent tree. Propagation by seeds is very easy; no pre-treatment is required. Seeds are orthodox; there is no loss in viability for about 5 years in hermetic storage at -20°C. However, seeds cannot be stored for long under ambient conditions. The number of seeds/kg is about 500,000. Seed can be sown in beds, pots or directly in the field at a depth of 1 cm; germination occurs within 15 to 20 days. Seedlings should be planted out when about 25 cm high. The seedling grows very rapidly, producing fruit in 2–3 years on good soil.



Improved varieties are vegetatively propagated to harvest high quality fruit for the fresh market. To produce large numbers of clones, shield or patch

budding onto seedling rootstocks is recommended. Budwood should be mature (bark no longer green) and the leaves cut 2 weeks before budding to allow the buds to swell. Budding is best done as soon as the rootstock is thick enough to take the bud; the buds do not sprout readily on older rootstocks. Budded trees are ready for field planting after 4–5 months. Other vegetative propagation methods, such as using cuttings or grafting, can also be used. Rootstocks should be about 1 m tall for grafting.

Trees are usually spaced at 4–6 m apart, but plants for fruit processing may be spaced up to 10 m x 8 m apart. The growth rate is very fast and plants coppice readily. Branching is extensive and pruning is necessary to form good orchard trees. Application of fertilizer results in higher yield and better quality of the fruit. Intercropping is possible in the first years after orchard establishment.



Pests and diseases: Insect pests in guava are numerous and, in some cases, severe. The most important pest is fruit fly including the species *Anastrepha striata*, *Bactrocera invadens*, *Dacus* spp. and *Ceratitis* spp. that may infest large proportions of the almost mature fruits. Control measures include pheromone traps and baits, orchard hygiene (destruction of infected fruits) and application of insecticides. Early harvesting of guavas can also reduce infestation with fruit flies. Additional pests include aphids (*Aphis* spp.) that feed on young growth and cause the curling of leaves, scales (*Coccus* and *Pulvinaria* spp.) that cause damage on

11 Calculations based on recommended nutrient intake/day: adults (19 to >65 years), Vitamin C: (45 mg/d) www.fao.org/nutrition/requirements/vitamins

leaves and fruits, and red-banded thrips (*Selenothrips rubrocinctus*) that puncture leaves and cause brown stains. Main fungal diseases include anthracnose by *Colletotrichum gloeosporioides* that causes dark coloured, necrotic lesions on fruits, fruit rot by *Phytophthora* spp. and wilt by *Fusarium* spp. that may result in die back of the tree.



Commercial/market value: Guava is an ideal homegarden fruit tree due to its hardiness, high yield, long supply season and high nutritional value. It can also be grown in orchards or incorporated into agroforestry systems and is widely planted (or has spread) in Kenya. However, it is a neglected fruit and mostly produced only for home consumption. In Kenya, production of guava was as low as 3,300 t in 2017 and its production area decreased from 770 ha in 2012 to 500 ha in 2017. Although some superior cultivars have been introduced, most guava trees in Kenya are just seedlings or wildlings of local landraces. The fruit is rarely sold in supermarkets in the big cities, and those sold in local markets are mostly of low quality. Almost no value addition such as juice or jam production is done. Guava has great potential for income generation and enterprise diversification, but farmers lack knowledge on the importance of the crop (particularly in international markets), its proper management on farms and its nutritional value.

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38. *Syzygium cumini* (L.) Skeels

MYRTACEAE

(Native to India and Tropical Asia)

Common name: Jambolan, Jamun, Java plum, Black plum

Local names: Mzambaru (Digo, Swahili); Mzambaru/zambarau (Giriama); Jamna (Luo); Eme (Teso).

Description and ecology: A large tree that grows to 30 m, usually 15–18 m; crown is well branched with dense, heavy foliage. **Bark:** Smooth or paler on young branches, dark and rough on the bole. **Leaves:** Opposite, large, oval, up to 20 cm, smooth and shiny, tip pointed, and strongly aromatic if crushed. Young leaves are soft and reddish. **Flowers:** Green/white, fragrant and small, about 1.5 cm across, in clusters below leaves. Flower branches are very symmetric, at right angles. **Fruit:** Fleshy berry, green when young, purple to black when ripe, smooth, thin-skinned, glossy, adherent, about 1.5–3.5 cm long and up to 2 cm in diameter, sweet, but astringent taste. Fruit pulp is purple or white, very juicy, and normally encloses a single, oblong, green or brown seed, up to 2 cm in length, though some fruits have 2–5 seeds tightly compressed within a leathery coat, and some cultivars are seedless.

In Kenya, a well-known ornamental evergreen exotic fruit tree, long planted in Mombasa and other humid lowland areas including Kisumu where it has become naturalized. It is also very common in Nairobi. It grows on many types of soil, even on slightly sodic or saline soils, but prefers well drained soil. Although jambolan grows best in areas with rainfall over 1000 mm, it can tolerate short dry seasons as well as waterlogging. Grows at 0–1800 masl in Kenya.

Uses: Ripe fresh fruit is usually eaten raw in Kenya. Elsewhere jambolan is processed into jams, jellies, juice and desserts as well as into wine, liqueurs, brandy and vinegar. The long-lasting hard wood is useful for timber (canoes, construction), fuelwood, charcoal, furniture-making, beehives, beams and rafters, plus boatbuilding. Leaves are used as fodder for animals, particularly cattle. The tree provides deep shade and bee forage and is used as an ornamental tree and for riverbank stabilization. The bark is used as fish poison and for tannin and dye. Several parts of the tree are used in traditional medicine, e.g., fruits and seeds in the treatment of diabetes.



Syzygium cumini – ripe fruit



Syzygium cumini – whole and cut ripe fruit showing the whitish fleshy fruit pulp



Syzygium cumini – bunches of small unripe fruit on the branch



Syzygium cumini – tree

Nutrient composition

Jambolan fruit, raw (<i>Syzygium cumini</i>)		
100 g edible portion on fresh weight basis (EP)		
Component	Mean (min-max)	n
Energy ¹ kcal (kJ)	52 (221)	
Water (g)	85.3	1
Protein ² (g)	0.5	
Fat (g)	0.4	1
Carbohydrate, available ³ (g)	11.1	
Fibre, total dietary (g)	3.4	1
Ash (g)	0.4	1
Calcium (mg)	44	1
Iron (mg)	0.8	1

Jambolan fruit, raw (<i>Syzygium cumini</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean (min-max)	n
Potassium (mg)	72	1
Magnesium (mg)	12	1
Phosphorus (mg)	17	1
Zinc (mg)	0.42	1
Thiamine (mg)	0.02	1
Riboflavin (mg)	0.04	1
Niacin (mg)	0.5	1
Vitamin C (mg)	33 (16-50)	2

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Syzygium cumini fruit contain good values of minerals and vitamins such as vitamin C. Moreover, the fruit is rich in phenolic acids such as gallic acid and flavonoids such as quercetin. These are secondary metabolites of plants and possess a high antioxidant capacity, protecting the cells from oxidative damage.



Season: Flowers from September to October and fruits from December to January. However, there is variability in harvest seasons in different parts of Kenya where jambolan occurs.



Cultivation: *S. cumini* is propagated by seedlings, air layering, inarching, grafting, budding and cuttings. Seed cannot be stored (i.e., they are recalcitrant) as drying kills the seeds. Fruit flesh should be removed and the seeds washed before sowing. No pre-sowing treatment of seed is necessary. Each seed produces 1–5 seedlings. Seeds are normally sown directly at the site or into pots at a depth of 2–2.5 cm during the rainy season; they germinate in 2–4 weeks at a rate of 20–



90%. Seedlings always need moist soil, while shading is less important. Seedlings in pots can be planted out 1–3 years after sowing. Seedlings at the age of one year can be used as rootstocks and grafted or budded to produce clones of improved varieties. There are about 500 seeds/kg.

Trees in an orchard should be spaced between 8 and 10 m but much closer if planted in a line as a windbreak. *S. cumini* is a fast-growing tree and seedlings may reach a height of 4 m in only 2 years. Young trees need some pruning to develop a good crown. Later, no regular pruning is needed. In orchards with good soil, no or only little fertilizer such as farmyard manure is required. Fruits for the fresh fruit market should be carefully picked by hand and handled with care as they are perishable.



Pests and diseases: Information on pests and diseases of jambolan in Kenya is scant. In general, jambolan is said to be attacked by pests such as

leaf-eating caterpillars (*Carea* spp.), leaf miners (*Eteoryctis* spp.) and leaf rollers (*Megalota* spp.). Fruit flies such as *Bactrocera* spp. often attack the fruits. These pests can partly be controlled by orchard hygiene, beneficial insects, traps or application of insecticides. Birds can also be a pest in jambolan orchards. *S. cumini* is susceptible to several diseases, but the most important one is anthracnose by *Colletotrichum gloeosporioides* that causes dark coloured, necrotic lesions on leaves and fruits. The young tree is also susceptible to browsing damage by livestock and needs protection during establishment.



Commercial/market value: In Kenya, jambolan is mainly a homestead tree. No commercial orchards exist and the perishable nature of the fruits with short shelf life restricts commercialization. The fresh fruit can sometimes be found in urban (e.g., Nairobi, Mombasa) and local markets when it is in season. So far, processing is not done on a commercial scale. Potential for larger scale production exists if markets for processed products such as jam, juice or wine could be developed.

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PART THREE: INTRODUCED, UNDERUTILIZED SPECIES WITH FUTURE POTENTIAL



Punica granatum (Pomegranate)



Litchi chinensis (Litchi)



Morus alba (Mulberry)



Diospyros kaki (Japanese persimmon)



Dovyalis caffra (Kei apple)



Pithecellobium dulce (Madras thorn)



Syzygium jambos (Rose apple)

39. *Annona muricata* L.

ANNONACEAE

(Native to West Indies, Tropical America)

Common name: Soursop

Local names: Mutomoko/Mtumoko (Kamba); Mstafeli (Swahili).

Description and ecology: A slender, evergreen tree, 5–7 m in height, usually less, branches low and wide, with an open shady crown. **Bark:** Grey and smooth with a pattern of shallow grooves. **Leaves:** Dark green, shiny and leathery, alternate, 8–15 cm long, oval with a sharp tip, dull or yellow below. Have a strong smell when crushed. **Flowers:** Large, solitary on branches and the trunk, 2–5 cm across, often opposite leaves and hanging down, 3 outer fleshy, yellow-green petals, curved, almost angular, 3 inner pale-yellow petals, thinner, rounded. **Fruit:** The fruit, an aggregate berry, is compound, oval, kidney- or heart-shaped, up to 25–30 cm long, 0.5–3 kg in weight, the leathery dark green skin is covered with soft, curved spines; enclosed white fibrous pulp separates easily into segments, covers many large brown/black seeds that are oval, smooth, hard and 1.25–2 cm long.

An exotic fruit tree planted throughout the warm tropical lowlands to midlands (best below 1000 masl). The species cannot tolerate cold temperatures < 5°C and needs sufficient rainfall of > 1000 mm per year. Although the species can grow on a wide range of soils, it prefers well-drained sandy to sandy loam soils. In Kenya, it is grown along watercourses or under irrigation in semi-arid and arid lowland areas of the eastern region (mainly Ukambani, Machakos, Kitui, Makueni), along the coast and in some parts of western Kenya. Mature trees once established

become drought-tolerant but are susceptible to waterlogging.



Annona muricata – tree



Annona muricata – unripe fruit hanging on the tree



Annona muricata – leaves

Uses: The slightly fibrous flesh is eaten when the fruit is ripe and soft. The flesh is juicy, sweet and sour with a distinctive pleasant taste. The seeds are toxic and should be separated from the flesh before consumption. *A. muricata* can be consumed fresh as such or mixed with ice cream or milk to make a delicious drink. After squeezing the pulp through a sieve, the juice can be used directly (after adding some sugar) or processed into jam, jelly, smoothies, candies or syrup. In Indonesia sweet cake ('dodol sirsak') is made by boiling *A. muricata* pulp in water

and adding sugar until the mixture hardens. In the Philippines, young fruit with seeds that are still soft are used as a vegetable. The tree is also grown as an ornamental in homegardens. All parts of the tree have insecticidal properties. The wood is soft, light and not durable; it is rarely used as timber. All parts of the tree are used as medicine and recently, the fruit extract gained popularity as a cancer treatment; however, there is no scientific evidence to support this view.

Nutrient composition

Soursop, fruit pulp, raw (<i>Annona muricata</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy¹ kcal (kJ)	66 (278)		
Water (g)	81.6 ± 0.9		3
Protein² (g)	1.1		
Fat (g)	0.3	0.2-0.3	2
Carbohydrate, available³ (g)	13.2		
Fibre, total dietary (g)	3.3		1
Ash (g)	0.6	0.5-0.7	2
Calcium (mg)	20	14-25	2
Iron (mg)	1.0	0.6-1.3	2
Potassium (mg)	270	261-278	2
Magnesium (mg)	20	19-21	2
Phosphorus (mg)	30	27-32	2
Copper (mg)	0.09		1
Zinc (mg)	0.10		1
Vitamin A (RE)⁴ (mcg)	0		
β-carotene equivalents⁵ (mcg)	2	1-3	2
α-tocopherol (mg)	0.08		1
Thiamine (mg)	0.08	0.07-0.09	2
Riboflavin (mg)	0.07	0.05-0.08	2
Vitamin B6 (mg)	0.06		1
Niacin (mg)	1.0	0.9-1.1	2
Folate (mcg)	14		1
Vitamin C (mg)	22	21-23	2

SD, standard deviation, calculated when the number of data points (n) ≥ 3;

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2(kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + 1/2 β-cryptoxanthin

The soursop fruit pulp is nutritious, containing good values of minerals such as magnesium, phosphorus and iron. Vitamins from the B-complex such as thiamine (B₁), riboflavin (B₂), vitamin B₆ and niacin are well represented. These components are important coenzymes in the body and play a central role in the metabolism of amino acids and carbohydrates.



Season: Flowers and fruit are reported throughout the year, but in many regions, there are certain main seasons, e.g., in Kakamega from October to December.



Cultivation: Propagated from seeds or by grafting, budding and cuttings. As seeds of good varieties will give plants with characteristics relatively similar to those of the mother tree, many commercial orchards are planted with seedlings. However, for high yielding cultivars, vegetative propagation such as grafting is preferred. Seed storage behaviour is orthodox; the seeds tolerate drying to 5%. Long-term storage under ideal conditions is possible.



When establishing an orchard, a spacing of 5 m x 5 m or 4 m x 6 m is suitable. The area around the base of the tree should be kept free from weeds and covered with mulch to avoid dehydration of the shallow roots during the dry season. In rather dry regions, the trees would benefit from supplementary irrigation. Moderate application of fertilizer and manure increases tree growth and fruit production. Pruning is usually not needed but in some cases, it is necessary to limit the tree to a single trunk by cutting out competing twigs at the base as early as possible. Fruit set and quality can be enhanced by hand-pollination.



Pests and diseases: Leaves and fruits may be attacked by scale insects and mealybugs. Aphids and larvae of moths may damage the leaves. Ants

feed on honeydew from aphids and protect them from natural enemies, while termites may attack the trunk during the dry season. Fruit fly maggots of several species destroy fruits as well as some fruit borers. The most important fungal diseases are anthracnose, root rot and several fruit rots.



Commercial/market value: Around Kitui, Machakos and Makueni, yields are reliable and contribute to the income of farmers. The fruit is marketed locally and is also sometimes available in markets and supermarkets in large cities in Kenya. Often the quality of the sold fruit is low as it is easily bruised and has a short shelf life. It has good potential for processing, but so far, this is not done in Kenya. This is one of the important underutilized *Annona* species; it should be promoted for cultivation in homegardens and on farms for both home consumption, sale and value addition.

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40. *Diospyros kaki* L.f.

EBENACEAE

(Native to East Asia)

Common name: Chinese persimmon, Kaki plum, Persimmon

Local names: Not known

Description and ecology: A slow-growing, deciduous tree, eventually reaching a maximum height of 15 m, with a short, crooked trunk and a profusely branched crown. **Bark:** Brown to grey, rough, with scaly appearance, young branches with dense hairs. **Leaves:** Oval or oblong, shiny dark green on the upper side, finely hairy and brownish beneath, 5–25 cm long and 2.5–15 cm wide, with a blunt tip. **Flowers:** Species is mostly dioecious (i.e., male and female flowers on different trees), few cultivars monoecious (i.e., male and female flowers on the same tree). Flowers are cream-white in colour, male flowers in small, 3–5 flowered, flat-topped heads (cymes) and female flowers solitary. Male flowers are bell-shaped with the white corolla twice as long as the green calyx, female flowers with a much larger calyx. **Fruit:** Oval, round or tomato-shaped with a persistent calyx; a berry of about 8 cm in diameter; smooth, glossy skin, first green, but yellow, orange or reddish when ripe; juicy, gelatinous fruit flesh of similar colour. The taste is sweet with an aroma of apricots, but could be astringent in some varieties when not fully ripe. Fruits are seedless or containing 4–8 flat, oblong, shiny brown seeds, up to 2 cm long.

The persimmon is a classical fruit of temperate and subtropical China from where it was introduced to Japan long ago. Over 1000 cultivars are distinguished in Japan and China. The variation is great, but cultivars are often classified into astringent and non-astringent. Most persimmons are produced in China, Japan and Korea while some commercial production exists in Pakistan, India, Brazil, Italy, Spain and Israel. In Kenya, not much effort has been made to cultivate persimmon, although it is adaptable to a range of climates, particularly those of tropical regions between 1000 and 2000 masl. *D. kaki* prefers well drained, deep and fertile soil and needs reasonable but not heavy rainfall. Established trees are drought-resistant, but in semi-arid areas, irrigation is needed for good yields.

Examples of cultivars of *D. kaki* include Fuyu or Jiro (non-astringent, few seeds) and Hachiya or Hiratanenashi (astringent). Newer cultivars include the astringent Sharon/Triumph (grown mainly in Israel) and Rojo Brillante (grown in Spain). The astringent taste, caused by tannins, can be removed artificially by applying CO₂ or ethylene to the picked fruits.



Diospyros kaki – whole tree with fruit



Diospyros kaki – female flowers showing the large calyx



Diospyros kaki – branch with almost ripe fruit



Diospyros kaki – whole and cut, ripe fruit showing the gelatinous flesh

Uses: The ripe, soft fruit can be eaten fresh with or without the skin, or processed into ice cream, jelly, jam or marmalade. The fruit can also be used in making pastries, puddings and mousses. Some cultivars can be made into an excellent dried product similar to dried figs. Astringency disappears with drying. It can also be used to make molasses, cider, beer and wine. Roasted seeds have served as a coffee substitute. Tea can also be made from fresh or dried leaves. Tannin from unripe persimmons can be used to make dyes and as a wood preservative. The wood is hard and heavy, but has a strong smell and is difficult to work with.

Nutrient composition

Japanese persimmon, pulp, raw (<i>Diospyros kaki</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean	min-max	n
Energy¹ kcal (kJ)	70 (297)		
Water (g)	80.5	80.3-80.7	2
Protein² (g)	0.6		
Fat (g)	0.2	0.19-0.20	2
Carbohydrate, available³ (g)	14.7		
Fibre, total dietary (g)	3.6		1
Ash (g)	0.3		1
Calcium (mg)	15	8-21	2
Iron (mg)	0.3	0.2-0.4	2
Potassium (mg)	166	161-171	2
Magnesium (mg)	9	9-9	2
Phosphorus (mg)	19	17-20	2
Copper (mg)	0.11	0.11-0.11	2
Zinc (mg)	0.11	0.10-0.11	2
Vitamin A (RE)⁴ (mcg)	200		
β-carotene equivalents⁵ (mcg)	1200	977-1420	2
β-cryptoxanthin (mcg)	1450		1
Thiamine (mg)	0.03	0.03-0.03	2
Riboflavin (mg)	0.04	0.02-0.06	2
Vitamin B6 (mg)	0.10		1
Niacin (mg)	0.2	0.1-0.3	2
Folate (mcg)	10	8-11	2
Vitamin C (mg)	8		1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + ½ β-cryptoxanthin

The ripe, fresh fruit pulp of *Diospyros kaki* is characterized by its high vitamin A content (200 mcg RE/100 g EP). Vitamin A is one of the most important micronutrients in public health terms. It is indispensable for the visual cycle, for the immune system and for the functioning of cells. By consuming 100 g of the fruit, 35% of the recommended daily intake of Vitamin A¹² can be met. β -cryptoxanthin is the main vitamin A-active carotenoid in this fruit. Together with lycopene and zeaxanthin, it is responsible for the orange colour of the pulp; all of these are good antioxidants, serving as a free radical scavenger.



Season: In temperate regions, fruits are ready for harvest in late autumn, when it is getting cold. As this tree is rarely grown in Kenya, there is little information available on its harvest season. In Meru and Embu, fruits are ripe around May or June, just before the cold season begins.



Cultivation: Improved cultivars must be propagated vegetatively (e.g., by grafting or cuttings) to maintain their characteristics. Rootstocks are raised from seeds that can be sown either directly from the fruit or after some cold treatment to enhance germination. Root suckers can also be taken and used as rootstocks. Different grafting and budding techniques can be applied. Propagation by cuttings works best with soft wood cutting, and application of rooting hormone can increase success.



Trees should be set out at spacing ranging from 4 x 4 m to 6 x 6 m, depending on the cultivar. Young trees are pruned back about 1 m when planted and new branches thinned to form a good crown. Later, some pruning is needed to remove weak and dense branches.



If an older tree shows signs of decline, it can be drastically cut back to give it a fresh start. Tree growth and yield can be enhanced by regular fertilization with manure or mineral fertilizer. However, over-fertilization should be avoided. In dry regions, irrigation is needed, particularly during flowering and fruit development, but too much water may cause root rot.

Pests and diseases: In general, persimmons have few insect or disease problems. Mealybugs and scales distort young shoots and excrete honeydew. In some regions, mites and thrips could be a problem. Fruit flies may attack fruit especially in dry years and should be controlled by use of biological or chemical methods. Anthracnose is a fungal disease that attacks fruit and leaves and should be controlled, for example, by orchard hygiene. Leaf spot disease may cause the leaves to fall, and root and crown rot caused by *Phytophthora* spp. will result in death of the tree.



Commercial/market value:

Persimmon is not yet cultivated on farms or grown in homegardens in Kenya, but was only planted in some prison farms around Mt Kenya for testing. In Tanzania, it has been planted in the Amani Botanical Garden and the Zanzibar Botanical Garden. Efforts should be made to introduce and test superior cultivars in Kenya. However, marketing of the fruit may be challenging as consumers are not yet aware about this nutritious and tasty fruit.

12 Calculations based on recommended safe intake/day: Vitamin A (retinol equivalents) average female & male: 19 to > 65 years: 575 mcg/day. www.fao.org/nutrition/requirements/vitamins/en/

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41. *Dovyalis caffra* (Hook.f. & Harv.) Sim

SALICACEAE

(Native to Southern Africa)

Common name: Kei apple, wild apricot

Local names: Rweso (Embu); Kikambua/Ngambua/Kaiyava (Kamba); Chinkongonywa/Ekayaba (Kisii); Kaiyaba (Kikuyu).

Description and ecology: A spiny, evergreen shrub or small tree, multi-stemmed, usually 3–5 m high. **Bark:** Brown, with strong spines to 6 cm, particularly on younger branches. **Leaves:** Shiny, dark green, thin texture, to 5 cm long, tip rounded or notched. **Flowers:** Male and female flowers on different plants (dioecious species), flowers small, cream/yellow, with many stamens (male flowers only), but no petals. Male flowers sitting in dense clusters, female flowers stalked and in groups of 1-3. **Fruit:** Round berry, orange/yellow, to 4-6 cm, with velvety and semi-tough skin. Fruit flesh orange-yellow, soft, very juicy and of tart or acidic-sweet, aromatic taste. Fruit contains 5–20 small flat seeds.

Kei apple is found naturally in open bush and in *Acacia* woodlands in southern Africa from Zimbabwe to South Africa. It is widely planted in tropical and subtropical areas, particularly in the eastern Africa region, as a protective hedge because of its dense growth when trimmed and its strong, sharp spines. In Kenya it is a popular species for live fencing and grows mainly at 1200–2000 masl. The species prefers deep, well-drained soils, but also tolerates loamy clay and even slightly saline soil. Once established, it is drought-resistant and tolerates both very high temperatures and light frost.

No cultivars are established, but selections with sweeter fruits or less spines are described in the literature.



Dovyalis caffra – leaves and fruit



Dovyalis caffra – shrubs growing as a hedge



Dovyalis caffra – fleshy ripe fruit hanging on the branch



Dovyalis caffra – harvested whole and cut fruit showing fleshy pulp

Uses: Only ripe fruit of sweet selections can be eaten fresh, sometimes sprinkled with sugar to complement their natural acidity. The more acidic fruits are made into jelly, jam, chutney, pies or pickles (their natural acidity means that vinegar is not needed). Fruits can also be used to add a sour, fruity aroma to other foods. Sweetened pulp can be used to make juice and fruit leather. The flowers are excellent for bee

forage. The leaves are eaten by cattle and goats in times of drought. The wood is white, dense and heavy but is usually too small to be of general use. Trees can be spaced close together and even intertwined to form an impenetrable hedge around homesteads, gardens, croplands and livestock corrals to keep out unwanted animals and thieves.

Nutrient composition

Kei apple, pulp, raw (<i>Dovyalis caffra</i>) 100 g edible portion on fresh weight basis (EP)		
Component	Mean (min-max)	n
Energy ¹ kcal (kJ)	57 (240)	
Water (g)	85.9	1
Protein ² (g)	0.4	
Fat (g)	0.4	1
Carbohydrate, available ³ (g)	12.7	
Fibre, crude (g)	0.3	1
Ash (g)	0.3	1
Calcium (mg)	5	1
Iron (mg)	0.1	1
Potassium (mg)	606	1
Phosphorus (mg)	11	1
Copper (mg)	0.06	1
Thiamine (mg)	0.01	1
Riboflavin (mg)	0.05	1
Niacin (mg)	0.3	1
Vitamin C (mg)	232 (117-347)	2

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

The fresh fruit of *Dovyalis caffra* is a good source of vitamin C. The kei apples contain four times more vitamin C than citrus fruits (average vitamin C in lemons and oranges: 50 mg/100 g EP). With 100 g pulp of kei apple, the recommended daily intake of vitamin C (45 mg/d)¹³ is easily met. A major role of vitamin C is the improvement of non-haem iron absorption in the body. Vitamin C is, however, a heat and light-labile vitamin. Hence, it is best to consume the fruit as fresh as possible. *Dovyalis caffra* is also

a good source of potassium, while calcium and phosphorus values are low compared to other fruits.



Season: Flowers in December to January and fruits in April to May.



Cultivation: Propagation is usually done by seeds, either direct at the site or in a seedbed and seedlings transplanted later. To get seeds, the fruits are soaked

¹³ Calculations based on recommended nutrient intake (RNI) of vitamin C/day, adults, 19 to > 65 years: 45 mg/d www.fao.org/nutrition/requirements/vitamins/en/



in water for 2–3 days, then drained and squeezed to separate the seeds from the pulp. No pre-treatment is needed before sowing. Germination is 60–90% within 18–20 days, or even faster under favourable conditions. Although fresh seeds have the highest germination rates, seed storage behaviour is orthodox; viability is maintained for over 2 years in hermetic air-dry storage at 5°C; viability can be maintained for several years in hermetic storage at 3°C with 6–10% moisture content. There are about 27,000–47,000 seeds/kg. To propagate selected cultivars and for early fruiting, vegetative propagation is recommended. Kei apple can be grafted or budded. Cuttings (both from hardwood and softwood) and air layering can also be used.

Young plants should be spaced about 3 x 3 to 4 x 4 m for orchard establishment, but much closer for planting a living fence. For every 20–30 female plants, a male plant is needed. Not much care is required, apart from pruning. In orchards, lower branches should be removed from the main stem and the crown kept open to make harvest easier. To maintain a good live fence, trees should be trimmed twice a year. As kei apple exhibits allelopathy (i.e., its roots excrete growth inhibitors which prevent the occurrence of other plants in its vicinity) and has a dense, shallow root system, it may not be suitable for intercropping.



Pests and diseases: Kei apple does not suffer from many pests and diseases. The most important problem is fruit fly attack. When kei apples are not picked, masses of fruit flies can breed in the fallen fruit and later cause significant losses in those fruit orchards that are surrounded by live fences of kei apples. A solution is to plant only male kei apples around valuable fruit orchards. Another problem

can be caused by larvae of the African leopard butterfly, *Phalanta phalanta*, that feeds on the leaves.



Commercial/market value: In Kenya, kei apple is mainly used as hedge and for live fencing, not for fruit production. In South Africa, however, kei apple is recognized as a traditional food plant and its products have a growing commercial value. Some initial breeding efforts aimed at improving the species have been reported in California, where consumers are said to be interested in kei apple products. In Kenya this underutilized, but robust species could have potential as a homegarden or commercial fruit with high nutritional value. However, improved cultivars as well as fruit processing technologies should be introduced and tested first.

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42. *Litchi chinensis* Sonn.

SAPINDACEAE

(Native to southern China)

Common name: Litchi, Lychee

Local names: Mlichì (Swahili)

Description and ecology: An evergreen, long-lived tree with a short stem, growing up to 10–15 m in height, with a dense, round or topped crown. **Bark:** Grey-black, smooth, on younger branches brownish-red. **Leaves:** Red and soft when young, later shiny, leathery and green; compound, with 2–4 pairs of leaflets with sharp, pointed tips, each 5–7 cm long. **Flowers:** Very small, yellow/white, fragrant, borne in terminal bunches (like mango), each up to 30 cm long. **Fruit:** In loose clusters of 5–20 or more, oval to ovate drupes, about 3–4 cm in diameter; rind purple/red when fully ripe and turning to dull brown as the fruit dries, surface of the hard and brittle rind divided into small scale-like projections, easy to remove; under the rind fleshy white and very juicy edible aril with aromatic smell and sweet flavour; enclosed a large, oblong, hard, dark-brown and shiny seed.

Litchi is a species of subtropical climate, but also occurs in higher altitudes of the tropics (500–1500 masl). For flower induction it needs some cold temperatures in winter, but the tree cannot survive frost below -4°C . It prefers moist climate, particularly in summer, with annual rainfall of at least 1000 mm. The species grows well in many types of soil with

good drainage, including acid sands with high organic content and clay-loam. Trees are sensitive to wind and need some protection when young.

Several cultivars of litchi exist, including those with lower chilling demand, smaller seed size and big fruits as well as with different shape of fruit, colour of rind, aroma, sweetness, etc. There are also cultivars that are specifically adapted to certain environments, e.g., high altitude or wet soil conditions, but all these cultivars are not yet available in tree nurseries of Kenya.

Uses: The fruit is mostly eaten fresh, mixed in fruit salads or used to make a refreshing juice. It can also be processed into ice cream, pies, different types of dessert or wine. In addition, the fruit can be pickled, canned in syrup or used in jams. In some regions, the fruit is also dried.

Flowers of litchi are a good bee fodder and yield honey of excellent quality and flavour. The wood is hard and durable but brittle and is used in construction or carpentry. Several parts of the tree are used in traditional medicine. Litchi trees are also planted as ornamentals.



Litchi chinensis – tree



Litchi chinensis – leaves



Litchi chinensis – harvested ripe fruit, in the centre two opened fruit showing the white pulp

Nutrient composition

Litchi, pulp, raw (<i>Litchi chinensis</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean ± SD	n
Energy¹ kcal (kJ)	71 (276)	
Water (g)	81.8	1
Protein² (g)	0.8	
Fat (g)	0.4	1
Carbohydrate, available³ (g)	15.2	
Fibre, total dietary (g)	1.3	1
Ash (g)	0.4	1
Calcium (mg)	5	1
Iron (mg)	0.3	1
Potassium (mg)	171	1
Magnesium (mg)	10	1
Phosphorus (mg)	31	1
Copper (mg)	0.15	1
Zinc (mg)	0.07	1
Vitamin A (RE)⁴ (mcg)	0	
β-carotene equivalents⁵ (mcg)	0	1
Vitamin E (mg)	0.07	1
Thiamine (mg)	0.01	1
Riboflavin (mg)	0.07	1
Vitamin B6 (mg)	0.10	1
Folate (mcg)	14	1
Niacin (mg)	0.6	1
Vitamin C (mg)	72	1

SD, standard deviation, calculated when the number of data points (n) ≥ 3

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + ½ β-cryptoxanthin

Litchi is a source of vitamins from the B-complex. These vitamins are important coenzymes in the metabolism of amino acids and carbohydrates in the body. Deficiencies of these components lead to dermatitis and fatigue. Moreover, it is an excellent source of vitamin C.



Season: Flowers in July to August and fruits in December and January.



Cultivation: *L. chinensis* is propagated by seed and vegetatively. Plants propagated by seed are useful as rootstock for grafting, but are not recommended for commercial planting as seedlings are not true-to-type. Seed storage behaviour is recalcitrant, i.e., seeds cannot survive drying or cold temperatures and can only be stored for a few days at about 8°C. Grafting as well as budding can be done by different methods, but often success rates are not very high due to incompatibilities. Girdling the branch of the mother tree 3 weeks before the scions or buds are taken is said to improve grafting success. The most common and successful vegetative propagation method is air layering, particularly if rooting hormones are used. Cuttings of both hard and soft wood can also work.



Planting should be done at a spacing of 6 x 6 m to 12 x 12 m, depending on the variety. As the tree grows slowly, intercropping is recommended for the first years. Protection from wind may be needed, e.g., by cultivating the tree in mixed systems with other fruit tree species. Litchi requires pruning to shape it for the first few years only. Older trees are just thinned out and weak branches removed. Irrigation may be needed in dryer regions, but a light dry spell of



2–3 months induces flowering. Fertilizer should be applied twice a year, i.e., when the flower bunches appear and after the fruit set. Harvest must be done by clipping whole fruit clusters; not by picking single fruits because this will break the rind and cause the fruit to spoil.

Pests and diseases: Several pests have been reported to attack lychee trees. Most important is the leaf-curling mite (*Eriophyes litchi*) that attacks young growth and inflorescences. In addition, several species of bugs, beetles, leaf miners, scales and aphids may cause problems on leaves and young growth or flowers. Fruits are mainly attacked by bugs, fruit borers and fruit-piercing moths, and sometimes by fruit flies. All these pests can be controlled through orchard hygiene, mechanical control or spraying biological or chemical insecticides. The few diseases that attack litchi include leaf spots, anthracnose and die back.



Commercial/market value: In Kenya litchi is rarely planted and not yet commercially grown. Imported fruits from litchi-producing countries such as Madagascar, South Africa and China are sold in high-end supermarkets or fruit shops in Nairobi at exorbitant prices. Production and marketing of litchi is well established in South Africa which has climatic zones similar to those in Kenya's midlands. This species has a high potential in Kenya as a nutritious and highly priced fruit for domestic and export markets and should therefore be tested in different regions of the country.

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43. *Manilkara zapota* (L.) P.Royen

SAPOTACEAE

(Native to Central America, Mexico and West Indies)

Common name: Sapodilla

Local names: Not known

Description and ecology: An evergreen, upright to spreading tree that can reach 20–25 m height, with a dense, rounded or conical crown. Branches often extend from the trunk horizontally or drooping; very tough and pliable, which makes sapodilla resistant to winds. **Bark:** Brown and rough, rich in a white latex called chicle. Latex exudes if any part of the plant is injured. **Leaves:** Simple, leathery, alternate, pointed, 5–13 cm long and 6–7 cm wide, pinkish when young, later green and glossy, clustered at the shoot tips. **Flowers:** Small, white, bell-shaped, solitary in the upper leaf axils, which are tight together, almost forming a cluster at the shoot tips. **Fruit:** Round or egg-shaped berry with a rough, brown skin (looks like a potato), 5–10 cm in diameter, with yellow/brown or dark- to red-brown flesh that is coarse and somewhat grainy, soft, very juicy, with a sweet flavour. Fruit with 3–6 brown or black, hard and glossy seeds that are long-oval, flat, about 2 cm long.

Sapodilla is a tropical species, thus it needs humid climate and cannot survive frost. However, it can also be grown in subtropical regions with short dry seasons. The tree prefers altitudes below 900 masl and an annual rainfall of 1000–1500 mm. Soil

should be rich, well-drained and not too heavy. Even calcareous and slightly saline soil is tolerated, e.g., close to the seashore. Sapodilla can tolerate strong winds. In Kenya, sapodilla is found from sea level to 1200 masl and is mainly cultivated along the coast, e.g., in Mombasa, Watamu, Kilifi and Malindi.

Several cultivars have been developed, e.g., with very big fruit, different fruit shape, excellent aroma, seedless fruit, adaptation to certain environments, regular fruiting and early, late or out-of-season fruiting. However, most of these cultivars are not available in Kenya.

Uses: The fully ripe fruit is usually eaten fresh and can be stored only for a few days. Fruits may also be used in making juice, ice cream, fruit salads, pies, preserves, dessert sauce or jam. Trees can be tapped for their latex which is used in production of natural chewing gum. The flowers are good bee fodder. The wood is durable and hard; it is used in construction, for furniture making and as fuelwood. Sapodilla is widely cultivated as an ornamental tree and can be planted as wind break. Several parts of the tree are used as traditional medicine.



Manilkara zapota – tree



Manilkara zapota – whole and cut fruit, showing the fleshy, yellow-brown pulp



Manilkara zapota – branches with almost ripe fruit



Manilkara zapota – leaves and fruit

Nutrient composition

Sapodilla, pulp, raw (<i>Manilkara zapota</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean	min-max	n
Energy¹ kcal (kJ)	82 (344)		
Water (g)	77.5	77.0-78.0	2
Protein² (g)	0.5		
Fat (g)	1.0	0.9-1.1	2
Carbohydrate, available³ (g)	15.0		
Fibre, total dietary (g)	5.6	5.3-5.9	2
Ash (g)	0.5		1
Calcium (mg)	23	21-25	2
Iron (mg)	0.8	0.7-0.8	2
Potassium (mg)	190	186-193	2
Magnesium (mg)	16	12-20	2
Phosphorus (mg)	12	11-12	2
Copper (mg)	0.09		1
Zinc (mg)	0.10		1
Vitamin A (RE)⁴ (mcg)	6		
β-carotene equivalents⁵ (mcg)	35		1
Thiamine (mg)	0.01	0-0.01	2
Riboflavin (mg)	0.02	0.02-0.02	2
Vitamin B6 (mg)	0.04	0.04-0.04	2
Niacin (mg)	0.2	0.2-0.2	2
Folate (mcg)	14		1
Vitamin C (mg)	14		1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + ½ β-cryptoxanthin

Sapodilla fruit pulp provides good values of dietary fibre, which positively influences the gastrointestinal tract and is inversely related to cardiovascular

diseases and type 2 diabetes. The fruit provides moderate values of minerals and vitamins.



Season: Flowers in November and December in Kenya, fruits mainly from July to September, depending on the type of cultivar and region. In some areas there are two seasons per year.



Cultivation: Propagated by seeds and vegetatively by grafting or air layering. Vegetative propagation is needed to maintain improved cultivars. Seeds for rootstocks germinate easily within a month. Seed storage behaviour is intermediate, thus viability can be maintained for only 24 months in air-dry storage at 5°C. Grafting can be difficult due to the latex and slow growth. Success rates are said to be improved by defoliating the scions some weeks prior to cutting them and by shading the rootstocks for 2 months before grafting. Air layering is easier and preferred in some regions.



Trees are spaced 7–10 m apart, depending on the growth habit of the cultivar. Pruning to shape the young trees is practised for the first 5 or 6 years. They require irrigation during the dry season for the first 3–4 years, after which they are able to withstand drought. Response to fertilizer is good and 3–4 small applications of manure or mineral fertilizer per year are beneficial. Cross pollination by bees and other insects is important, but there are also self-fertile cultivars. Sapodilla is a climacteric fruit, i.e., it can be picked when mature, but still firm, and will soften within a few days after harvesting.



Pests and diseases: Sapodilla is not very susceptible to diseases and may be attacked only by leaf spots or anthracnose and in rare cases, by a form of cancer in some regions. Fruit flies of different species are serious pests, as their larvae infest the ripe fruit and render it unfit for consumption. Leaf miners, mealybugs,

beetles, caterpillars and aphids are among the insects that attack leaves, young shoots, flowers or young fruit. Pests and diseases can be controlled through orchard hygiene and application of biological or chemical pesticides.



Commercial/market value:

Sapodilla is a popular fruit tree in many tropical countries and is produced for local and international markets since the fruit has good transport and long shelf life properties. In Kenya, this expensive fruit is rarely sold in markets in Mombasa and Nairobi; it is practically unknown in local markets. Sapodilla has a high potential in several parts of Kenya and should be promoted for homestead gardens and commercial fruit orchards.

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44. *Morus alba* L.

MORACEAE

(Native to China)

Common name: Mulberry

Local names: Kitae/Ndae (Kamba); Mutare (Kikuyu); Onunga (Luo); Mforsadi (Swahili).

Description and ecology: A small, fast-growing tree, to 6–10 m, rounded in shape, straggly, hanging branches downwards. **Bark:** Grey-brown, rough and grooved in older trees, exuding yellowish latex when injured. **Leaves:** Very variable in shape even on the same branch, oval to 3-lobed or heart shaped, 5–15cm long, edge roughly toothed, tip pointed, on stalks to 5 cm, upper leaf surface bright green and smooth. **Flowers:** Dioecious species, thus usually there are male and female trees (rarely both male and female flowers on one tree), flowers very small and greenish, in drooping (male) or upright (female) catkins that emerge from the leaf axils. **Fruit:** Compound fruit made of numerous nuts surrounded by the fleshy sepals of the flower's calyx, looking like a blackberry, about 2-3 cm long; white, pink, red or black when ripe; sweet and juicy 'flesh' surrounding each of the numerous tiny seeds.

Mulberry originates from subtropical to warm temperate climate zones but tolerates tropical climate very well. It is also frost resistant, depending on the cultivar, and can be grown in altitudes up to 3300 masl in the tropics. The tree prefers a moist climate with an annual rainfall of 700-2500 mm, but can also be grown in drier regions. Mulberry does not require a specific soil type but prefers deep, moist and rich soil for good growth. The species somehow tolerates wind and can cope with slightly saline soil.

Numerous cultivars of mulberry exist, varying in fruit size, colour or flavour, but also in fruiting season, leaf shape, branching type, or adaptation to certain environments such as cold winters. Certain cultivars were particularly bred for silkworm production, thus producing lots of leaves with high nutritious value for the silkworms.

Uses: Fruits are extremely perishable and are mostly eaten raw or dried for later consumption. They can also be made into jellies, jam, juice, wine or tart syrups and used for pies and mulberry muffins. Trees are extensively grown (e.g., southern Europe, India, China) for their leaves as food for silkworms. The leaves are also excellent fodder for livestock e.g., cattle and rabbits. Young leaves can also be used for tea or eaten as vegetables. The bark is fibrous and can be used for paper making. Wood is moderately heavy but durable and flexible when steamed. It is used for construction, sports equipment, boat building, furniture, posts, flooring, cabinet work, tool handles and fuelwood. An excellent tree grown as a living fence, ornamental or windbreak as well as for bee forage, shade, mulching and soil conservation. Several parts of the mulberry tree are used for traditional medicine.



Morus alba – branch of a black-fruited cultivar with ripe fruit



Morus alba – leaves



Morus alba – young tree

Nutrient composition

Mulberry, raw (*Morus alba*)

100 g edible portion on fresh weight basis (EP)

Component	Mean	min-max	n
Energy ¹ kcal (kJ)	59 (249)		
Water (g)	84.6	82.3-86.9	2
Protein ² (g)	1.3		
Fat (g)	0.7	0.3-1.1	2
Carbohydrate, available ³ (g)	11.0		

Mulberry, raw (<i>Morus alba</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean	min-max	n
Fibre, neutral detergent (g)	1.7		1
Ash (g)	0.7	0.6-0.9	2
Calcium (mg)	41	30-52	2
Iron (mg)	0.9		1
Potassium (mg)	194	153-234	2
Magnesium (mg)	18	13-22	2
Copper (mg)	0.09		1
Vitamin C (mg)	17		1
Anthocyanins (mg)	2179		1
Total phenols expressed in gallic acid equivalent (mg)	236		1
Total flavonoids expressed in quercetin equivalents (mg)	477		1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

Mulberries are high in water and comparatively low in energy. Next to minerals and vitamins, *Morus alba* contains high levels of bioactive components, particularly anthocyanins, flavonoids and total phenols. These substances act as antioxidants in the body and have anti-inflammatory and anti-carcinogenic effects.



rootstock production. Seeds germinate more or less quickly in warm and humid conditions; however, cold stratification is said to improve germination. Seed storage behaviour is orthodox, with viability being maintained for several years in hermetic storage at room temperature. Mulberry has about 325,000 to 700,000 seeds/kg. Seedlings can then be used for grafting, but the best method of propagation is by cuttings. Softwood cuttings should be 7–10 cm long and hardwood cuttings 25–30 cm. Use of rooting hormone can increase success rates.



Season: Flowers from March to April and fruits from May to June in Kenya.



Cultivation: *Morus alba* is propagated by seeds or vegetatively by cuttings or grafting. Seedlings are not true-to-type and half of them will be male plants, thus seedlings are not suitable for commercial orchard establishment. Seed propagation is only used if strong roots are required, e.g., in drought-prone regions or for



Young trees are planted at a spacing of 3 m x 3 m or more to allow intercropping with other food crops. Irrigation may be needed in dry regions for establishment.

Young trees should be trained in an ‘open vase’ formation. Later, older branches are pruned to allow the growth of new shoots as fruiting mainly takes place on young branches. Fertilizer application is needed for good production on poor soils. Harvest is done carefully by hand picking only fully ripe fruits.



Pests and diseases: In general, mulberries do not have many problems with pests and diseases. Larvae of several moth species (e.g., *Ascotis selenaria* and *Archips micaceana*) can defoliate the tree. Mealybugs, white flies and thrips can also damage the plants and fruit fly larvae the fruits. Some fungal diseases attack mulberry leaves including *Cercospora* leaf spot, powdery mildew or rust, while root rot can cause wilting and death of the whole tree.



Commercial/market value: In Kenya, mulberry is widely planted in homesteads as a fruit tree, but it is mostly grown on farms for its leaves and twigs, which are used as fodder for livestock (cattle, goats, etc.) and – in some regions – for silkworms. The fruits are rarely sold in big towns by main grocery stores. They are usually used for home consumption and are very popular among children. Mulberry should be promoted for commercial cultivation to meet the demand of local markets and – for dried or processed fruit – added to the range of export fruit. To do this, improved cultivars with bigger fruits and longer shelf life must be introduced.

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45. *Phoenix dactylifera* L.

ARECACEAE (PALMAE)

(Native to North-Eastern Africa and the Middle East)

Common name: Date palm

Local names: Tende (Borana); Tembe (Luo); Ndende (Kamba); Ntende (Meru); Timir/Timiis (Somali); Mtende/Tende (Swahili); Epapai (Teso).

Description and ecology: A palm tree with an unbranched long trunk, can grow up to 20–30 m. The trunk is covered with persistent fibrous leaf bases. Many offshoots develop at the base of the trunk. **Leaves:** Grey/green, 3–7 m long with numerous stiff leaflets, each 20–40 cm long and folded along the midrib, sharply pointed, leaflets reduced to spines on the base part of the leaf. **Flowers:** Dioecious species, each tree producing either male or female inflorescences (some individuals may have both male and female flowers); male inflorescence up to 20 cm long, female inflorescence 30–75 cm long, branched, with up to 10,000 very small yellow/cream, fragrant flowers. **Fruit:** Oblong-cylindrical drupes, 2–8 cm long, with fleshy, sweet pulp, yellow/brown or red/brown when ripe, hang in long bunches. Each fruit has one cylindrical, slender, deeply grooved stone with very hard endosperm.

Date palm occurs in arid and semi-arid areas of the tropics and subtropics at 0–1500 masl. It rarely thrives in the more humid tropics. It needs high temperatures (over 30°C during ripening) and can even survive extreme frost (-15°C) and heat (52°C). Supply of water should be high (usually via irrigation or by a high groundwater table) for good yields, while humidity and rainfall should be low, particularly during fruit development. It requires well-drained, fertile soil and can even tolerate saline and alkaline, but not

waterlogged conditions. Date palms are quite wind resistant.

More than 1500 different date cultivars are documented, broadly grouped into three types based on the moisture content of their fruit flesh: dry, semi-dry or soft types. The cultivars also vary with regard to fruit size, colour, sweetness, season of ripening, suitability for different uses, shelf life, adaptation to variable environments, etc.

Uses: Ripe fruits are sometimes eaten fresh but mostly consumed in dried form. Dates can also be used in desserts, cakes, biscuits or pie and processed into a substitute for sugar, syrup, wine and spirit or vinegar. Dates have always been an important food for the inhabitants of the Middle East and North Africa with a certain social, cultural and religious value. In the past, dried dates enabled long journeys in the desert and were used as means of payment. Today, they are considered important among Muslims who traditionally eat a date to break their fast in the evening during Ramadan. Tapping the upper part of the trunk produces a sugary juice used for making palm wine or palm sugar. Date seeds can be crushed and added to animal feed. Even low-quality fruit and young leaves are used for fodder. Date seed oil is suitable for use in soap and cosmetics. The leaves are widely used for weaving mats, baskets and for thatching roofs. The

trunk wood is suitable for construction and is used for making furniture (beds), posts and utensils as well as

for fuel. The date palm is also grown as a shade and an ornamental tree.



Phoenix dactylifera – old palm tree



Phoenix dactylifera – whole and cut ripe fruit showing edible, white flesh



Phoenix dactylifera – young palm

Nutrient composition

Dates, pulp and skin, dried, raw (<i>Phoenix dactylifera</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy¹ kcal (kJ)	313 (1320)		
Water (g)	17.0 ± 8.2	10.6-36.1	8
Protein² (g)	1.8		
Fat (g)	0.9 ± 0.4	0.5-1.4	4
Carbohydrate, available³ (g)	70.3		
Fibre, total dietary (g)	8.3 ± 2.0	6.3-11.4	7
Ash (g)	1.6 ± 0.2	1.5-1.8	3
Calcium (mg)	71 ± 15	55-85	4
Iron (mg)	1.3 ± 1.1	0.6-3.0	4
Potassium (mg)	662 ± 62	603-742	4
Magnesium (mg)	65 ± 8	58-76	4
Phosphorus (mg)	68 ± 8	59-74	4
Copper (mg)	0.68 ± 0.08	0.64-0.77	3
Zinc (mg)	0.48 ± 0.12	0.32-0.60	4
Vitamin A (RE)⁴ (mcg)	2		
β-carotene (mcg)	14 ± 22	3-70	9
Thiamine (mg)	0.06		1
Riboflavin (mg)	0.10		1
Vitamin B6 (mg)	0.15		1
Niacin (mg)	1.7		1
Folate (mcg)	28		1
Vitamin C (mg)	2		1

SD, standard deviation, calculated when the number of data points (n) ≥ 3

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

Dried dates have a low water content, which results in a higher concentration of most other components. The fruit provides high energy values, mostly derived from the high content of available carbohydrates.

With 8.1 g/100 g edible portion, the fruit is also a good source of dietary fibre. While potassium, zinc and copper are well represented, the dried fruit is not a source of vitamins A and C.



Season: No information available for Kenya. In northern Africa and the Middle East, fruits are ready for harvest in the early winter months, and in India from June to September.



Cultivation: Propagation can be done by seeds or vegetatively by suckers (offshoots) that develop at the base of the palm. Seeds do not require any treatment. Seed storage behaviour is orthodox; viability can be maintained for 8–15 years at room temperature. There are approximately 800 seeds/kg. For commercial production, the use of vegetative propagation – usually by suckers – is preferable to seedlings because male or female plants can be selected, the cultivar maintained and the time until first fruiting shortened. Suckers develop at the base of young palms and should be carefully detached from the mother palm together with their roots. Micropropagation is also used in some countries.



After removal from the mother tree, the suckers are planted at a spacing of 8–10 m. Watering is essential for establishment during the 1-2 years, and must be continued unless the roots reach the groundwater table. Pruning is only done by removing the dead leaves. Fertilization should be done once or twice a year. Pollination of the female flowers is critical for good fruiting and is usually done manually by cutting male flowers and hanging them between the female flowers or dusting them with pollen. Male trees are planted with females in ratios of about 1:50. To produce quality fruits of reasonable size, female inflorescences are thinned out. First fruiting is after 2–3 years, full production after 5–8 years, continuing for 20–60 years. An adult tree can produce 20–100 kg of fruit per year.



Pests and diseases: Sucking insects including scales and mites attack date palms. Others such as caterpillars, grasshoppers and locusts feed on the leaves of date palms. The stem may be attacked by several species of boring beetles that may cause the death of the palm. Larvae of several beetle and butterfly species feed on the fruits and are often simply controlled by covering whole inflorescences with netting. Date palm also suffers from several diseases, including fungal diseases such as blight, leaf spots and root rot. Usual control methods include orchard hygiene and application of fungicides.



Commercial/market value: In Kenya, date palm is found in arid, semi-arid and coastal regions including Lamu, Garissa, Taveta, Isiolo, Malindi, Wajir, Moyale, Turkana, Kitui and Mwingi, as well as along the Turkwel River near Lodwar. In Kenya it is not cultivated for commercial purposes and rarely produces a lot of fruit. Imported dates are sold at exorbitant prices in markets, grocery stores and major supermarkets in urban centres. Dates could have a high potential for family consumption and perhaps as a cash crop for selected sites in dry areas in Kenya. They can also be used during drought as dried fruits can be stored for up to 10 months. The species is very suitable for intercropping in agroforestry systems under irrigation. However, to develop date farming in Kenya, suitable cultivars should be introduced and improved tree management practices such as manual pollination applied.

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46. *Pithecellobium dulce* (Roxb.) Benth.

LEGUMINOSAE (MIMOSACEAE) (Native to Latin America)

Common name: Madras thorn, Manila tamarind, Sweet tamarind

Local names: Maramata (Swahili)

Description and ecology: A fast-growing, nitrogen-fixing shrub or small tree with short trunk and irregular, rounded crown, 4–15 m high, branches flexuous and pendulous, usually with thorns in pairs.

Bark: Smooth, pale with horizontal marks, later rough and fissured. **Leaves:** Thin stalks bear 2 pairs of 2 leaflets each, leaflets 2.5–5 cm, asymmetric, oval, tip rounded or notched, of deep olive green colour.

Flowers: Small, fragrant, cream/yellow, in clusters, each flower on a short stalk, most visible are the long bunches of numerous stamens that stick out of the flower. **Fruit:** Spirally twisted pods, about 12 cm long, narrowed between the seeds, green when unripe, turning red and dry when ripe, splitting to release glossy black seeds, 7–13 mm long; seeds roundish, almost completely covered with the fleshy white or sometimes red, edible aril that has a sweet, sometimes astringent taste.

Manila tamarind is a species of dry to subhumid tropical and subtropical regions. It prefers lowland conditions and only grows up to 1500 masl. The tree cannot tolerate frost. It produces best with rainfall of 700–1800 mm, but can also survive with as little as 250 mm. A range of soil conditions is accepted by this species, including infertile sand, black cotton soil, shallow, rocky and slightly saline soil. The tree copes well with pruning and coppicing.

No cultivars are documented, but selections of individual trees exist that have larger pods and sweeter arils of red, not of white colour.



Pithecellobium dulce – unripe and almost ripe fruit



Pithecellobium dulce – ripe, just opened fruit showing the red arils around brown seeds



Pithecellobium dulce – leafy branches



Pithecellobium dulce – tree

Uses: The edible arils of the Manila tamarind may be eaten fresh or made into a sweet drink similar to lemonade. The seeds are used in curries in India. An edible oil can be pressed from the seeds. The leaves, pods and seeds are excellent fodder for livestock while the flowers are good bee fodder. Tannin and a yellow dye can be extracted from the bark. The yellowish wood is strong and durable and is used for

light construction, poles, boxes, tool handles and low-quality fuelwood. This tree is grown as an excellent live fence around houses or fields and also used for shade, soil conservation, sand stabilization and as a windbreak or robust ornamental, e.g., along roads. However, this species can become an invasive weed if not well managed. In some regions, several parts of the tree are used as traditional medicine.

Nutrient composition

Manila-tamarind, fruit, raw (<i>Pithecellobium dulce</i>)			
<i>100 g edible portion on fresh weight basis (EP)</i>			
Component	Mean ± SD	min-max	n
Energy ¹ kcal (kJ)	84 (353)		
Water (g)	76.3 ± 1.6	74.5- 77.8	3
Protein ² (g)	2.8		
Fat (g)	0.5 ± 0.6	0.1-1.1	3
Carbohydrate, available ³ (g)	14.3		
Fibre, total dietary (g)	5.5 ± 0.9	4.4-6.1	3
Ash (g)	0.6	0.5-0.7	2
Calcium (mg)	20 ± 13	9-35	3
Iron (mg)	0.7 ± 0.1	0.6-0.7	3
Potassium (mg)	329 ± 45	286-376	3
Magnesium (mg)	30 ± 3	28-33	3
Phosphorus (mg)	37 ± 31	16-74	3
Copper (mg)	0.19 ± 0.04	0.15-0.22	3
Zinc (mg)	0.56		1
Vitamin A (RE) ⁴ (mcg)	<1		
β-carotene (mcg)	2		1
Thiamine (mg)	0.18		1
Riboflavin (mg)	0.14		1
Vitamin B6 (mg)	0.04		1
Niacin (mg)	0.4		1
Folate (mcg)	4		1
Vitamin C (mg)	81	78-83	2

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β -carotene + 1/12 α -carotene + 1/12 β -cryptoxanthin

Manila tamarind fruit contains good levels of dietary fibre and protein. Its high dietary fibre content is close to dried dates. The fruit is also nutritious in terms of its mineral and vitamin content, particularly of vitamin C.



Season: Flowers in June to July and fruits from October to November; some fruits can still be seen on trees in December.



Cultivation: Propagation is usually by seed and sometimes by cuttings. Manila tamarind can grow very easily and quickly from seeds that do not need any pre-treatment. Seed storage behaviour is recalcitrant, i.e., seeds cannot be dried and stored but must be sown as fresh as possible. There are about 7000 seeds/kg. For planting a hedge, seeds should be sown at 15 cm distance in 2 rows 30 cm apart. Seeds can also be raised in pots in the nursery and later planted. Selected trees with superior traits must be propagated vegetatively, e.g., by cuttings or grafting.



After establishment, the trees do not need any special care. They are fast growing and may reach a height of 10 m in 5–6 years in fertile soils. After 4-5 years the first fruiting will occur. The tree can tolerate frequent pruning, lopping and browsing. To grow a dense hedge, trimming and coppicing is necessary.



Pests and diseases: Manila tamarind is not attacked by many pests and diseases. In certain regions, larvae of some moth species may feed on the leaves or attack the bark or fruits and seeds. Thorn bugs that suck plant juice are a problematic pest in Puerto Rico. However, there is no information on the occurrence of these pests in Kenya. There are also no plant diseases reported in Kenya, but elsewhere Manila tamarind can suffer from fungal diseases such as leaf spots and heart rot.



Commercial/market value: Manila tamarind is widely naturalized in Kenya and is commonly planted, but mainly as a live fence or hedge particularly in coastal towns and Kisumu. The fruits are usually used for home consumption and not sold in any local market. In other countries such as Mexico, Cuba, Thailand, India and Pakistan, the pods are harvested and sold in markets. The short shelf life of the fruit, however, is a challenge in marketing. Selected clones with larger pods containing small seeds and lots of sweet arils had been selected. These clones may be introduced to Kenya and cultivated in homegardens or hedges, not exclusively as a fruit tree, but as a multi-purpose tree for fodder and fencing with secondary use of its fruit.

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47. *Punica granatum* L.

LYTHRACEAE

(Native to Northern India, Iran and Afghanistan)

Common name: Pomegranate

Local names: Mkomamanga (Swahili).

Description and ecology: A multi-stemmed, evergreen, deep-rooting shrub with many upright stems, or a small tree that grows up to 6 m. Branches often end in a spine; there may also be spines at the leaf axils. **Bark:** Grey/brown, smooth, but rough on older branches. **Leaves:** Opposite or arising in clusters, often on short side shoots, shiny, narrow, oval, 3–7 cm long, on a short stalk. **Flowers:** About 3–4 cm across, tubular, with 5–7 fleshy red, pointed calyx lobes that persist on the ripe fruit, 3–7 deep red or orange petals that are very thin and creased, many stamens. Flowers may be solitary or up to 5 together, on short side shoots at the top of the twigs. **Fruit:** Nearly round leathery berry, crowned at the base by the persisting calyx, about 6–12 cm wide, with tough, yellow, orange, red or violet skin. Interior separated into several compartments by thin walls and white spongy tissue, packed with transparent sarcotestas (i.e., thin seed covers) filled with tart, flavourful, red/pink/white juice and surrounding one white or red, angular, soft or hard seed.

Pomegranate grows best in semi-arid, warm climates but is very adaptable. It requires high temperatures during fruit ripening and sufficient moisture to give good yields. Cold winters can enhance flowering and fruit development, but the tree does not tolerate severe frost below -10°C . The species prefers a mean annual rainfall of 900–1200 mm. It is very drought-tolerant, but in arid areas it is usually planted where the water table is high or orchards are irrigated. It is cultivated throughout the eastern Africa region including Kenya, where pomegranate is grown from 0–1900 masl. The tree prefers well-drained fertile soils, but tolerates both heavy and light soils as well as slightly alkaline or saline conditions.

There are numerous cultivars that differ depending on their fruit size, fruit and juice colour, size and juiciness of the sarcotesta, taste of the juice, softness of the seeds or ecological requirements of the trees. Popular cultivars include 'Wonderful', 'Spanish Ruby', 'Akko' or 'Emek'.



Punica granatum – ripe fruit hanging on the tree



Punica granatum – tree



Punica granatum – whole and cut fruit of a local pomegranate variety with large, whitish seeds



Punica granatum – cut fruit of an improved variety with small and soft seeds

Uses: Pomegranate seeds with their juicy sarcotesta are consumed fresh or made into an excellent refreshing juice. The taste differs depending on the cultivar of pomegranate and its ripeness. The juice can be used in soups, sauces, jellies, ice cream and cakes, or to make syrup. Dried seeds are used as a seasoning in different Indian dishes, e.g., dal, biryani or fried samosa. A red to black dye is obtained from

the flowers and from the rind of unripe fruit. The stem bark and dried peel of the fruit are used as a source of tannin. The tree is also grown as an ornamental, as a wind break or for erosion control. Different parts of the species are used in traditional medicine. The leaves are browsed by livestock, while its branches are used as fuelwood.

Nutrient composition

Pomegranate, raw (<i>Punica granatum</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy ¹ kcal (kJ)	78 (330)	
Water (g)	78.7	1
Protein ² (g)	1.4	
Fat (g)	0.6	1
Carbohydrate, available ³ (g)	14.8	
Fibre, total dietary (g)	4.0	1
Ash (g)	0.5	1
Calcium (mg)	12	1
Iron (mg)	0.7	1
Potassium (mg)	243	1
Magnesium (mg)	9	1
Phosphorus (mg)	33	1
Copper (mg)	0.14	1
Zinc (mg)	0.38	1
Vitamin A (RE) ⁴ (mcg)	2	
β-carotene equivalents ⁵ (mcg)	23	1
Thiamine (mg)	0.07	1
Riboflavin (mg)	0.05	1
Vitamin B6 (mg)	0.13	1
Niacin (mg)	0.3	1
Folate (mcg)	24	1
Vitamin C (mg)	15	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β -carotene + 1/12 α -carotene + 1/12 β -cryptoxanthin

⁵ β -carotene equivalents = β -carotene + 1/2 α -carotene + 1/2 β -cryptoxanthin

Pomegranate is a source of minerals, including zinc and copper, and contains moderate values of vitamin C. B-complex vitamins are also well represented in the fruit.



Season: Flowers in March to April; fruits from August to September, sometimes in October as well.



Cultivation: Pomegranate can be propagated from seed. However, to avoid the variability of trees grown from seed, vegetative propagation is preferred for cultivation of improved cultivars. No seed pre-treatment is required. Average germination rate is 30–70%. Seeds should be sown fresh as they lose viability after a month. For vegetative propagation, air layering or cuttings can be used, while grafting is not common. Air-layered, rooted branches can be separated from the mother tree after 3–4 months. For cuttings, hardwood of pencil thickness and 25–50 cm in length should be taken from the mother tree, leaves removed and almost the entire length planted into the soil, leaving just the top bud exposed. Use of rooting hormones can increase success. Young trees can be transplanted after 9–12 months.



For orchard establishment, a spacing of 5 m x 2 m to 5 m x 5 m is recommended. Irrigation may be needed in dry areas until the young trees are established. Generally, pomegranate is slow growing. However, repeated pruning is recommended to train the young tree by removing suckers and low branches.



Thinning should be done occasionally to ensure good aeration within the crown and interception of sunlight. Application of manure or other fertilizer should be done once in a year before the flowering season. Fruiting starts after 2–4 years. Overripe fruit may crack in some cultivars; however, only fully ripe fruits should be harvested for good aroma. Ripe fruit ships well and has a long shelf life; it may be stored in cold rooms for 5–6 months.

Pests and diseases: Although pomegranate is a rather robust species, there are some pests and diseases that attack it. In India, the most serious pest is the fruit borer or Anar butterfly, *Virachola isocrates* while elsewhere, the larvae of several fruit fly species could be a problem, e.g., *Anastrepha ludens* in Northern America or *Bactrocera* species in Asia and Africa. Additional pests include aphids, scales, mealybugs and bark- or leaf-eating caterpillars. A bacterial disease induced by *Xanthomonas campestris* pv. *punicae* causes bacterial blight of pomegranate with irregular light-brown leaf lesions that become dark brown. There are several fungal diseases of pomegranate, resulting for example, in fruit rot (caused by *Alternaria*, *Aspergillus* or *Botrytis* spp.), black spots on leaves and fruits (anthracnose caused by *Colletotrichum* spp.) or twig canker and die-back (caused, for example, by *Lasiodiplodia theobromae*). Generally, most of the mentioned pests and diseases are managed by orchard hygiene and application of natural or synthetic pesticides.



Commercial/market value:

Pomegranate is a hardy, drought-resistant subtropical species which is cultivated in most of the warmer regions of the world. In Kenya it is occasionally grown on farms or in homegardens for its fruit and as an ornamental. Cultivars in Kenya are local ones with hard seeds and sour fruit juice, which have a low market demand. Fruits produced locally are rarely sold in markets or along roadsides. However, imported fruit of improved cultivars are sold in urban markets and grocery shops in Nairobi at inflated prices. The prospect for commercial production of such improved cultivars is bright as consumption of pomegranate has many health benefits, the export markets are expanding, the fruit is easy to handle and its shelf life is long. Improved cultivars have recently been introduced and tested in Kenya, and production of suitable cultivars should be promoted for export as well as for local markets.

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48. *Syzygium jambos* (L.) Alston

MYRTACEAE

(Native to Southeast Asia)

Common name: Rose apple, Plum rose, Pomarrosa, Malabar plum

Local names: Not known

Description and ecology: An evergreen, medium-sized tree (sometimes shrubby), growing 7–12 m high, with a dense crown of slender, wide-spreading branches. **Bark:** Grey, slightly rough. **Leaves:** Lance-shaped or narrow-elliptic and pointed at the end, opposite, 10–22 cm long and 2–6 cm wide; leathery, glossy, dark-green when mature, reddish when young. **Flowers:** Showy, cream/white, up to 10 cm across due to the long, numerous stamens, scented, very prominent in clusters of 4–5. **Fruit:** Round berry looking like a small guava, up to 4 cm across, turning from green to lemon yellow tinged with pink when ripe, rose-scented, calyx lobes large and persistent on the fruit. Fruit flesh is crispy, dry to juicy and of yellowish colour with a sweet rose-like taste. In the hollow centre of the fruit there are 1–4 brown, rough-coated, medium hard, rounded seeds of 1–1.5 cm in diameter, which loosen from the inner wall during ripening and rattle when a ripe fruit is shaken.

The rose apple is a species of tropical and subtropical climates, where it occurs at 0–2300 masl. The species is not demanding regarding soil conditions and can even grow on sand and limestone or slightly saline soil. However, deep, loamy soil is considered ideal for good fruit production. Rose apple requires mean annual temperatures of 18–27°C, but it can even survive light frost. Annual rainfall should be 1100–2100 mm, but the tree can tolerate both waterlogging and drought for a while.

A few different cultivars are available in those countries with developed rose apple production, including cultivars with slightly different skin colours or more juicy or dry fruit flesh as well as seedless ones.



Syzygium jambos – tree



Syzygium jambos – fruit at different stages of maturity



Syzygium jambos – leaves and flowers



Syzygium jambos – flower and buds

Uses: The ripe fruit is usually eaten raw, but also used to make jelly and jam (with lemon juice added) or processed in combination with other fruits of more pronounced flavour. Sliced fruits can also be candied or made into syrup for use as a sauce or to flavour cold drinks. Fruits are sometimes stewed with some sugar and served as dessert. It can also be distilled to yield a liquid similar to rosewater. Rose apple flowers are a rich source of nectar for honeybees (bee forage). Rose apple wood makes very good charcoal and can be used as fuelwood and for timber. The heartwood is dark red/brown, fibrous, close-grained, medium-heavy to heavy and strong; and has been used for construction and to make furniture, spokes for wheels, keels in boats, frames for string musical instruments and packing cases. However, it is not durable in the soil and is prone to termite attacks. The bark has been used for tanning and also yields a brown dye. The tree may be planted as a living fence post or in hedgerows and as an ornamental. Many parts of the tree are used for traditional medicine.

Nutrient composition

Rose apple, raw (<i>Syzygium jambos</i>)		
<i>100 g edible portion on fresh weight basis (EP)</i>		
Component	Mean	n
Energy¹ kcal (kJ)	56 (239)	
Water (g)	85.0	2
Protein² (g)	0.8	
Fat (g)	0.3	1
Carbohydrate, available³ (g)	12.1	
Fibre, crude (g)	1.2	1
Ash (g)	0.6	1
Calcium (mg)	30	1
Iron (mg)	0.5	1
Potassium (mg)	223	1
Magnesium (mg)	19	1
Phosphorus (mg)	14	1
Copper (mg)	0.03	1
Zinc (mg)	0.13	1
Vitamin A (RE)⁴ (mcg)	37	
β-carotene equivalents⁵ (mcg)	222	1
Thiamine (mg)	0.02	1
Riboflavin (mg)	0.03	1
Niacin (mg)	0.8	1
Folate (mcg)	6	1
Vitamin C (mg)	33	1

n, number of data points

¹ Metabolizable energy values calculated based on protein 4(kcal)/17(kJ), fat 9(kcal)/37(kJ), carbohydrate available 4(kcal)/17(kJ), total dietary fibre 2 (kcal)/8(kJ), alcohol 7(kcal)/29(kJ) - estimated 0.

² Total protein derived from total nitrogen via Kjeldahl method; nitrogen to protein conversion factor 6.25

³ Carbohydrates available, calculated by difference: 100 - (water + protein + fat + fibre + ash + alcohol)

⁴ Vitamin A expressed as mcg retinol equivalent (RE) = retinol + 1/6 β-carotene + 1/12 α-carotene + 1/12 β-cryptoxanthin

⁵ β-carotene equivalents = β-carotene + ½ α-carotene + ½ β-cryptoxanthin

Rose apple is a nutritious fruit containing good values of vitamin C and moderate values of vitamin A. Moreover, it is a source of minerals such as calcium

and magnesium. Overall, it is a fruit with very high water values (up to 85%) and low levels of fat and energy.



Season: Flowers from October to November and fruits from January to February in the central Kenya region.



Cultivation: Rose apple is normally propagated by seed. As the seeds are recalcitrant, they have no dormancy and germinate well when fresh but cannot be stored. The seeds are polyembryonic, thus a single seed often develops into 3–5 seedlings, most of which are true-to-type. Methods of vegetative propagation include air layering, budding and grafting or the use of cuttings. However, apart from air layering, these methods have low success rates.



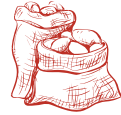
For orchard establishment, a spacing of 5 x 5 m to 6 x 6 m is recommended. Newly planted seedlings require some shade, while older trees need full sun. First fruiting may take place about 4 years after planting. Rose apples are robust trees and do not need specific care. Pruning is not required after the young tree has been trained to have a well-shaped crown. A dry period may enhance flowering. Fertilizer application should take place after flowering, and not before, to avoid the development of too many new leaves.

Rose apples are highly perishable and must be freshly picked to ensure good quality. However, as the fruit is non-climacteric it cannot continue to ripen after it has been picked.



Pests and diseases: The rose apple tree has few problems with pests or diseases. Aphids and fruit flies may attack the leaves and fruits, respectively, and may then spread to other nearby fruit tree species. With regard to diseases, the tree is prone to leaf spot, anthracnose and root rot. Rose apple is a host for the fungal disease guava rust, which can

then attack guava, eucalypt and certain other tree species in the neighbourhood.



Commercial/market value: In Kenya, rose apple is grown only as a garden ornamental plant or a homestead fruit tree mainly in Mombasa, Embu, Thika and Nairobi. The tree is rarely cultivated on farms and its fruits used only for home consumption. However, in Tanzania, the tree is grown on a larger scale and fruits sold in Dar es Salaam and Zanzibar. Commercialization of rose apple will remain a challenge as long as markets are not well developed and consumers are not aware of this tasty and nutritious fruit.

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49. *Terminalia catappa* L.

COMBRETACEAE

(Native to South-East Asia)

Common name: Indian almond, Singapore almond, Beach almond

Local names: Mukungu (Digo); Mkungu (Giriama, Swahili).

Description and ecology: A conspicuous, semi-deciduous tree, 8–25 m tall, with horizontally layered branches distinctively arranged in tiers, whorls about 1–2 m apart. Mature trees have a wide, spreading crown. **Bark:** Grey/brown, rough with age. **Leaves:** Leathery, shiny, very large (up to 30 x 15 cm), wider at the tip, veins very clear, in clusters at the apex of each branch, dark green but turning bright red before falling. **Flowers:** In long spikes, single flowers about 1 cm wide, green/white, inconspicuous but fragrant. **Fruit:** A hard and leathery drupe, up to 7 cm long, green when young, turning to orange or red when ripe, rounded or oblong, flattened with 2 ridges. Fruit encloses the edible cylindrical, oil containing seed that tastes like almond and is encased in a tough, fibrous husk within an edible, but thin fleshy mesocarp of slightly sweet and aromatic taste and whitish or red colour. Fruits are floating and seeds stay viable for a long time even in sea water.

Indian almond is a fast-growing, wind-resistant tropical species that often occurs on sandy or rocky beaches. It prefers a warm and humid climate with more than 750 mm of annual rainfall. The tree cannot survive frost but is relatively drought-tolerant. It has been planted at low elevations up to about 800 masl in tropical countries throughout the world because it is

both hardy and attractive. Indian almonds prefer well-drained soils but can also grow in very different soil types, including heavy clay and saline soil. In Kenya it is naturalized at the coast, in Voi and Kisumu.

There are no documented named cultivars of Indian almond, but some individuals have larger seeds or bigger fruit with more edible pulp of better taste than other trees. This natural variability can be used for selection of superior mother trees for propagation.

Uses: The fruit flesh of Indian almond is eaten raw; however, due to the variability of its taste, it is not widely used. The seed inside the kernel is the main food product of this species and is eaten raw or roasted and can be added to cakes, biscuits, bread, sweets or stews. In addition, an oil can be pressed from the seeds for use in cooking or cosmetics. The outer shell of the fruit is rich in tannin and the trunk, roots and fruit contain dye. The valuable, water-resistant timber is red and is used to build boats, bridges, floors, furniture, boxes, planks, carts, barrels and water troughs. The foliage is used as a feed for silkworms and livestock. The tree with its shady crown and vast root system is excellent for soil conservation, dune fixation and mulching, and as an ornamental and shade tree. Several parts of the tree are used as ingredients in traditional medicines.



Terminalia catappa – ripe fruit



Terminalia catappa – branches with unripe fruit and green and red leaves



Terminalia catappa – tree



Terminalia catappa – opened stone showing the edible seed



Terminalia catappa – ripe fruit whole and partly opened to show the fleshy reddish pulp

Nutrient composition

There is a lack of food composition data on this fruit. More research is needed to evaluate the nutritional potential of *Terminalia catappa*.



Season: Flowers in April to May and fruit ripen in October to December.



Cultivation: Indian almonds are propagated by seeds. Mature fruits are collected, and the pulp removed. The seeds are then carefully extracted from the stones. Seeds are soaked in cold water for 24 hours before sowing. About 70% of seeds germinate in about 20 days, but germination can take up to 8 weeks. Seeds should be set 25 x 25 cm apart in nursery beds or planted directly into polybags of rather large size. Transplanting to the field is done after



Pests and diseases: Indian almond is a rather robust species with few pest and disease problems. When young, trees are susceptible to defoliating insects such as grasshoppers, caterpillars and beetles but they usually recover quickly. Sucking insects such as thrips can attack the trees, which may cause leaf discoloration and premature defoliation. The fruits are attacked by several species of fruit flies, e.g., *Bactrocera* and *Ceratitis* spp. Indian almonds are also susceptible to termite attack. In Asia, the thermophilic fungus *Paecilomyces varioti* causes dieback of seedlings.



Commercial/market value: Indian almond is usually not grown as a fruit tree, but rather as a multipurpose tree for several service functions such as shade. In some regions such as India

about 4 months at the start of the rainy season, when the seedlings are 20–30 cm tall. Indian almonds are said to have orthodox seed storage behaviour as seeds remain viable even after floating in sea water for long distances. However, other sources mention that seeds can be stored for only 4–6 weeks after harvest. There are 150–860 seeds/kg.

The seedlings develop slowly at first, but growth accelerates afterwards. Before planting, fertilizer should be applied to poor soils. Spacing depends on the purpose of the planting and should be dense for windbreaks and shade, but rather wide for ornamental trees. Weeding is necessary for a few months after planting but there is soon sufficient cover of the tree's crown to shade out competition from weeds. Regular application of mulch and fertilizer enhance growth and fruiting. Need for pruning is minimal and only used to shape the tree, but young trees should not be pruned too hard.

and Pakistan, seeds and seed oil is sold in local markets and shops. In Kenya it is grown as a homegarden tree for shade and as an ornamental. The fruits and seeds are not sold in local markets, but children and farmers sometimes eat the aromatic fruit flesh. Use of the seeds should be promoted, but more research is required on development of improved cultivars with larger seeds and softer stones for easy seed extraction to better exploit the potential of Indian almond.

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Appendix 3: Species distribution maps

Species distribution maps were prepared in R (version 4.0.2; R Core Team 2020) with a baseline map obtained from wikimedia maps (<https://maps.wikimedia.org>; accessed 15 March 2021) via the basemapR package (<https://github.com/Chrisjb/basemapR>) and the ggplot2 (version 3.3.3; Wickham 2016) and ggspatial packages (version 1.1.5; Dunnington 2021). Red circles in the maps correspond to 0.5 degree grid cells shown in Beentje (1994) for herbarium observations of species across Kenya. The calibration procedure of species distribution models was done with BiodiversityR (version 2.12-3; Kindt 2018) with similar methods as those employed by van Zonneveld et al. (2021) such as ensemble suitability modelling via different algorithms, spatial thinning, environmental thinning and spatial folding. Presence observations for model calibrations were obtained via R function BIEN::BIEN_occurrence_species on 18th January 2021 (version 1.2.4; Maitner et al. 2018) and from the RAINBIO database (Dauby et al. 2016). From climatic data sets covering Africa (including Madagascar) that were obtained from WorldClim 2.1 (version 2.1; Fick and Hijmans 2017) and calculated via the envirem package (version 2.1; Title and Bemmels 2018), three grid layers at resolution of 30 arc-seconds were selected: (i) growing degree days above 5°C; (ii) the minimum temperature of the coldest month; and (iii) the moisture index, calculated by dividing annual precipitation by annual evapotranspiration. These three bioclimatic variables were recently recommended by Booth (2016) to estimate the potential ranges and climatic adaptability of tree species. Whereas models were calibrated at the scale of Africa, suitability maps were clipped to Kenya. The area where a species was predicted to be present (estimated via the threshold where sensitivity and specificity is maximal as recommended by Liu et al. 2013) was subdivided in four equally-sized ranges between the absence-presence threshold and the maximum suitability value observed in Kenya.

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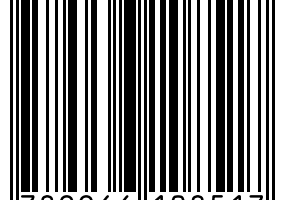
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