

## Classification of Kenyan Wood Carving Species Using Macroscopic and Microscopic Properties

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### Abstract

Wood carving is one of the most lucrative industries in Kenya. It is highly associated with the tourism industry and enjoys large volume of export market worldwide. However, a number of the indigenous wood carving species have been over exploited and it is crucial to identify alternative species to sustain the industry. The main objective of the study was to determine physical, macroscopic and microscopic features of Kenyan wood carving species and use these properties to classify them. Samples for 52 wood carving species (including the potential alternative species) were obtained from Coast, Eastern and Nairobi regions. The wood characteristics were determined at KEFRI Forest Products Laboratory using standard procedures. Information on local names, tree characteristics, wood characteristics, geographical distribution and uses are also provided. The 52 species are ranked based on macroscopic features, density and hardness and classified into 3 categories; major (4), minor (7) and alternative (41). The alternative ones are further classified into 3 groups i.e. high potential (23), medium potential (15) and low potential (3). The results indicate that some of the salient macroscopic features important for wood carving species are: heartwood darker than sapwood, non irritating odour, minute pores and rays, fine to medium wood texture, straight grains and distinct growth rings. High wood density is also found to be an important feature and about 80% of the species have densities ranging between  $0.60 \text{ g/cm}^3$  to  $1.23 \text{ g/cm}^3$ . Wood hardness is also an important feature and most of the wood carving species are moderately hard to very hard (4 to 20KN). The important microscopic features are: minute rays (1-3 cells wide), pores solitary or in radial multiples of 2 or more, vessels with simple perforations, very thick walled fibres and few parenchyma cells.

**Key words:** Kenyan wood carving species, microscopic, macroscopic, classification

### 1.0 Introduction

The woodcarvings industry has potential for improving livelihoods of rural communities in the drylands of Kenya. At local level, woodcarvings have been used to improve rural livelihoods through provision of household utensils, ornaments, wooden jewel, furniture and interior decorations that are sold to generate income. Many households are increasingly relying on woodcarvings industry for their livelihoods. Currently, this industry employs about 60,000 carvers and directly supports over 300,000 people. Most of beneficiaries are vulnerable groups such as women, youth, physically challenged persons, ex-prisoners and elderly people. At national level, woodcarving industry has an annual export worth of US\$20 million and is growing steadily at a rate of 1.8% per annum (Handicrafts Sector Strategy, 2006).

Preference for handicrafts from Kenya on the American and European markets is on an upward trend presenting a lot of opportunities for the local players. In addition, Kenya has signed market and trade protocols in favour of handicrafts. Notable ones include African Growth and Opportunities Act (AGOA) for the American market and Everything But Arms (EBA) for the European Market. The two protocols list woodcarvings as priority export commodities from Kenya with emphasis on compliance to standards for forest products including ethical sourcing and traceability.

International and local research and development organizations have supported woodcarvings production. Notably, People and Plants (a partnership of WWF-UK, UNESCO and Royal Botanical Gardens of Kew) and Kenya Forestry Research Institute (KEFRI) identified and promoted alternative tree species for wood carving under banner of the “good woods” to avoid over exploitation of preferred indigenous tree species like *Dalbergia melanoxylon* and *Brachyleania huliensis*. Some of the main “good woods” promoted for this industry include neem (*Azandratchica indica*), mango (*Mangifera indica*) and Jacaranda (*Jacaranda mimosifolia*). Farmer groups have also been sensitized and encouraged to initiate planting and sustainable harvesting of “good woods” for woodcarving. USAID has also funded local wood carvers in product development and design. All these initiatives have emphasized quality products, market access, sustainability, social responsibility, fair trade and ethical sourcing for woodcarvings.

The Project on *Sustainable development of the wood carving industry in Kenya* was formulated with a view to identifying constraints to sustainable development and proposing viable solutions. Jointly funded by the People and Plants initiative of the World Wide Fund for Nature (WWF), the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the Royal Botanic Gardens, KEW (UK), it had three components; socio-economic and resource surveys and information dissemination.

Socio-economic and resource surveys revealed a high preference by the wood carvers on a limited number of preferred species. The preference is based more on the tradition in the industry which has resulted in over-exploitation of the candidate species to the extent that some have experienced population declines. The studies revealed further that owing to the shortage of preferred species, carvers have been experimenting with alternative species [both indigenous and exotic] in an effort to meet the ever-increasing demand for wood carving products. In the course of the surveys, additional species were identified as potentially suitable for carving. Availability of these alternative species offers opportunity for species selective harvesting and trade which would enable recovery of wild stocks of over exploited species.

The wood carving species can be classified into 3 main categories, i.e. major, minor and alternative. The major ones are those that are the most popular and those found in almost all wood carving centres. These are Mpingo [*Dalbergia melanoxylon*], African brown olive [*Olea europaea*], Muhuhu [*Brachylaena huillensis*] and Mugurure [*Combretum schumanii*]. The minor ones are those occasionally used as alternatives to the most popular ones. Most of these are historically linked to the origin of wood carving in Ukambani. These include: Mwangati [*Terminalia spinosa*], Muhutu [*Terminalia brownii*], Mbambaro [*Terminalia kilimandscharica*], Mutula [*Terminalia prunoides*], Mjafari [*Zanthoxylum chalybeum*], Muthea [*Cordia sinensis*] and Mukau [*Melia volkensii*]. The alternative species are those that have not been widely used for wood carving but have potential.

The eleven main raw materials for wood carving in their ranked order of preference are *Dalbergia melanoxylon*, *Olea europaea*, *Combretum schumanii*, *Terminalia spinosa*, *Brachylaena huillensis*, *Terminalia brownii*, *Terminalia kilimandscharica*, *Zanthoxylum chalybeum*, *Cordia sinensis*, *Terminalia prunoides* and *Melia volkensii* (Obunga, 1995). The criteria for preference are based on multiple attributes: durability (the carvers emphasize that the wood should not change physically under any weather condition, with particular reference to the European weather); resistance to insects (wood borers); workability (the wood should be easy to work, yet hard enough to resist splitting and cracking); aesthetic values derived from grain texture, colour and patterns. The sum of these factors dictate the price of the product. The all time popular species is Mpingo [*Dalbergia melanoxylon*] marketed under the trade name Ebony. It combines all the above attributes, and therefore its products command the highest premium prices as compared to any other standard item from the rest of the species. For both the preferred and alternative species there is very limited documented information regarding suitability for wood carving. The area of wood properties which would provide valuable information on rational utilization of available resources is, in particular, devoid. The need to generate this valuable information, produce keys that could be used to identify the species in trade and promote use of alternative species led the WWF/UNESCO/KEW Plants and People initiative programme to formulate an activity spearheaded by KEFRI to examine *the Anatomical and related properties of the wood carving species in Kenya* - both those currently in use and the alternative ones.

## 2.0. Methodology

A list of species currently used for wood carving and the alternative ones was compiled from an earlier study [Obunga, 1995]. The study had identified a total of 52 species as suitable for carving.

The species are found in Coast (Gede, Malindi and Kwale), Eastern (Machakos, Kitui and Makueni) and Nairobi (Karura and Ngong'). A sampling programme was designed to obtain wood samples from these areas in close collaboration with Forestry Officers in the field and local communities in the wood carving industry. Wood samples from a total of 52 species were obtained from the field. For each species, a 1.3 metre billet was removed from the butt log and details of the standard, local and botanical names, location, and diameter at breast height, tree height and date of felling were recorded. The samples were transported to KEFRI Forest Products laboratory in Nairobi for analyses of wood characteristics based on standard procedures. Other relevant details such as the distribution, tree characteristics, durability, and the main uses were also obtained from various publications.

Full taxonomic information on the specimen i.e. family, genus, species were recorded. Scientific names for species and local or common synonym were obtained from the Kenya Trees, Shrubs and Lianas (Beentje 1994) and other authoritative publications.

Wood Characteristics which included hardness, density, macroscopic and microscopic features were determined using standard procedures.

### 2.2.1 Macroscopic features.

These are the features that can be seen by the naked eye or through a hand lens. The macroscopic features used in the description of the wood specimens were:

- I. Colour of the heartwood based on a freshly cut longitudinal surface. For those species that do not form distinct heartwood, the colour of sapwood was given.
- II. Odour of freshly cut green samples.
- III. The growth rings classified as either distinct or not distinct.
- IV. The pore size on cross section surface of wood - whether they were visible to the naked eye or with a hand lens.
- V. The wood grain - described as straight, wavy or interlocked.
- VI. The ray size on Tangential section - whether they were visible to the naked eye or with a hand lens.
- VII. Wood texture - fine, medium or coarse.

### 2.2.2. Microscopic features

These are the minute features that can only be seen under a microscope. In the description of the microscopic structures, The IAWA list of microscopic features for hardwood identifications were adopted (Wheeler *et. al.* 1989). The description of wood anatomical features was based on close examination of photomicrographs representing all the three phases (cross, tangential and radial sections) for all the species used in this study.

The features described in the cross section included arrangement of pores, arrangement of parenchyma cells in respect to the pores, thickness of fibre walls and presence of coloured deposits in vessels. On the tangential section the width of the rays was described in terms of number of the cells at the widest portion. The other features described from this phase were the intervacular pitting and the type of perforation plates; presence of intercellular canals, ray cells with perforations and septate fibres. On the radial section, the composition and arrangement of the ray cells was described and ray tissues classified either as heterogenous or homogenous based on these factors. Perforation type, intervacular pitting and the presence of deposits were also described in cases where these were visible.

### 2.2.3 Wood Density

The basic density obtained by dividing the oven dry weight of wood by green volume was classified as:

Light (low)	< 0.40 g/cm <sup>3</sup>
Moderately heavy (medium)	0.40 - 0.74 g/cm <sup>3</sup>
Heavy (high)	≥ 0.75 g/cm <sup>3</sup>

## 3.0 Results

### 3.1 General observations

There are over one thousand trees and shrubs in Kenya from about 332 families (Beentje, 1994). Most of the common trees of Kenya both indigenous and exotic are from 58 families (Noad and Birnie, 1989). Out of these, 24 families (42 genera) produce tree species that are used or have potential for wood carving.

Anacardiaceae family has the largest number of genera (5) used for wood carving followed by Caesalpiniaceae (4). However, Mimosaceae family has the highest number of tree species (8), followed by Combretaceae (6) and then Anacardiaceae (5), Table 1.

### 3.2 Macroscopic and physical features

The main macroscopic and physical features of the species are recorded in Table 1. From the table it is evident that some of the salient features that make Mpingo [*Dalbergia melanoxylon*] the most preferred species for wood carving are: heartwood distinctively darker than sapwood, non irritating odour, minute pores and rays, fine to medium wood texture, straight grains, distinct growth rings and high density (Plate 1-1). The macroscopic features and the densities for *Brachylaena huilensis* (Plate 1-2), *Olea europaea* (Plate 1-3), the 7 minor and fifteen alternative species compare closely to those of Mpingo (Table 1). Based on the macroscopic features (pores, heartwood colour, growth rings, wood texture) and density the alternative wood carving species can be broadly classified into three groups namely: high potential (those with more than 69 % of their characteristics similar to those of Mpingo), medium potential (those with at least 50-69 % of their characteristics similar to those of Mpingo) and low potential (those with less than 50 % similar characteristics to those of Mpingo) as shown in Tables 1 and 2. Based on the wood characteristics (density, hardness and macroscopic features) the 52 species have been ranked in terms of their suitability for wood carving (Table 2).

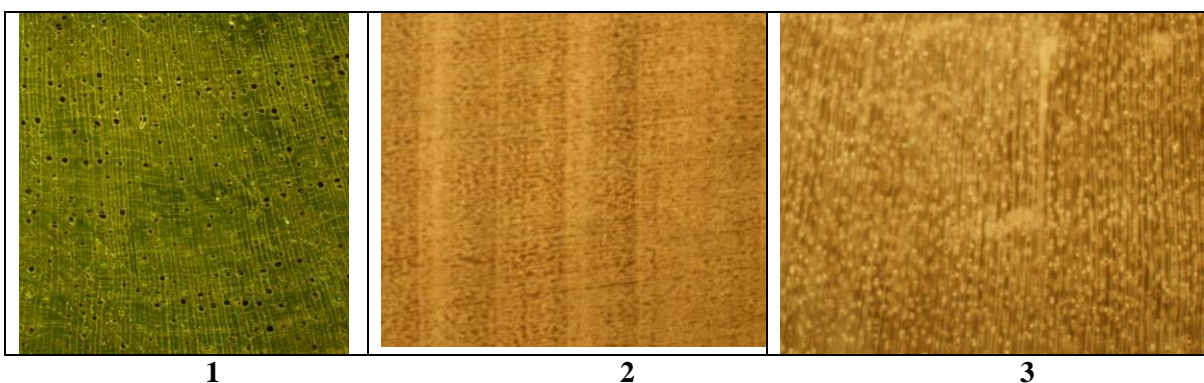


Plate 1. Macroscopic features of: *Dalbergia melanoxylon* (1), *Brachylaena huilensis* (2) and *Olea europaea* (3)

### Plate 3. Macroscopic features of

### 3.3 Microscopic features

The photomicrographs revealed that Mpingo [*Dalbergia melanoxylon*] the most popular wood carving species has minute rays (1-3 cells wide), pores partly solitary and partly in radial multiples of 2 or more, vessels with simple perforations, very thick walled fibres and few parenchyma cells (Plate 2). The other major wood carving species *Brachylaena huillensis* (Plate 3) and *Olea europaea* (Plate 4) have properties similar to Mpingo except for the arrangement of parenchyma cells. A number of the minor and alternative wood carving species also have similar characteristics to Mpingo [*Dalbergia melanoxylon*] - for example, *Casuarina equisetifolia*, *Combretum molle*, *Cynometra webberi*, *Eucalyptus grandis*, *Manilkara sansibarensis*, *Ocotea usambarensis*, *Oldfieldia somalensis*, *Spirostachys africana*, *Terminalia brownii*, *Terminalia kilimandscharica*, *Terminalia spinosa*, *Zanthoxylum chalybeum* and *Ziziphus mucronata*, (Table 3).

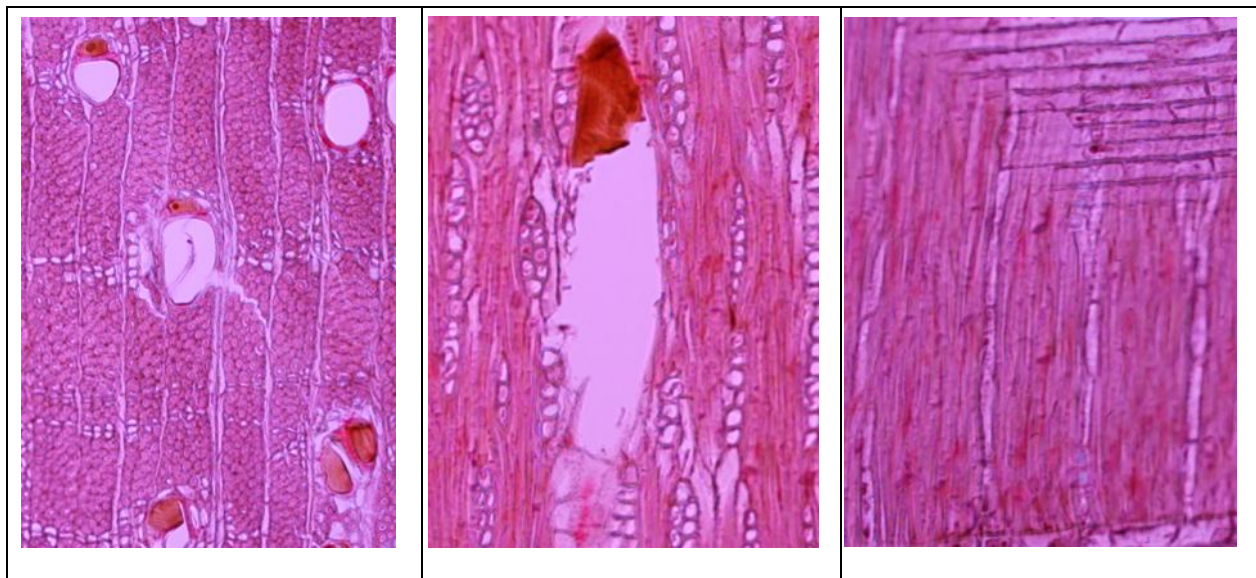


Plate 2. Photomicrographs of *Dalbergia melanoxylon*

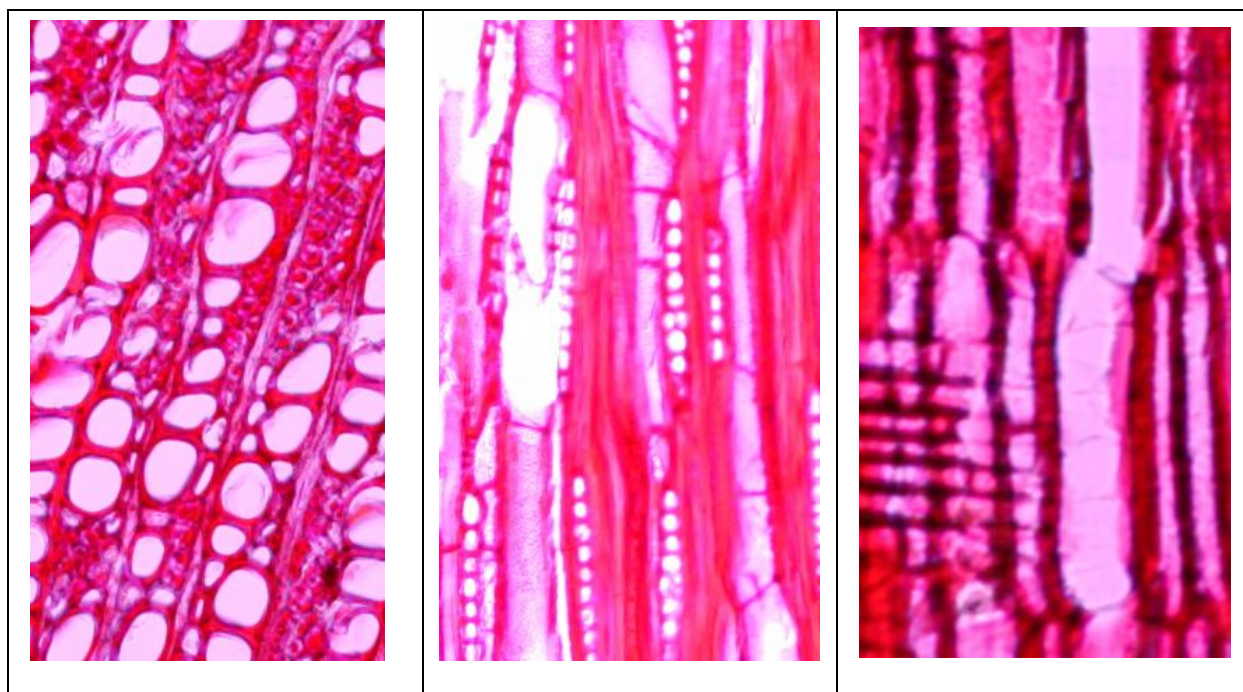
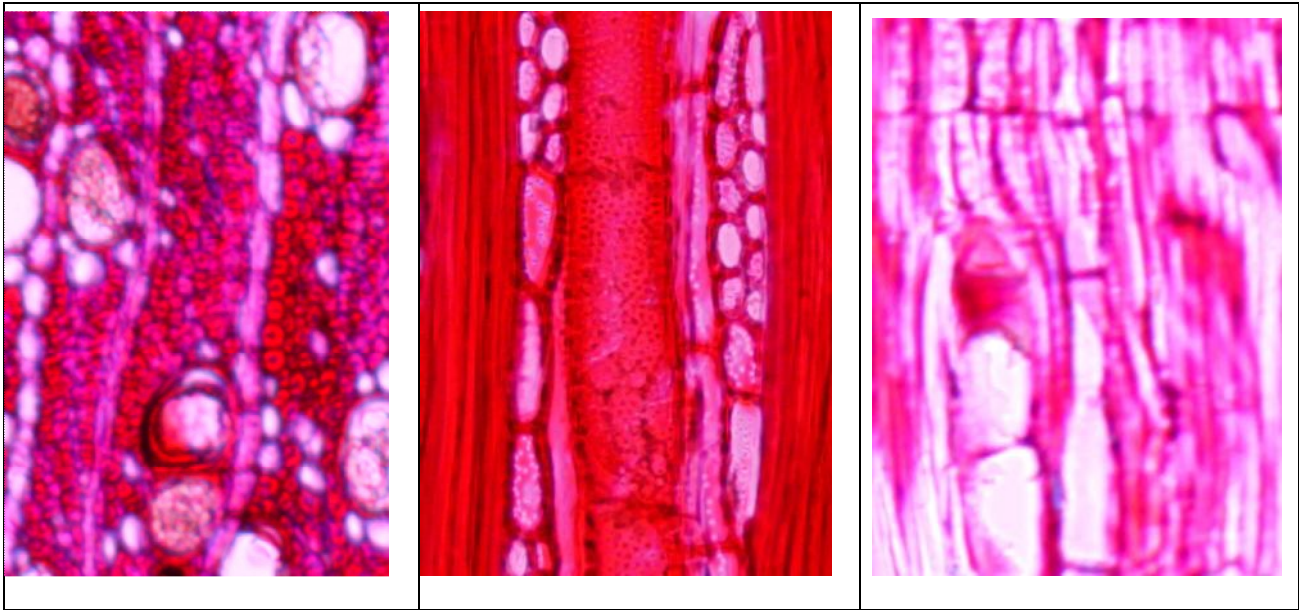


Plate 3. Photomicrographs for *Brachylaena huilensis*



**Plate 4. Photomicrographs for *olea europea***

#### **4.0 Conclusions and Recommendations**

##### **Conclusions**

From the study a number of conclusions can be made:

1. The salient macroscopic features for wood carving species are: heartwood darker than sapwood, non-irritating odour, minute pores and rays, fine to medium wood texture, straight grains and distinct growth rings.
2. Wood from 19 families namely: Papilionaceae, Compositae, Oleaceae, Combretaceae, Boraginaceae, Meliaceae, Rutaceae, Mimosaceae, Anacardiaceae, Caesalpiniaceae, Myrtaceae, Tiliaceae, Euphorbiaceae, Rhamnaceae, Rosaceae, Proteaceae, Verbeneaceae, Sapotaceae and Cuppressaceae, have heartwood distinctively darker than the sapwood.
3. The important microscopic features for the wood carving species are: minute rays (1-3 cells wide), solitary pores or pores in radial multiples of 2 or more, vessels with simple perforations, very thick-walled fibres and few parenchyma cells.
4. Wood from 10 families namely: Combretaceae, Euphorbiaceae, Lauraceae, Oleaceae, Compositae, Rutaceae, Caesalpiniaceae, Myrtaceae, Sapotaceae and Rhamnaceae have microscopic features similar to those of Mpingo.
5. Tree species preferred for wood carving are of high or medium densities (ranging from 0.68g/cm<sup>3</sup> to 1.23 g/cm<sup>3</sup> and are hard or very hard (with a Janka hardness of about 5.5KN to about 20 KN)
6. Out of the 41 alternative wood carving species, 38 have more than 50% of their physical and macroscopic features similar to those of Mpingo and can be used as alternatives for the scarce popular species. Among these is *Azadirachta indica* - the major alternative carving species for “responsible sourcing”
7. 52 wood carving species from Kenya can be identified using their physical, macroscopic and microscopic features.

**Table 1: The Macroscopic features, density and categories of 52 Wood Carving Species from Kenya**

SPECIES	FAMILY	PORES	COLOUR HW/SW	ODOUR	GROWTH RINGS	GRAINS	TEXTURE	RAYS	DENSITY	CATE-GORY
<i>Brachylaena huillensis</i> (Muhuhu [Swa])	<i>Compositae</i>	NVNE	Grey/Yellow Brown	Distinct but non irritating	Distinct	Straight	Fine	NVNE	Heavy	M
<i>Combretum schumanii</i> (Mgurure[Swa])	<i>Combretaceae</i>	NVNE	Purplish brown/Whitish yellow	Distinct but non irritating	Distinct	Straight	Medium	VNE	Heavy	M
<i>Dalbergia melanoxylon</i> (Mpingo [Swa])	<i>Papilionaceae</i>	NVNE	Purple to Brownish Black/Yellow to White	Distinct but non irritating	Distinct	Straight	Fine	VHL (x8)	Heavy	M
<i>Olea europaea</i> (Mutamaiyu [Kik])	<i>Oleaceae</i>	NVNE	Medium to dark brown/Pale yellow	Distinct but non irritating	Distinct	Straight	Fine	VNE	Heavy	M
<i>Cordia sinensis</i> (Muthea [Kam])	<i>Boraginaceae</i>	NVNE	Dark brown / Brown	Not distinct	Not distinct	Straight	Medium	NVNE	Heavy	MR
<i>Melia volkensii</i> (Mukau [Kam])	<i>Meliaceae</i>	VHL(x8)	Light pink/Light yellow	Not distinct	Distinct	Straight	Medium to coarse	VNE	Moderately heavy	MR
<i>Terminalia brownii</i> (Muuku [Kam])	<i>Combretaceae</i>	NVNE	Brown/Yellow	Not distinct	Distinct	Interlocked	Medium	VHL (x8)	Moderately heavy	MR
<i>Terminalia kilimandscharica</i> (Muuku [Kam])	<i>Combretaceae</i>	NVNE	Greyish brown / Pale yellow to brown	No smell	Distinct	Straight	Fine to medium	NVNE	Heavy	MR
<i>Terminalia prunoides</i> (Mutoo [Kam])	<i>Combretaceae</i>	VHL (x8)	Light yellow to brown	Distinct but non irritating	Distinct	Interlocked	Medium	VHL (x8)	Moderately heavy	MR
<i>Terminalia spinosa</i> (Mutula [Kam])	<i>Combretaceae</i>	Minute	Yellow to chocolate brown/Light yellow to brown	Not distinct	Distinct	Interlocked	Medium	VNE	Heavy	MR
<i>Zanthoxylum chalybeum</i> (Mukenea [Kam])	<i>Rutaceae</i>	NVNE	Greyish brown/Yellow	Distinct but non irritating	Distinct	Straight	Fine to medium	VNE	Moderately heavy	MR
<i>Acacia elatior</i> (Munga [Dur])	<i>Mimosaceae</i>	VNE	Yellow to white	Distinct but non irritating	Not distinct	Straight	Medium to coarse	NVNE	Heavy	A <sub>1</sub>
<i>Acacia mellifera</i> (Muthiia [Kam])	<i>Mimosaceae</i>	VNE	Dark brown with black markings/ Yellowish brown	Not distinct	Not distinct	Straight	Medium	VNE	Heavy	A <sub>1</sub>
<i>Acacia nilotica</i> (Musemi [Kam])	<i>Mimosaceae</i>	VNE	Purple to Reddish brown/Light yellow to white	No smell	Distinct	Straight	Medium	VNE	Heavy	A <sub>1</sub>
<i>Albizia amara</i> (Mwona [Kam])	<i>Mimosaceae</i>	VNE	Light yellow to light brown	Distinct but non irritating	Distinct	Straight	Medium to coarse	VNE	Heavy	A <sub>1</sub>
<i>Albizia versicolor</i> (Mtango [Kam])	<i>Mimosaceae</i>	VHL (x8)	Dark brown/White to pale cream	Distinct but non irritating	Distinct	Straight	Medium	VHL (x8)	Moderately heavy	A <sub>1</sub>
<i>Azadirachta indica</i> (Mwarubaini [Swa])	<i>Anacardiaceae</i>	VHL (x8)	Pinkish brown/Light yellow	Distinct and irritating smell	Distinct	Interlocked	Medium	VNE	Moderately heavy	A <sub>1</sub>

SPECIES	FAMILY	PORES	COLOUR HW/SW	ODOUR	GROWTH RINGS	GRAINS	TEXTURE	RAYS	DENSITY	CATE-GORY
<i>Balanites aegytiaca</i> (Mulului [Kam])	<i>Balanitaceae</i>	VHL (x8)	Yellow to light brown	Distinct but non irritating	Distinct	Straight	Medium	Very large	Moderately heavy	A <sub>1</sub>
<i>Boscia angustifolia</i> (Mulule [Kam])	<i>Capparaceae</i>	VHL (x8)	Light brown/White to Pale cream	Distinct but non irritating	Distinct	Interlocked	Fine to medium	VHL (x8)	Heavy	A <sub>1</sub>
<i>Casuarina equisetifolia</i> (Mvinje [Swa])	<i>Casuarinaceae</i>	NVNE	Light pink to creamish white	Not distinct	Not distinct	Straight	Fine	VHL (x8)	Heavy	A <sub>1</sub>
<i>Cordia monoica</i> (Msasa (Swa), Muthii [Kam])	<i>Boraginaceae</i>	VHL (x8)	Brown to greyish brown	Not distinct	Not distinct	Straight	Medium	VHL (x8)	Moderately heavy	A <sub>1</sub>
<i>Cupressus lusitanica</i> (Cypress)	<i>Cupressaceae</i>	Absent	Pink to pale brown/White	Distinct but non irritating	Distinct	Straight	Fine	NVNE	Moderately heavy	A <sub>1</sub>
<i>Cynometra webberi</i> (Mfunda [Gir])	<i>Caesalpiniaceae</i>	NVNE	Reddish brown/White brown	No smell	Not distinct	Straight	fine	NVNE	Heavy	A <sub>1</sub>
<i>Eucalyptus grandis</i> (Musanduku[Kam])	<i>Myrtaceae</i>	VNE	Pinkish brown/ Creamish white to light grey	Not distinct	Distinct	Straight	Medium	VNE	Heavy	A <sub>1</sub>
<i>Eucalyptus saligna</i> (Musanduku[Kam])	<i>Myrtaceae</i>	VNE	Pink to red/White to light brown	Distinct but non irritating	Distinct	Straight	Medium	VHL (x8)	Heavy	A <sub>1</sub>
<i>Grewia bicolor</i> (Mulawa [Kam])	<i>Tiliaceae</i>	NVNE	Yellow to dark brown/Yellow	Distinct but non irritating	Distinct	Straight	Fine-Medium	VNE	Heavy	A <sub>1</sub>
<i>Hymenaea verrucosa</i> (Mtandarusi [Swa])	<i>Caesalpiniaceae</i>	VNE	Purple to reddish brown/Creamish white to light brown	Distinct but non irritating	Distinct	Straight	Medium	VNE	Heavy	A <sub>1</sub>
<i>Juniperus procera</i> (Mutarakwa [Kik])	<i>Cupressaceae</i>	Absent	Pale yellow to red/ White	Distinct but non irritating	Distinct	Straight	Fine	NVNE	Moderately heavy	A <sub>1</sub>
<i>Manilkara sansibarensis</i> (Mngambo [Gir])	<i>Sapotaceae</i>	NVNE	Light pink/Light brown	Not distinct	Distinct	Straight	Fine	NVNE	Heavy	A <sub>1</sub>
<i>Oldfieldia somalensis</i> (Mbilandu [Gir])	<i>Euphorbiaceae</i>	NVNE	Greyish brown/Light brown	Distinct but non irritating	Distinct	Wavy	Fine	NVNE	Moderately heavy	A <sub>1</sub>
<i>Rhus tenuinervis</i> (Kitheu [Kam])	<i>Anacardiaceae</i>	NVNE	Pinkish/Pinkish white	Distinct and unpleasant	Distinct	Straight	Fine	NVNE	Moderately heavy	A <sub>1</sub>
<i>Spirostachys africana</i> (Mutanga [Kam])	<i>Euphorbiaceae</i>	VHL (x8)	Dark brown with dark markings / Light yellow	Distinct but non irritating smell	Distinct	Straight	Fine	VHL (x8)	Heavy	A <sub>1</sub>
<i>Tamarindus indica</i> (Kithumula (Kam), Mkwaju [Swa])	<i>Caesalpiniaceae</i>	VNE	Black to dark purple / White	Distinct but non irritating	Distinct	Interlocked	Medium	VNE	Moderately heavy	A <sub>1</sub>
<i>Ziziphus mucronata</i> (Mkunazi [Swa])	<i>Rhamnaceae</i>	NVNE	Pinkish brown/White	Not distinct	Distinct	Interlocked	Medium	NVNE	Moderately heavy	A <sub>1</sub>



SPECIES	FAMILY	PORES	COLOUR HW/SW	ODOUR	GROWTH RINGS	GRAINS	TEXTURE	RAYS	DENSITY	CATE-GORY
<i>Afzelia quanzensis</i> (Mbambakofi [Gir])	<i>Caesalpiaceae</i>	VNE	Reddish brown/Light yellow	Distinct but non irritating	Distinct	Interlocked	Coarse	VNE	Heavy	A <sub>2</sub>
<i>Acacia etbaica</i> (Muswiswi [Kam])	<i>Mimosaceae</i>	VNE	Light yellow to pale cream	Distinct but non irritating	Distinct	Straight	Medium to coarse	VNE	Moderately heavy	A <sub>2</sub>
<i>Albizia anthelmintica</i> (Mporojo [Swa], Mwowa [Kam])	<i>Mimosaceae</i>	VNE	Yellow to white	Distinct but non irritating	Not distinct	Wavy	Medium to coarse	VNE	Moderately heavy	A <sub>2</sub>
<i>Brachystegia spiciformis</i> (Mrihi [Swa])	<i>Caesalpiaceae</i>	VNE	Pale Brown /Pale cream to white	Not distinct	Not distinct	Interlocked	Medium to coarse	VNE	Moderately heavy	A <sub>2</sub>
<i>Combretum molle</i> (Kiama [Kam])	<i>Combretaceae</i>	VNE	Yellow/Purplish black	No smell	Not distinct	Wavy	Medium	NVNE	Moderately heavy	A <sub>2</sub>
<i>Grevillea robusta</i> (Mukima [Kik])	<i>Proteaceae</i>	VNE	Pale pink to brown / Creamish	Not distinct	Distinct	Straight	Moderately coarse	Very large	Moderately heavy	A <sub>2</sub>
<i>Hagenia abyssinica</i> (Mumondo [Kik])	<i>Rosaceae</i>	VNE	Reddish brown/Pink to cream	Not distinct	Not distinct	Straight	Medium	VNE	Moderately heavy	A <sub>2</sub>
<i>Jacaranda mimosifolia</i> (Jacaranda)	<i>Bignoniaceae</i>	NVNE	Creamish white	Distinct but non irritating	Distinct	Straight to wavy	Medium	VNE	Moderately heavy	A <sub>2</sub>
<i>Lanmea schweinfurthii</i> (Muasi [Kam])	<i>Anacardiaceae</i>	VHL (x8)	White/ Light brown	Distinct but non irritating	Distinct	Straight to Interlocked	Medium	VHL (x8)	Moderately heavy	A <sub>2</sub>
<i>Melia azedarach</i> (Persian-lilac, Dwele [Luo])	<i>Meliaceae</i>	VNE	Pinkish brown/White	Not Distinct	Distinct	Straight	Medium	VNE	Moderately heavy	A <sub>2</sub>
<i>Newtonia buchananii</i> (Mukui [Kam])	<i>Mimosaceae</i>	VNE	Pale brown to golden brown / Greyish white	Not distinct	Distinct	Interlocked and straight	Medium to coarse	VNE	Moderately heavy	A <sub>2</sub>
<i>Tectona grandis</i> (Teak)	<i>Verbenaceae</i>	VNE	Yellowish brown with dark brown marks/White	No smell	Distinct	Straight	Medium	VNE	Moderately heavy	A <sub>2</sub>
<i>Mangifera indica</i> (Mwembe [Swa,Gir])	<i>Anacardiaceae</i>	VNE	White to pale cream	Distinct but non irritating	Not distinct	Interlocked	Medium to coarse	VNE	Moderately heavy	A <sub>2</sub>
<i>Ocotea usambarensis</i> (Muthaiti [Kik])	<i>Lauraceae</i>	VNE	Yellowish brown to deep brown	Not distinct	Not distinct	Straight to interlocked	Medium	VNE	Moderately heavy	A <sub>2</sub>
<i>Trichilia emetica</i> (Muwamaji [Swa], Mgalana [Gir])	<i>Meliaceae</i>	VNE	Creamish white to light pink	Distinct but non irritating	Not distinct	Interlocked	Medium to coarse	VNE	Moderately heavy	A <sub>2</sub>
<i>Anarcadium occidentale</i> (Mkanju [Swa])	<i>Anacardiaceae</i>	VHL (x8)	White to light brown	Not distinct	Not distinct	Interlocked	Medium to coarse	VHL (x8)	Light	A <sub>3</sub>
<i>Commiphora africana</i> (Ikuu Kam)	<i>Bursereceae</i>	VHL (x8)	Lightbrown	Distinct but non irritating	Not Distinct	Interlocked	Medium to coarse	VNE	Light	A <sub>3</sub>
<i>Erythrina abyssinica</i> (Muruti [Kam])	<i>Papilionaceae</i>	VNE	Light yellow	Not distinct	Not distinct	Straight	Coarse	VNE	Light	A <sub>3</sub>

**Key**

NVNE - Not Visible to the naked eye

VNE - Visible to the naked eye

VHL - Visible with hand lens

M - Major wood carving species

MR - Minor wood carving species

A<sub>1</sub> - Alternative wood carving species with high potential

A<sub>2</sub> - Alternative wood carving species with medium potential

A<sub>3</sub> - Alternative wood carving species with low potential

Swa - Swahili

Kik - Kikuyu

Gir - Giriama

Kam - Kamba

Luo - Luo

Dur - Duruma

**Density**

≥ 0.75 g/cm<sup>3</sup> - Heavy

0.40 g/cm<sup>3</sup> to 0.74 g/cm<sup>3</sup> - Moderately heavy

< 0.40 g/cm<sup>3</sup> -Light

**Table 2: List of 52 Wood carving species from Kenya in matrix ranked order of suitability for carving based on macroscopic features, density and hardness as compared to those of Mpingo (*Dalbergia melanoxylon*)**

Category	Botanical name	Local/Standard Names	Source
1	<i>Dalbergia melanoxylon</i>	Mpingo (Swa)/Ebony	Kitui, Makueni, Kwale
	<i>Brachylaena huillensis</i>	Muhugu (Kik)/Muhuhu (Swa)	Ngong, Karura, Nyeri (Kabarua) forests
	<i>Combretum schumanii</i>	Mgurure (Gir)/Mku-mari (Luh)	Kyulu Hills, Kitui, Kwale, Kilifi
	<i>Olea europaea</i>	Mutamaiyo (Kik)/Brown olive	Kyulu Hills, Kwale, Rift Valley forests
2	<i>Spirostachys africana</i>	Mutanga (Kam)/Tambootie	Kitui, Makueni, Coast (Kilifi)
	<i>Terminalia spinosa</i>	Mutula (Kam) / Mwangati	Kitui, Wamunyu
	<i>Manilkara sansibarensis</i>	Mbichuma (Swa)/Mngambo	Coast, Machakos, Kitui
	<i>Grewia bicolor</i> <i>Terminalia kilimandscharica</i>	Mulawa (Kam) Muuku (Kam)/Mbambaro (Swa)	Kitui, Makueni, Machakos
3	<i>Cordia sinensis</i>	Muthea (Kam)	Kitui
	<i>Oldfieldia somalensis</i>	Mbauri (Swa)	Malindi
	<i>Cynometra webberi</i>	Mfunda (Swa)	Malindi
	<i>Casuarina equisetifolia</i> <i>Boscia angustifolia</i>	Mvinje (Swa)/Whistling pine Mulule (Kam)	Malindi Kitui, Malindi, Machakos
4	<i>Rhus tenuinervis</i>	Kitheu (Kam)	Kitui, Wamunyu
	<i>Ziziphus mucronata</i>	Mkunazi (Swa)/Buffalo thorn	Wamunyu, Kitui
	<i>Acacia nilotica</i>	Musorii (Kam)	Malindi, Kitui
	<i>Acacia elatior</i>	Munga (Dur)	Kitui, Makueni, Machakos
5	<i>Terminalia brownii</i>	Kivuku (Kam)/Muhutu	Kitui, Malindi
	<i>Albizia amara</i>	Mwona (Kam)	Kitui, Machakos, Makueni
	<i>Acacia mellifera</i>	Muthiia (Kam)	Kitui, Machakos, Makueni
	<i>Zanthoxylum chalybeum</i>	Mukenea (Kam)	Wamunyu, Malindi
	<i>Albizia versicolor</i>	Mtango (Kam)	Kitui, Machakos, Makueni
	<i>Eucalyptus saligna</i>	Masanduku (Kam)/Saligna gum	Nairobi
	<i>Terminalia prunoides</i>	Mutoo/Mwangati-Punda	Kitui, Wamunyu
	<i>Hymenaea verrucosa</i>	Mutandarusi (Swa)/Gum copal tree	Kilifi, Kwale
	<i>Eucalyptus grandis</i>	Musanduku (Kam)/Rose gum	Nairobi, Rift Valley
	<i>Juniperus procera</i> <i>Azadirachta indica</i>	Mutarakwa/Cedar Mwarubaini (Swa)/Neem	Nairobi, Rift Valley Kwale, Kilifi
6	<i>Tamarindus indica</i>	Kithumula (Kam)/Tamarind	Kitui, Coast
	<i>Balanites aegyptiaca</i>	Mulului/Desert date	Kitui, Machakos, Makueni
	<i>Cordia monoica</i>	Muthii (Kam)	Kitui
	<i>Cupressus lusitanica</i> <i>Melia volkensii</i>	Cypress Mukau (Kam)	Nairobi, Rift Valley Kitui
7	<i>Azalia quanzensis</i>	Mbambakofi (Swa)/Azalia	Kwale, Kilifi
	<i>Melia azaderach</i>	Dwele (Luo)/Persian lilac	Nairobi
	<i>Tectona grandis</i>	Teak	Malindi
	<i>Combretum molle</i>	Muama (Kam)	Kitui
	<i>Brachystegia spiciformis</i> <i>Hagenia abyssinica</i>	Mrihi Bondet (Kam)/Hagenia	Kwale, Kilifi, Kitui Central, Rift Valley Provinces Nairobi
<i>Grevillea robusta</i>	Mukima (Kik)/Grevillea		
8	<i>Lannea schweinfurthii</i>	Muasi (Kam)	Machakos, Kitui
	<i>Albizia anthelmintica</i>	Mporojo (Swa)	Kitui, Machakos, Makueni
	<i>Jacaranda mimosifolia</i>	Mucakaranda (Kik)/Jacaranda	Nairobi
9	<i>Acacia etbaica</i>	Muswiwi (Kam)	Kitui, Machakos, Makueni
	<i>Newtonia buchananii</i>	Mukuu (Kik)/Newtonia	Kitui, Wamunyu
	<i>Ocotea usambarensis</i>	Muthaita (Kik)/Camphor	Mt. Kenya/Nyeri
	<i>Mangifera indica</i> <i>Trichilia emetica</i>	Mwembe (Swa)/Mango Muwamaji (Swa)/Natal Mahogany	Coast Malindi
10	<i>Anarcadium occidentale</i>	Mkanju (Swa)/Cashewnut	Kwale, Kilifi
	<i>Commiphora africana</i>	Mbambara (Swa)	Kitui, Makueni, Machakos
	<i>Erythrina abyssinica</i>	Mbamba Ngoma (Swa)/Red hot poker tree	Kitui, Makueni, Machakos

**Key (showing categories and the percentage of features of the species that are similar to those of Mpingo)**

Category 1 - 95-100%	Category 6 - 69%	Category 10 - < 50%
Category 2 - 94%	Category 7 - 63%	
Category 3 - 88%	Category 8 - 56%	
Category 4 - 81%	Category 9 - 50%	
Category 5 - 75%		

**5.0 References**

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