2
Literature review

The Peach Palm (*Bactris gasipaes Kunth)* (Figure 2.1) is recognized as a fruit tree in many indigenous communities in the Tropical America and Africa. It is a traditional palm in the Amazon of Brazil, Peru, Ecuador and Colombia.

Figure 2.1. Peach Palm.

In “Los Desano”, an indigenous community of Vaupés (Colombia), Peach Palm is known as Ri and cultivated as a fruit tree. (Reichel, 1986 *apud* Grazón *et al,.* 1993). The people of “Los guayabero”, a community located by the Guaviare river (Colombia), refer to peach palm as Piit or Pupi, and it is one of the most important palms they utilize for handicrafts and food. Among the “Huitotos” from the Amazon, it is recognized as a plant of long tradition and domestication (Figure 2.2). Multiple uses are known and, within their cultural context, the palm makes part of the indigenous genesis and domestication of plants, presented in social events like the Chontaduro Festival (Grazón, 1986; Macuritofe, 1990 *apud* Grazón, *et al.* 1993). In general, the peach palm has specific names within indigenous cultures where it is recognized by some typical management or cultural significance.

Figure 2.2 Palms and indigenous communities.
Source: http://www.flickr.com/photos/der/149425497/in/set-72157600762485088
Image by: Climbing the Peach Palm Documentary.

2.1. Origin, domestication and distribution

The Peach palm is native in the tropical latitudes of Latin America. Its origin is presumed to be the west region of the Amazon basin (Corpoica, 1996). Other authors suggest a diversified origin including the western Amazon Basin, western and northwestern side of the Andes and lower America (Mora-Urpí, 1984; Arroyo and Mora-Urpí, 1996; Mora-Urpí *et al.* 1997). Native palm populations have been found specifically in Peru, Brazil, Colombia, Ecuador, Venezuela, Bolivia, Panamá and Costa Rica (Corpoica, 1996).

Those who proposed the hypothesis that cultivated peach palm had multiple origins as Mora-Urpí (1984) and Arroyo and Mora-Urpí (1996) could be supported by two accurate facts: spontaneous mutations and early techniques on plant breeding (domestication). Several small-fruited wild species could be progenitors of cultivated peach palm, since spontaneous mutations in small-fruited individuals occasionally give rise to larger fruits (Mora-Urpí, *et al.* 1997). On the other hand, it has been registered that indigenous communities used to select (breed) individuals with larger fruits to continue cultivating, a practice that would lead into the domestication of wild species (Grazón, *et al.* 1993).

Therefore, cultivated peach palm possibly came about from repeated domestication in the American tropics from different wild populations and the occurrence of some hybridization. The two events gave rise to great diversity of cultivars. Its later distribution by the Indians, the application of different criteria of selection by the natives and in some cases, the occurrence of new hybrids, gave rise to the formation of the peach palm populations having differentiating characteristics. However, each population includes considerable variations, that it may not be defined as a variety (Mora-Urpí, *et al.* 1984).

The domestication of peach palm has resulted in many different types, which have been defined as landraces. Each landrace appears to differ in fruit composition, as well as macromorphologic characteristics (Clement, 1988).

The wild population found in the immense area of the western Amazon Basin, northern Andean region and Central America (Martius, 1847; Antezana, 1972; Dugand, 1976; Clement *et al,.* 1989 *apud* Mora-Urpí *et al.,* 1997) are geographically separated by physical barriers such as rivers, mountains, dry and humid areas. They have experienced climatic changes that probably affected their geographical distribution and subsequent evolution.

It is not known when or where Native Amerindians began to domesticate peach palm. Stone (1951) cited by Mora-Urpí *et al.* (1997) proposed that a pre-Colombian Chibcha civilization introduced peach palm as a staple food item into Central America. Judging from seed remains found in Costa Rica, the Chibchas may have cultivated Peach Palm from 2300 to 1700 years ago (Ulloa and Mora-Urpí, 1990).

By the time the Spanish colonized the Americas, the fruit was a staple food of many Amerindian communities from Bolivia and Brazil to the lower Central America. The oldest reference found of Pejibaye dates from 1540 - 1546. The data points out limits toward the northwest of America where it was found by the Spanish conquerors. It refers to the actual territory of Costa Rica and Panamá by the Atlantic (Patiño, 1960).

During the American conquest period, the peach palm was described by several conquerors over the regions of Central America, the South American west coast; Atrato and Cauca´s basins and the Magdalena Valley in Colombia; the Amazon region, Orinoquia region and Guyanas. Ever since that period, uses of the Pejibaye palm were already known to indigenous inhabitants of those regions (Patiño, 1960).

Nowadays, the cultivated peach palm has a wide geographical distribution, it extends north from Mexico to some Caribbean Islands besides being present in the Amazon region (Brazil, Peru, Colombia, Venezuela), Guyanas and the Pacific Coast of Ecuador and Colombia (Mora-Urpí *et al.,* 1997).

2.2. Taxonomy

The peach palm first indigenous name registered by the Europeans was Pixbae. The scientific name *Bactris gasipaes* was given by Humboldt and Bonpland (Glassman, 1972 *apud* Clement, 1988) to the collected samples from Ibagué, Colombia in 1801, introducing to the Spanish vocabulary the word “cachipai” (Jardín Botánico del Valle “Juan María Céspedes”, 1979).

The cultivated peach palm is correctly referred to as *Bactris gasipaes Kunth*. Uhl and Dransfield (1987) the current standard, place *B. gasipaes* within the genus *Bactris* without defining a subgeneric category (Uhl and Dransfield, 1987 *apud* Mora-Urpí *et al.*, 1997).

Bactris genus belongs to the Kingdom: Plantae; Division: Magnoliophyta; Order: Arecales; Family: Arecacea. Because of its actual distribution, peach palm today involves a complex pattern of landraces as it was mentioned. It has been divided into Occidental and Oriental subcomplexes (Figure 2.3) based on vegetative differences and further divided into classes based on fruit size: the “microcarpa” landraces have small fruits (less than 20g), the “mesocarpa” landraces have fruits of intermediate size (20-70g), while the “macrocarpa” landraces have very large fruits (70-250g) (Mora-Urpí *et al.*, 1997).

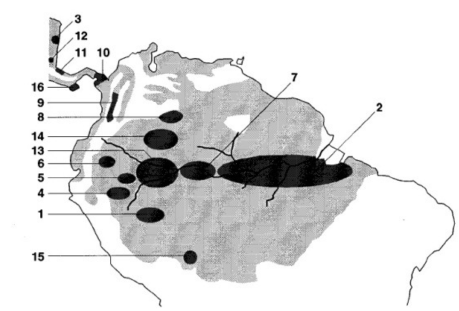


Fig. 1. Geographical distribution of *Bactris gasipaes* and its landraces: **‘microcarpa’** (1) Juruá, (2) Pará, (3) Rama, (16) Azuero; **‘mesocarpa’** (4) Pampa Hermosa, (5) Tigre, (6) Pastaza, (7) Solomões, (8) Inirida, (9) Cauca, (10) Tuira, (11) Utilis, (12) Guatuso; **‘macrocarpa’** (13) Putumayo, (14) Vaupés, (15)

Figure 2.3. Origin, domestication and distribution.
Source: Peach Palm Book. Charles Clement.

Bactris gasipaes Kunth, has a variety of common synonyms: *Guilielma speciosa* Martius, *Guilelma gasipaes* (kunth) Bailey, *Guilielma utilis* Oersted (Mora-Urpí *et al.,* 1997).

There are more than 200 vernacular names for *Bactris gasipaes kunth* (Patiño, 1960). The most common are: peach palm and pewa palm (Trinidad), *pejibaye* (Costa Rica and Nicaragua), piba (Panama) *pijiguao* and *macana* (Venezuela), *chontaduro* (Colombia and Ecuador), *pijuayo* (Peru), *tembe* and *palma de Castilla* (Bolivia), *pupunha* (Brazil), *parepon* (French Guayana) (Figure 2.4). The botanical epithet (*gasipaes*) is derived from the vernacular name used in the Magdalena River valley of Colombia (*cachipay*) (Mora-Urpí *et al.,* 1997).

Figure 2.4. Map of principal vernacular names.

2.3. Morphological description

Early studies performed by Mora-Urpí *et al.* (1984) determined that peach palm has a main stem and a number of shoots growing from its rhizome. The main stem together with the shoots form a clump. There is a bud at the base of each leaf that develops into a shoot if it is located at the base of the stem and into an inflorescence if it is in the aerial part. The stem may potentially produce an inflorescence and a new raceme of fruit for each leaf (Figure 2.5). Nevertheless, the palm only develops a number of inflorescences and racemes according to its nutritional condition.

2.3.1. Roots

As the plant develops, adventitious roots produce a thick, partially superficial mat that may extend 5 m around the plant (Figure 2.6-a). Most roots occupy the upper 20 cm of the soil horizon, although some primary roots may extend to a depth of 2 m or more, depending upon soils and presumably genotype (Ferreira *et al*., 1995 *apud* Mora-Urpí *et al*. 1997). Roots have mostly a lateral and superficial growth (Corpoica, 1996).

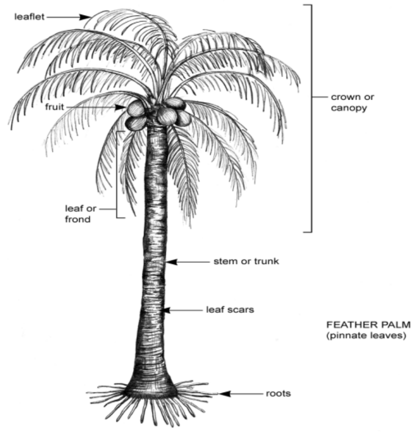


Figure 2.5. Morphological description.
Source:<http://itp.lucidcentral.org/id/palms/palm-id/fs_images/anatomy-feather-palm.png>

2.3.2.
Stem

The cylindrical, straight, unbranched stem reaches diameters of 10-25 centimeter, and it is about 25 meters tall, leaf scars represent nodes 2-9 centimeters long and internodes 7-27 centimeters long (Corpoica, 1996). Most peach palms have thorns on the stem internodes; when present, they number 1-97 per $16cm^2$, are usually dark in color and the majority are 3-14 cm long (Figure 2.6). Offshoots are managed for heart-of-palm, they arise from basal axillary buds and usually vary in numbers from 1 to 2. Apical dominance in the main stem controls the number of offshoots that develop into stems.

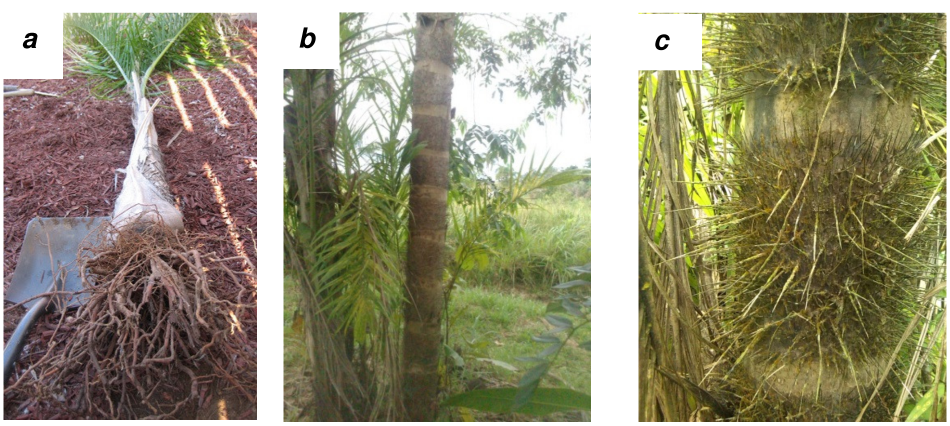


Figure 2.6. Morphological description. a) Peach Palm roots, b) Peach Palm Stem, c) Peach Palm Thorns.

2.3.3. Leaves

Figure 2.7 shows the leaf parts: The canopy has 10-30 pinnate leaves which have no thorns at all or have short thorns along the sheath, petiole and midrib. Thorns may also occur on the abaxial and adaxial midribs and veins, and along margins of leaflets. The petiole-sheath is 49-179 cm long, the rachis is 179-396 cm long, and has 180-386 leaflets. The bifurcated leaflets are 58-115 cm long, 3-6 cm wide, and are often fused basally and apically (Mora-Urpí *et al.*, 1997).

Juvenile leaves have pubescent leaflets which are fused along a reduced rachis. Multibranched inflorescences develop in the axil of the leaves. They are initially covered by two bracts. The exterior bract (prophyle) is hard and triangular, about 13 cm wide and weighs 50-875 g. The internal bract (peduncular) may have no thorns or have thorns that cover its entire surface or only the tip. The spathe, when fully developed but still closed, is 51-126 cm long, 6-18 cm wide, 2-15 mm thick and weighs 1-6 kg. The spathes internal surface is cream or light yellow. The peduncle is 10-17 cm long and rarely has spines. The rachis is 31-75 cm long, has 0-16 aborted rachillae and 25-145 fertile rachillae that are 16-47 cm long. Rachillae may be straight or curved. Rachis and rachillae are covered with trichomes. Bracteoles vary in length, diameter and shape (Mora-Urpí *et al.*, 1997).

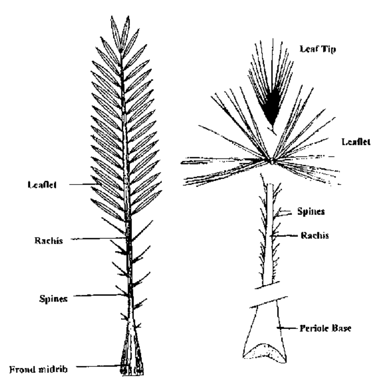


Figure 2.7. Peach Palm Leaves.

2.3.4. Flowers and Fruit

The Peach palm is monocots, with unisexual male and female flowers developing on the rachillae. Female flowers are irregularly arranged among male flowers (Figure 2.8-a). Male flowers are cream-light yellow, 2-6 mm long and 2-6 mm wide, with six stamens arranged in pairs on the sides of the corolla. Female flowers are usually yellow, or rarely green, 3-13 mm long and 4-12 mm wide. The gynoecium is syncarpous, trilocular. Occasionally functional hermaphrodite flowers are present, especially in young plants. Poorly differentiated, sterile flowers also may be observed (Mora-Urpí *et al.,* 1997).

The fruit is a drupe, usually shiny orange, red or yellow and may have superficial striations. The tip of the fruit may be rounded, angular or truncated. Dimensions are quite variable: length 2-7 cm, width 2-8 cm and weight 4-186 g. Color of the mesocarp varies from creamy white to orange. The number of mature fruits per inflorescence (commonly referred to as raceme or bunch) varies from 0-764, with total fruit weight 0-20 kg. Parthenocarpic fruits are common (average 21 per raceme) and generally slightly smaller than fertile fruit. The dark endocarp, containing the seed, is usually located centrally in the fruit, but may occur at the distal end. The endocarp varies considerably in shape and dimensions: ovoid, elliptic, round, oblong or cuneiform; length 1-4 cm, width 1-2 cm, weight 1-9 g. The endocarp has three pores, two usually above the equator and the third (the germ pore) farther away; it generally has flattened fibers on its surface, and these may be free from or adhere to the mesocarp. Seeds are recalcitrant and rapidly lose viability when dried. Germination is hypogeal. In peach palm, the endocarp with its enclosed seed is commonly known as the ‘seed’. The embryo produces a shoot and radicle, and the radicle is soon replaced by adventitious roots arising from the obconic seedling axis (Tomlinson, 1990 *apud* Mora-Urpí *et al.,* 1997).

Figure 2.8. a) Flowers and fruit, b) Fruit.
Source: <http://palmaoazis.blogspot.com/2011_11_01_archive.html>
Image by: Szabolcs Molnár

2.3.5. Cultivation and management

Cultivated peach palm is adapted to a wide range of ecological conditions, reflecting its wide geographical distribution in the humid tropics of Latin America. Its productivity is determined by soil quality, the amount of precipitation and an optimum temperature above 24ºC. Soils must be fertile and well-drained, at a range altitude below 800 m. Precipitation must be abundant but well distributed (2000 – 5000 mm/year). It produces relatively well on low fertility soils, highly eroded with 50% aluminium-saturated acid soils, but production decreases in the long term without additional nutrient inputs. It does not tolerate waterlogged soils (Janos, 1977 and Ruíz, 1993 *apud* Mora-Urpí *et al.,* 1997). Wild individuals of peach palm are generally scattered and isolated, or can be found at low density in small patches. Extensive natural stands of wild peach palm have not been reported (Mora-Urpí *et al.,* 1997).

In general, the peach palm reaches its maximum height at 4 years of planted under optimal conditions. Seedlings develop very slowly under forest shade conditions and mature plants require full sunlight for optimal production of flowers, fruits and offshoots (Table 2.1). For the extraction of palm heart, seeded and cut logs from 6 months to 2 years old. The fruit is extracted from 3 to 12 years old (Mora-Urpí *et al.,* 1997).

Table 2.1. Ecology and cultivate.

<table>
<tr><th colspan="5">Natural conditions of climate and soil for Peach Palm</th></tr>
<tr><td>Precipitation rate:</td><td>2000 - 5000 mm</td><td rowspan="2">Soil:</td><td rowspan="2">Clay loam to clay, including low fertility soils</td><td rowspan="2">Where grown better: In moist places without prolonged dry season, preferably down 900 MSL</td></tr>
<tr><td>Dry season:</td><td>0 - 4 months</td></tr>
<tr><td>Altitude:</td><td>0 - 1200 MSL</td><td>Texture soil:</td><td>Medium and heavy</td><td rowspan="4">Limiting factors: peach palm does not tolerate flooded soils. There are no genetically improved seeds. Most have thorns on stems and leaves making harvest difficult and dangerous.</td></tr>
<tr><td>T°Max Average Warm month:</td><td>28°C</td><td>PH soil:</td><td>Acid</td></tr>
<tr><td>Cold month:</td><td>18°C</td><td>Drainage:</td><td>Free</td></tr>
<tr><td>Annual average:</td><td>24° - 28° C</td><td>Slope Soil:</td><td>Planar or wavy</td></tr>
</table>

Note. From “Programa de Investigación Forestal”. Copyright by OFI/CATIE 2003.

2.4.
General uses

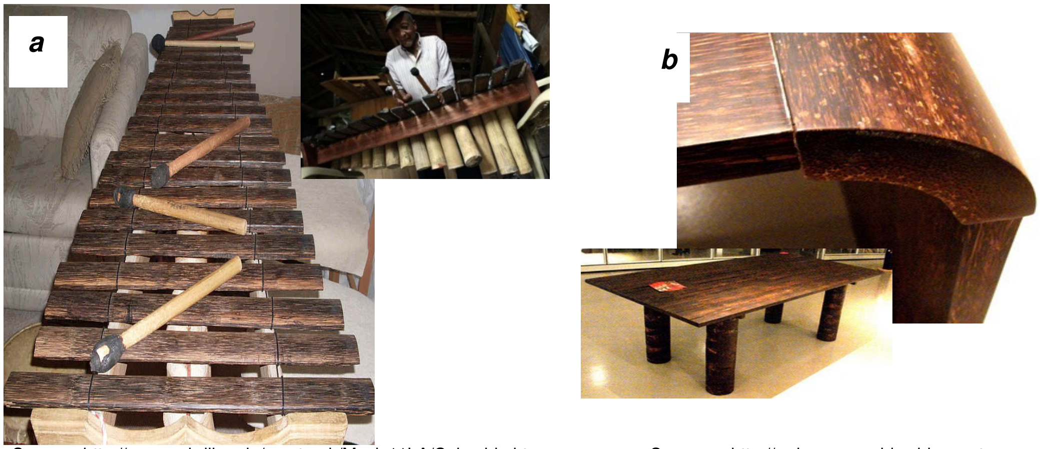
Peach palm provided basic staple food products for many Amerindian communities in Central and South America (Patiño, 1989). It was domesticated and introduced to social development (Figure 2.9) of the main core of Amazonian populations (Corpoica, 1996). Its importance was attributable to the nutritional value of the fruit, and the variety of foods it provided. Native Amerindians prepared peach palm fruits in various ways (Patiño, 1989). The simplest was to boil the fruit and then eat the mesocarp. A very common preparation was a beverage prepared by cooking the fruit, extracting the mesocarp, chewing it into a mash and then leaves it to fermentation over 24 hours (Pellizzaro, 1978 *apud* Mora-Urpí *et al.,* 1997).

Traditional preparations of the fruit have evolved over time, and some have significant commercial potential. To prepare a beverage, fruit is cooked, mesocarp is ground, sugar and water added, and the mixture is fermented for 1-2 days (Mora-Urpí *et al.,* 1997). In Colombia and Brazil, a similar beverage is prepared using the mesocarp mixed with milk, sugar and several condiments (Calvo, 1981).

Figure 2.9. Fruit and food.
Source:<https://www.mincomercio.gov.co/minturismo/loader.php?lServicio=Galeria&lFuncion=verAlbum&id=898&lTipo=user&tipoGaleria=fotos# >
Image by: Andrés Estefan Ramírez

Today, peach palm is associated to other family orchard that provides food. Chontaduro (the fruit) and heart-of-palm are consumed directly on a daily diet. Also, grown mature stems and leaves are used for the construction of farm houses (Corpoica, 1996). Nevertheless, uses have been given to the peach palm besides food. Many of its parts have also served indigenous communities as medicine and handcrafted construction. Some of the uses given to several structure parts of peach palm as well as the location have been reported:

Trunk: The trunk is used for the construction of houses in Colombia (Figure 2.10 and 2.11) Brazil and Peru, Furthermore, in many countries is used for making furniture, musical instruments and gifts (Rutter, 1990 *apud* Grazón *et al.,* 1993).



Source:<http://www.cabrillo.edu/~mstrunk/Music11LA/Colombia.htm
Image by: Michael Strunk.

Source: < http://rodomor-muebles.blogspot.com >
Image by: Rodolfo Morales.

Figure 2.10. Peach palm trunk for a) Musical Instruments, b) Furniture.

Figure 2.11. Peach Palm House in Colombia.

Roots: In Brazil, roots are used as an Anthelmintic (Wenzel, 1990 *apud* Grazón *et al.,* 1993).

Leaves: (Figure 2.12) Also used as food in Colombia; as paintings in Peru and to build houses in Brazil (Brooks, 1984; Duke, 1977 *apud* Grazón *et al.,* 1993).

Figure 2.12. Indigenous House, roof built with peach palm leaves.

Heart palm: (Figure 2.13) According to "Superintendência da Zona Franca de Manaus – Suframa" peach palm stands out as an excellent alternative, given its hardiness, earliness, tillering and excellent quality heart of palm for agro-business. There are more than 10,000 ha of peach palm crop for fruit extraction in Costa Rica and about 8,000 ha in Brazil. Brazil´s acreage concentration is in the North, and it goes up to 1,322 ha.

Figure 2.13. Heart palm of young peach palm.
Source:< http://palmasenresistencia.blogspot.com/2007/02/creador_20.html >Image by: José A. Grassia.

2.5.
Anatomy of palm stem – Anatomic Structure.

The stem serves the basic functions of mechanical support. The inner portion of a palm stem consists of a central cylinder of woody tissue and a narrow cortical region. Vascular bundles are distributed throughout the central cylinder, but usually concentrated toward the periphery. Each bundle has a fibrous mechanical sheath, but bundles toward the stem periphery have the most extensive sheaths. Consequently, strength and stiffness are concentrated toward the outer portion of the stem (Rich, 1986). The outer portion consists of narrow cortex that is composed of unspecialized ground parenchyma and fibrous or fibrovascular strands (Rich, 1987).

Developmental anatomy studies performed by Rich (1985; 1986) on two different species of palm stems *Welfia georgii* and *Iriartea gigantean* showed that vascular bundles were concentrated toward the stem periphery and peripheral bundles contained more fibers than central bundles (Figure 2.14). Sustained sclerification or process of formation of sclerenchyma (Tissue support of certain plants formed by dead cells at maturity), with major thickening of cell walls of fiber cells, accounted for dramatic increases in stem stiffness and strength for both species. Studies of developmental anatomy of the palm stem demonstrated the importance of secondary changes in the stem below the crown. Sustained cell expansion allows limited but significant stem diameter increase in many palm species. Sustained sclerification, however, results in major increases in stem stiffness and strength in all arborescent palms.

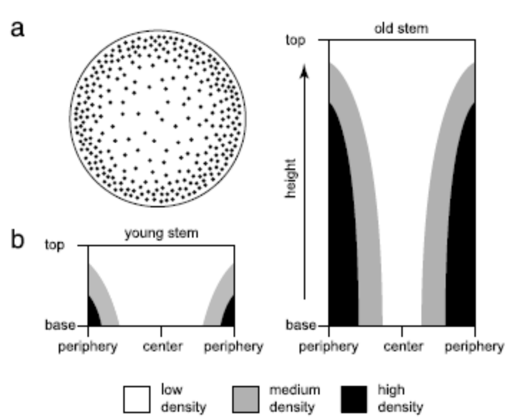


Figure 2.14. a) Schematic of the cross-section of a palm tree, a fiber composite with a radially varying volume fraction of fibres producing a radial modulus gradient. (b) Schematic representation of the distribution of the stem tissue modulus within a young palm stem (left) and an old palm stem (right) (after Rich, 1987b and West, 2011).

2.6. Bamboo and peach palms: functionally graded composite material

Another characteristic shared by stem of these two engineering-like materials, is that the distribution of their fibers aligned parallel to the stem is not uniform. Palms and bamboo have a radial density gradient of parallel fibres in a matrix of honeycomb-like cells, a feature that increases its flexural rigidity (Wegst, 2011).

A preliminary assessment of the mechanical behaviour of composite materials in the elastic range can be achieved using the rule of mixtures, which is a group of equations that gives the values of mechanical properties of composites based on the mechanical properties and the volume fraction of their constituents, fibres and matrix. As an example, eq. (1) shows how to establish the Young modulus for a composite knowing the values of the Young modulus of the fibres and matrix and their volume fractions.

$$Ec = E_f V_f + E_m V_m = E_f V_f + E_m (1 - V_f) \tag{1}$$

The hypothesis in the development of the equations of the rule of mixtures assumes long and aligned fibres, with a perfect bonding between fibres and matrix and uniformly arranged fibres inside the matrix. However, it is observed that both - area and distribution of fibres- are not uniform, varying through the thickness of the bamboo culms and palm trees. Many research works have demonstrated how Bamboo can be classified as a Functionally Graded composite material due to its fiber composition and distribution, which follows an organized pattern with higher concentration of fibers on the outer surface of the culm (Ghavami and Solorzano, 1995; Amada 1996 *apud* Ghavami *et al.,* 2003). According to Wegst (2011) peach palms have a similar arrangement of fibers around the matrix.

To make it possible to apply the equations of the rule of mixture to analyze bamboo and to study peach palms, it is necessary to modify these equations in order to consider the volume fraction variation of the fibers along its thickness. Admitting an “x” axis in the transversal radial direction of the bamboo culm and palm trees with its origin on the internal surface of the stem and its maximum limit at the external surface, the equations of the rule of the mixtures can be used in the form of eq. (2).

$$Ec = f(x) = E_f V_f(x) + E_m\left(1 - V_f(x)\right) \qquad (2)$$

Since the equations used to model the behaviour of composite materials assume uniform distribution of the fibres in the matrix, Ghavami *et al.* (2003) were able to apply the equations of the rule of mixture to analyze bamboo by considering the volume fraction variation of the fibers along its thickness. This equation can be used for the Palms tree, with a digital image of the cross section and help of new tools for digital image processing considering the function of the fibers relative to the thickness.

2.7.
Peach Palm as structural material.

Palms and bamboos are known to provide the most efficient materials when mechanical performance at minimum mass is sought (Wegst and Ashby, 2004 and Gibson *et al.,* 2010 *apud* Wegst, 2011).

They can achieve efficiency in three ways: 1. by using efficient composite materials, 2. by shaping the component into a tube and 3. by distributing the composites components efficiently, through property gradients (Wegst, 2011).

Gibson and Ashby showed that one of the great benefits of palms, apart from ecological advantages, is in its strength to weight ratio (Figure 2.15). Wegst (2011) highlighted the remarkable performance of palm stems and bamboo culms to survive severe weather conditions such as tropical storms. It seems the material they are made of allows them to elastically bend to a quarter circle without failure, which significantly reduces the wind loads in hurricanes. Both, palm and bamboo are fibre composites with an axisymmetric density. They are formed by sclerenchymatous fibre cells that form the important load-bearing fibre bundles. The fibres are embedded in the parenchymatous ground tissue; they lack a cambium through which radial growth can occur to provide support with increasing height. Instead, they rely on increasing the cell wall thickness and degree of lignification, and possibly a higher alignment of the cellulose fibrils with the fibre axis during cell wall thickening (Schoute, 1912 and Tomlinson, 1961, *apud* Rich, 1986).

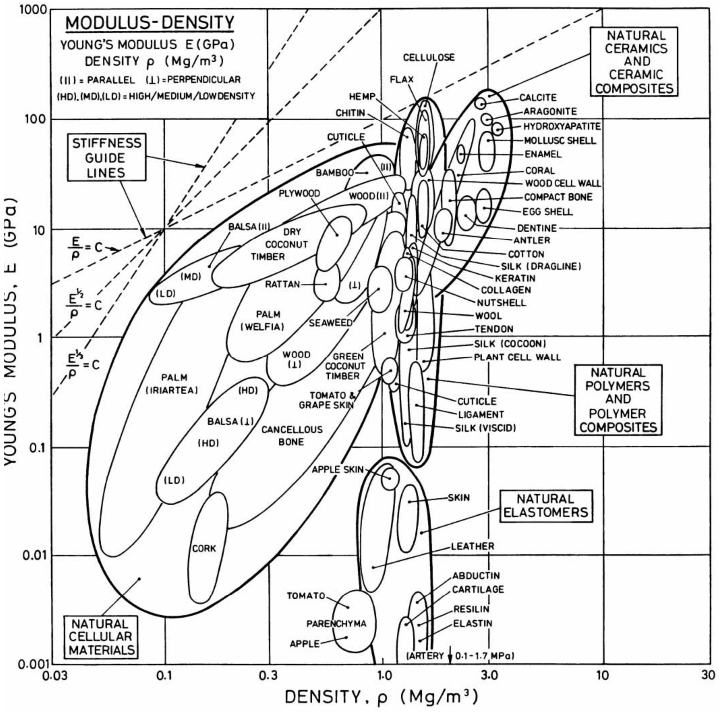


Figure 2.15. A material property chart for natural materials, plotting Young modulus against density. (M.F. Asby, et al (2004)).

It has been proved that bamboo scaffolding can compete with steel tubing due to its bending efficiency. Additionally, bamboo offers convenient advantages such as its relative low-cost, its abundance renewably material which also offers corrosion resistance, a property of great advantage in humid climates (Ghavami and Hombeeck, 1981; Liese, 1986; Ghavami and Culzoni, 1987; Ghavami, 1988; 1995a; Amada, 1996, Ghavami and Achá, 2011) like the ones of tropical regions where it is common to be found.

However the use of peach palm as structural material is limited to cultural traditions with little or no standardization. To develop sustainable building materials in engineering one should evaluate traditional construction techniques in terms of engineering standards and develop design methods to evaluate and improve structural performance (Harries, 2011).

In modern structural timber codes as Eurocode 5 and AF&PA/ASCE 16-95, ultimate limit state design is adopted and structural adequacy is assessed with characteristic values of both loading and resistance using appropriate partial safety factors. Among many physical properties that affect the strength characteristics of structural members, moisture content, specific gravity, slope of grain, elasticity modulus and defects are considered as the most important ones.