Wood Characteristics and properties of *Cocos nucifera* (the coconut tree) grown in Kwale District

Nellie Oduor and Joseph Githiomi

Kenya Forestry Research Institute (KEFRI), Forest Products Research Centre,
P. O. Box 64636, 00620 Nairobi, Kenya
Email: nelliecoduor@yahoo.com; githiomikefri@ngara.org

Abstract

The coconut, *Cocos nucifera* L., has been described as "the tree of life" or the tree of plenty and nature's greatest gift to man. Coconut products provide food, shelter and energy to farm households, and can be made into various commercial and industrial products. In Kenya the Coconut tree is a key source of household livelihood in coast region. About 44,000 hectares is under coconut along the Kenyan coast which constitutes 4.4 million coconut trees under cultivation (Mayende, 2006). About 70% of these trees are senile (they are no longer productive -age 60+). The wood from these senile trees are potential renewable resource for timber and a good substitute for traditional hard woods. Wood working properties for Kenyan grown coconut are not well documented. This paper highlights the results observed from wood conversion and seasoning behaviour, and the determination of the strength and physical properties. These were compared with known data from other parts of the world.

Generally the characteristics and properties obtained were comparable with those from other parts of the world. The density ranges from low to heavy density 0.248 – 0.852 gcm^{-3}. The bending strength, bending stiffness and crushing strength also range from very weak to very strong due to the density variation. Efforts to promote the use of the coconut wood in Kenya started in early 2003 in an attempt of searching for alternative wood species which could be used in the woodcarving sub-sector. However, there are challenges in utilisation of coconut wood and in its production expansion. This paper also highlights these challenges

Key words: *Cocos nucifera*, utilisation of coconut wood, physical properties, mechanical properties, Kenya

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Introduction

The coconut, ***Cocos nucifera*** L., has been described as "the tree of life" or the tree of plenty and nature's greatest gift to man. Each part of the coconut tree can be used to produce items of value for the community. Coconut products provide food, shelter and energy to farm households, and can be made into various commercial and industrial products. The major coconut products in the world include: copra, toddy, leaves, brooms, baskets and mats, oil, desiccated coconut, coconut cream, coconut shell, shell flour, shell charcoal, activated carbon, charcoal briquettes, coir fibre, coir dust, and fresh coconut juice.

Coconut grows well in Agro-ecological zones CL2 and CL3 at the coast, and requires 1000mm of well distributed rainfall in the year with a mean annual temperature of 27°C with a lower limit of 20°C. Alluvial loam and sand soils are more suitable, but grows on sand and clay soils as well.

In Kenya the Coconut tree is a key source of household livelihood in coast region. About 44,000 hectares is under coconut along the Kenyan coast which constitutes 4.4 million coconut trees under cultivation (Mayende, 2006). About 70% of these trees are senile (they are no longer productive -age 60+). The wood from these senile trees are potential renewable resource for timber and a good substitute for traditional hard woods.

In Kenya coconut is mainly used for making copra and very little has been achieved in terms of developing and promoting other uses of coconut products. Copra is the most important coconut product that is further processed into oil, which is mainly used in the soap industry, cosmetics, candle manufacture and some oil has been refined to edible quality. Due to the current high cost of vegetable oils, many rural people in the producing districts have turned to fresh grated coconuts as an alternative (Mangi, 2000). A field visit made by KEFRI officers in October 2003 to Kwale District revealed that the coastal people are now using the coconut tree heavily in furniture making and in construction. Wood working properties, mechanical and physical properties for Kenya grown coconut are not well documented. A meeting with the Forest Department personnel within the District agreed that research on wood properties of this tree should be one of the priorities areas of study. The objective of the study is to determine the wood characteristics and properties of *Cocos nucifera***,** where the wood conversion and seasoning behaviour will be assessed. Also the physical, strength and wood working properties and the microscopic features will be determined.

Methodology

Sampling

Logs were sampled from farmers in Kwale District. The trees selected and felled had to have a relatively straight form. Once felled, they were cross cut into maximum lengths of 6-7 ft (where possible). This was the maximum length of a log the lorry could carry. The logs once crosscut they were labelled as butt log, mid log and top log. A total of nine logs were purchased and transported to the Forest Products Research Centre at KEFRI-Karura.

Wood conversion

The logs were converted into timber using a bandsaw at the KEFRI – Karura workshop. Once the timber was sawn it was planed using a thicknesser (planer).

Seasoning behaviour of the timber

The timber was air-seasoned to about 15% moisture content. Here the behaviour of the timber while drying is observed; looking for any drying defects or insect attack.

Physical and Strength Properties of *Cocos nucifera*

The physical and strength properties for green samples were carried out. The density, Modulus of Elasticity (bending stiffness), Modulus of Rupture (bending strength), crushing strength, Shear strength (parallel to grain) and hardness of the species were determined.

Microscopic features of *Cocos nucifera*

Microscopic features are the minute features that can only be seen under a microscope. The description of these features is based on close examination of photomicrographs representing all the three phases (cross, tangential and radial).

Wood blocks of 20 x 20 x 20 mm were made and soaked in water for about 24 hours. They are then kept in a mixture of glycerol and ethanol for about a week.

Six to eighty sections of between 13-20 microns were cut from the cross, radial and tangential faces of the samples using a sledge microtome. The sections were put on labelled slide glasses, covered with another slide glass, and put in an oven for 2 days at 60°C to prevent curling.

The sections were then double stained using safranin stain and gentian violet for about 5 minutes and washed in running water to remove excess stain. The stained sections were dehydrated through an ethanol series of 30, 50,70,85,95 and 100%, then in creosote/xylene (50:50), and finally in xylene. The sections were the immediately mounted on a slide glass, 3 sections per slide glass, with Canada balsam. The mounted slides were dried for about 2 days at 60°C before the final labels were pasted.

Results

Tree dimensions

Five trees out of the nine were planted in 1932 thus were 72 years old while the other four trees were planted in 1957 thus making them 57 years old. The farmers told us that they were two different types of this species- a green one and a red one (determined by their fruits).

Wood conversion

Since the coconut log diameter is small – 25 – 30 cm in diameter (Figure 1) with very high density on its periphery, the saw tends to go out of the saw line and a conventional saw easily becomes blunt. The butt portion of the coconut stem is likely to cause sawing difficulties particularly in a large diameter saw. In addition, considerable amount of fine substances similar to sand granules and pieces of small pebbles is present in the bark which contributes to the rapid dulling of saw teeth during sawing operation. For these reasons, it is necessary to apply hard facing materials on the saw teeth.

Figure 1: ***Cocos nucifera logs***

Seasoning behaviour of the timber

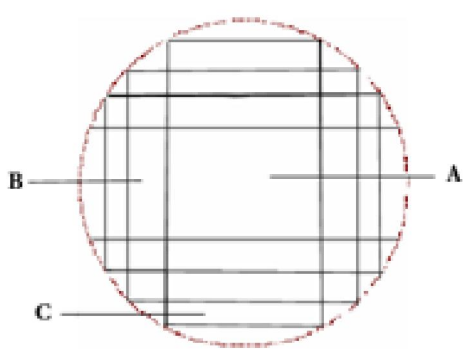
The coconut timber took more than twelve months to dry (whilst stacked shown in Figure 2) to a moisture content of 12%. In the first couple of months some mould and stain fungi was noted on the timber due to the high moisture content in the timber (Figure 3)

Figure 2: Sawn *Cocos nucifera* timber stacked to dry

Figure 3: Mould on the *Cocos nucifera* drying timber

Physical and Strength Properties of *Cocos nucifera*

The results are shown in Table 1. The wood is classified as ranging between light and heavy (Wimbush, 1957) due to its varying heterogeneity (density) over its cross section and along the stem height. There are three density areas as indicated in the Figure 4.



A: Center (very light/faint grains), low density.
B: Towards the outer ring (light grains), medium density
C: Outer ring (deep grains), high density or hard wood

Figure 4: Three density areas in a cross-section of the *Cocos nucifera* wood

Under mechanical properties, two properties are considered - Modulus of Rapture (MOR) for the bending strength and compression strength for Crushing Strength. This too there was a range from very weak to very strong. Other physical and mechanical properties are listed below in Table 1.

Table 1: Physical and Strength Properties of *Cocos nucifera*

Density (g/cm^3)-[air dry]	0.248 – 0.852	Light - Heavy
Bending strength (MOR) [N/mm^2]	16.34 – 109.21	Very weak – very strong
Bending stiffness (MOE) [KN/mm^2]	1.982 – 12.705	Very weak – very strong
Crushing strength [N/mm^2]	9.84 – 77.56	Very weak – very strong
Shear strength (parallel to grain) [N/mm^2]	2.1 – 17.37	Soft - hard
Hardness (KN)	0.66 – 14.905	Soft – very hard
Machining	Moderately easy	
Drying rate	Slow rate	

Macroscopic and Microscopic features of *Cocos nucifera*

Unlike conventional trees coconut palms being monocotyledon has no vascular cambium. Hence, its trunk once formed does not increase in diameter with age. In cross sections, the stem has three distinct zones, namely the dermal, sub-dermal and the central zone (Figure 5). The dermal is most peripheral portion just below the cortex; the sub-dermal is a transitory zone between the dermal and the central regions, and the central zone or core.

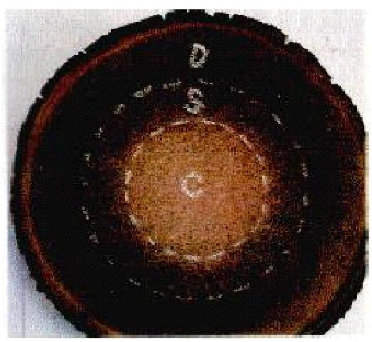


Figure 5: Cross-section of *Cocos nucifera* trunk (D- Dermal, S-sub-dermal, C- Central zone or core)

The gross structure comprises of extremely soft tissues (parenchyma) alternating with extremely dense (vascular bundles) tissue thus giving a aesthetically beautiful 'figure' as shown on Figure 6.

Figure 6: *Cocos nucifera timber showing unique 'figure'*

Three principal planes are recognised in which wood is customarily examined due to its growth behaviour and the arrangement of wood cells within the stem. These planes or surfaces are – Transverse (cross section), Radial and the Tangential. The transverse surface is the surface presented at the end of a log. The radial and the tangential surfaces of the wood are at right angles to the transverse section. The radial surface is exposed when the cut follows a radius of a cross section of the log. The tangential surface of wood is exposed when the bark is peeled from a tree. This surface is approximately tangent to the growth rings.

Conclusions/recommendations

Efforts to promote the use of *Cocos nucifera* in Kenya started in early 2003 in an attempt of searching for alternative wood species which could be used in the woodcarving sub-sector. Micro Enterprise Development Project (MEDP) of the Ministry of Labour together with other partners looked at the possible use of coconut wood especially among micro-enterprises in the country. The project aims at supporting the efforts by Micro Enterprise Development to enhance the economic development of Coastal Province, and to open up additional sources of income to small farmers, wood carvers, and carpenters by looking at more possible use of senile coconut palms.

However, there are challenges in utilisation of coconut wood and in production expansion. These are:

- Selection of the senile coconut tree, splitting/sawing and grading for specific use not yet fully understood by most players in the Kenyan market.
- High cost of seasoning (Kiln technology) and other operations on coconut wood.
- Lack of know-how in coconut wood finishing and preservation technology.
- Inadequate market acceptance of coconut wood products at “premium” prices.
- Low level of coconut tree replenishment in the country for sustainable harvesting and utilization of the resource.
- Lack of appropriate local regulatory mechanisms to ensure only senile coconut trees are harvested and at competitive prices.
- Stimulate market as incentive for planting new coconut trees,
- Enact coconut policy and set institution to promote active research, production and marketing. (Current coconut laws were formulated almost 100 years ago by colonial government - The coconut industry preservation Act cap 332 of 1915 and The coconut Industry Act Cap 331 of 1923)
- Strengthen coconut production research
- Encourage formation of coconut farmer organizations to coordinate production and marketing,

In view of the increasing demand of timber and coupled with the ban on timber harvesting from gazetted forests, coconut wood will become with further research and promotion, an extremely valuable commodity. Perhaps it can be certified and enlisted as a Good Wood (Forest Stewardship Council-FSC). Increased utilisation of coconut wood may thus contribute to the conservation of tropical rain forest species which form the bulk in local markets.

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