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Hearts of palm (*Bactris, Euterpe* and others)

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7.1 INTRODUCTION

The heart of palm is the large meristem of diverse palm species. It is pickled and bottled or canned for international commerce, but is often used as a fresh vegetable in areas where the palms are grown. It ranks among the favourite salads of South and Central America and also Southeast Asia. Heart of palm use goes back to pre-Colombian times in the New World. The indigenous tribes had multiple uses for it, i.e., direct consumption of the fresh 'cabbage' or heart itself or the fermentation of the palm cabbage sap as an alcoholic beverage. In Southeast Asia palm cabbages may be pounded and soaked to collect a starchy product that settles to the bottom upon standing. The starch is dried and used for breadmaking. Not all hearts of palm are edible: some are very bitter and some may actually be toxic, for example, the heart of *Orania* sp. (NAS, 1975) used for arrow poisons (Jones, 1984).

In this account, the focus is on the use of the heart of palm as a vegetable. Three major palms are extensively discussed because of their present economic importance: those of the genus *Euterpe* (juçara and açai) from Brazil, those of *Bactris* (pejibaye) of South and Central America and *Cocos* (coconut) in Southeast Asia. All three groups have provided the international market with as much as 25 000 tons of heart of palm valued at about $65 millions as of 1990. Brazil dominates the world market by supplying 85% of the heart of palm – extracted mostly from wild stands in the Amazon and in the southern states of San Paolo, Santa Catarina and Parana but cultivation has begun. Costa Rica has been cultivating pejibaye palms exclusively for heart of palm production and has now some 2000 ha planted. Southeast Asia (mainly Philippines and Thailand) have sporadic

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plantings of coconuts specifically for heart of palms but most hearts are from old palms being felled for replanting programmes. Large consumers of heart of palm have been France and the USA.

The above three palms typify three diverse types of taste in heart of palm. *Euterpe edulis* (juçara) has a distinct 'bite' favoured by the French market. The juçara has been replaced by *Euterpe oleracea* (açai) which also has a bite although not as strong. *Bactris* has a more neutral taste, although some varieties have a faint bite, a little less than *Euterpe oleracea*. Coconut typifies a sweet type favoured in mixed vegetable sautées and curries.

There are many local names for heart of palm, but the following are the major ones: Florida and Trinidad, palm cabbage or palmetto; South and Central America, palmito; Philippines, ubod; France, coeur de palmier; Spain, corazón de palma or col de palma; Portugal, curaçao do palma; Italy, cafaglione.

7.1.1 **Morphology and anatomy**

All palm hearts can be divided into three parts: the base, the cylinder and the free top (Bernhardt, 1987, Mora-Urpi, 1989a), all of which are edible. The **Cylinder** is a tube-like leafsheath enclosing the less developed petioles and leaflets, so called because it is shaped as an even cylinder until the point where it splits or opens and reveals the rachis and the free leaflets. The **free top** is the composite of the tender rachis and leaflets not enclosed or clasped by the cylinder. The **heart base** includes the enlarged bulbous mass of the tender portion up to the final curve at the beginning of the cylinder immediately after the last exposed heart base.

Palm hearts can be obtained from large mature trees, but the present palm heart technologies emphasize the use of shoots of juvenile plants from recent seeding or of suckers aged 12–36 months depending on the type of palm (Figure 7.1). The recommended size of the shoot to cut is about 7–11 cm whole stem diameter in order to have a standard 1.7–3.5 cm diameter range of the cylinder needed for canning. Single stem palms include *Euterpe edulis*, and *Cocos nucifera*. The multiple stem palms include *Euterpe oleracea*, and *Bactris* sp.

There are many other palms with very little or none of the desired long or evenly round cylinder such as the African oil palm, *Elaeis guineensis*; American oil palm, *Elaeis melanococca*; *Orbigyna* sp.; *Jessenia* sp.; *Acrocomia* sp.; and *Corypha* sp., but they are processed as heart of palm by slicing the bases into appropriate sizes. The African oil palm is notably triangular in shape (Zantua *et al.*, 1989).

The bases of the palm hearts have a coarse appearance with either a vertical or horizontal cut as the unorganized vascular bundles are cut. These resemble the cut section of bamboo shoots. Pejibaye, with its naturally yellowish tint and smaller diameter at the base, has a particular

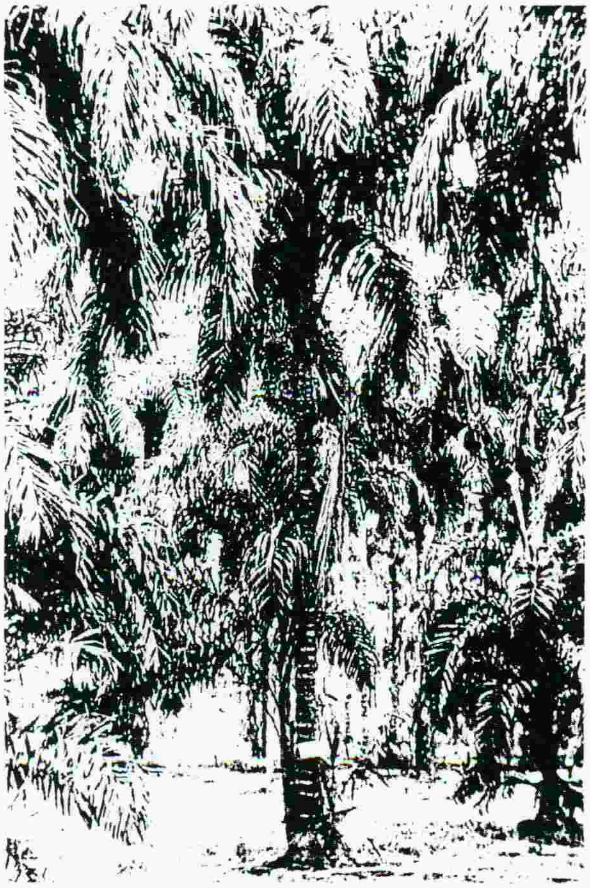

Figure 7.1

bamboo resemblance. The slight astringent taste and firm texture of the basal pejibaye make it a very good bamboo shoot substitute.

From the tops the rachis is sometimes used as a filler in canning because of its roundness. The leaflets often become disorganized and are set aside for animal feed, but are sometimes pickled.

7.1.2 Biochemical composition, nutritional and culinary values

Hearts of palm are relatively rich in protein (Table 7.1) as they are immature meristems, and contain 17 amino acids (Ferreira and Paschoalina, 1987). They are low in fats and sugars and are excellent diet fibre sources (Table 7.2). They are also a moderate source of calcium (Mora-Urpi *et al.*, 1991; Ferreira and Paschoalino, 1987) (Table 7.3).

Pejibaye shows a very low polyphenoloxidase enzyme activity (1.37 units/ml in cathecol of 0.2 M and 4.5 units/ml of guaiacol 0.0072 M) which is advantageous over juçara. Juçara shows a high polyphenoloxidase enzyme activity (41.7 units/ml) and also high peroxidase activity (13.4 units).

Table 7.1 Amino acids for hearts of palm of pejibaye and juçara expressed in g/100 g of dry matter

	Pejibaye	*Juçara*
Lysine	1.09	1.71
Histidine	0.36	0.52
Arginine	1.13	1.76
Aspartic acid	2.18	1.99
Threonine	0.78	0.90
Serine	0.92	1.24
Glutamic acid	1.50	1.56
Proline	0.86	0.99
Glycine	0.80	1.13
Alanine	1.03	1.19
Cystine	1.48	1.89
Valine	0.83	1.22
Methionine	0.28	0.36
Isoleucine	0.84	0.93
Leucine	1.46	1.56
Tyrosine	0.37	0.70
Phenylalanine	0.49	0.70
Tryptophan	0.47	0.35
Essential amino acids	6.24	7.73
Total amino acids	16.87	20.70

Source: Ferreira and Paschoalino, 1987.

Table 7.2 Chemical composition of the hearts of pejibaye and juçara palms

Components	*Pejibaye*[a]	*Pejibaye*[b]	*Juçara*[b]
Water(%)	90.47	88.40	90.81
Crude Protein (%)	2.27	2.32	2.18
Fat (%)	0.13	2.16	2.51
Ash (%)	0.93	1.21	1.35
Crude Fibre (%)	0.89	1.05	0.99
Total sugars (%)	2.7	35.80[c]	12.28
Ascorbic acid (mg/100 g)	14.0	3.20	11.6
Tannin	–	0.80	1.68
Organic acids	–	Lactic acid	Maleic acid
Cyanohydric Acid	–	3.73	0.95
Initial pH	6.58	–	–

Sources: [a] De la Asunción, cited by Mora-Urpi *et al.*, 1991;
[b] Ferreira and Paschoalino, 1987
[c] Expressed on the basis of dry matter of lyophilized material

Table 7.3 Mineral composition of hearts of pejibaye and juçara expressed in mg per 100 g of dry matter

Mineral	*Pejibaye*	*Juçara*
Phosphorus	94.0	68.0
Iron	4.3	3.5
Calcium	114.0	110.0
Magnesium	80.0	63.0
Sodium	1.33	4.17
Potassium	337.6	438.9
Copper	0.159	0.086
Zinc	0.79	1.38
Manganese	0.48	0.61

Source: Ferreira and Paschoalino, 1987.

This difference accounts for the rapid browning of juçara when cut and exposed to air. Pejibaye does not oxidize.

Comparing juçara and pejibaye, there are less reducing sugars in juçara which attests to its non-sweet flavour. This is also compounded by higher tannin in juçara (twice that of pejibaye) which gives the distinct astringent flavour to juçara. To add to flavour distinction, juçara has more maleic acid and pejibaye has more lactic acid (Ferreira and Paschoalino, 1987).

The colour reactions after heat treatment differ. Pejibaye turns creamy or yellowish when cooked and even its carrier solution turns yellowish. Juçara and coconut are whiter when cooked (Ferreira and Paschoalino, 1987). With months of storage pejibaye has a pronounced yellowish tint and juçara and coconut have a pinkish tint.

As to texture, pejibaye is firmer than juçara (Ferreira and Paschoalino, 1987), but this is easily corrected by more cooking time to make the pejibaye softer. The açai is also firmer than juçara. The pejibaye's firmness makes it more crunchy in salads than juçara. Juçara's tenderness or mushiness however, is preferred in some culinary preparations.

The coconut meristem has also been analysed and is also a good protein source (Bondad, 1978) and compares well with cabbage (Table 7.4) not only in protein, but also in carbohydrate. Crude protein can be as high as 11%. The coconut heart oxidizes fast and has to be soaked in a brine solution upon cutting, just like açai and juçara, to arrest oxidation. Its texture is also soft just like the juçara.

7.1.3 **Post-harvest technology and processing**

The heart of palm for international commerce requires few standards, and standards are not very rigidly imposed due to the problems of extraction in Brazil. Standards are, however, the basis for post-harvest practices and

Table 7.4 Nutritional value of coconut compared to cabbage

Value	*Coconut*	*Cabbage*
Protein (g)	4.3	1.10
Carbohydrates (g)	5.6	4.30
Fat (g)	0.8	0.20
Vitamin A (units)	0.0	100.00
Thiamine (mg)	0.5	0.04
Riboflavin (mg)	0.3	0.04
Niacin (mg)	16.0	35.00
Calcium (mg)	33.0	45.00
Iron (mg)	0.2	0.30

Source: Martin, 1984.

technologies. In Costa Rica the requirements for the palm hearts are: (a) white colour, (b) tender with low fibre and (c) a can of 220–225 g drained weight must have at least six sticks (trozos) (Mora-Urpi *et al.*, 1991; Astorga, 1989) of 10 cm long (9 cm long in Brazil).

These qualifications are often re-interpreted and white can mean a range from white to yellow, or does not oxidize to give brown or pink colour. Tender with low fibre can mean that the tissues crumble upon chewing, as opposed to hard which means that the fibres have become too lignified and resist chewing. The requirement of six sticks can mean diameters of 1.5–3 cm as a common range. More slender sticks akin to asparagus spears are now preferred. The ideal shoot or stem size could mean a circumference of 7–10 cm diameter or 20–36 cm circumference so as to give palm hearts of about 2 cm diameter, 40 cm long and weighing 150 g or more.

Upon harvest in Costa Rica the drying external sheaths (cascara I) are stripped from the shoot and left in the field, but one or two protecting sheaths (cascara II) covering the internal hearts are kept to minimize bruising damage during transit to the processing plant. These two protective sheaths are removed in the factory, prior to processing. All shoots must be at the processing plant within 24 h after harvesting. In Brazil as many as four sheaths are left to protect the palm heart due to longer distances of transportation. The quicker the shoots are processed, the higher the yields and the better the quality and the less the microbial contamination. As shoots are stored longer, they become more fibrous. Harvested shoots must also be kept in cool places to minimize dehydration.

Processing

Heart of palm processing is basically a pasteurization treatment to deactivate micro organisms. The heart of palms are sterile at cutting, but the

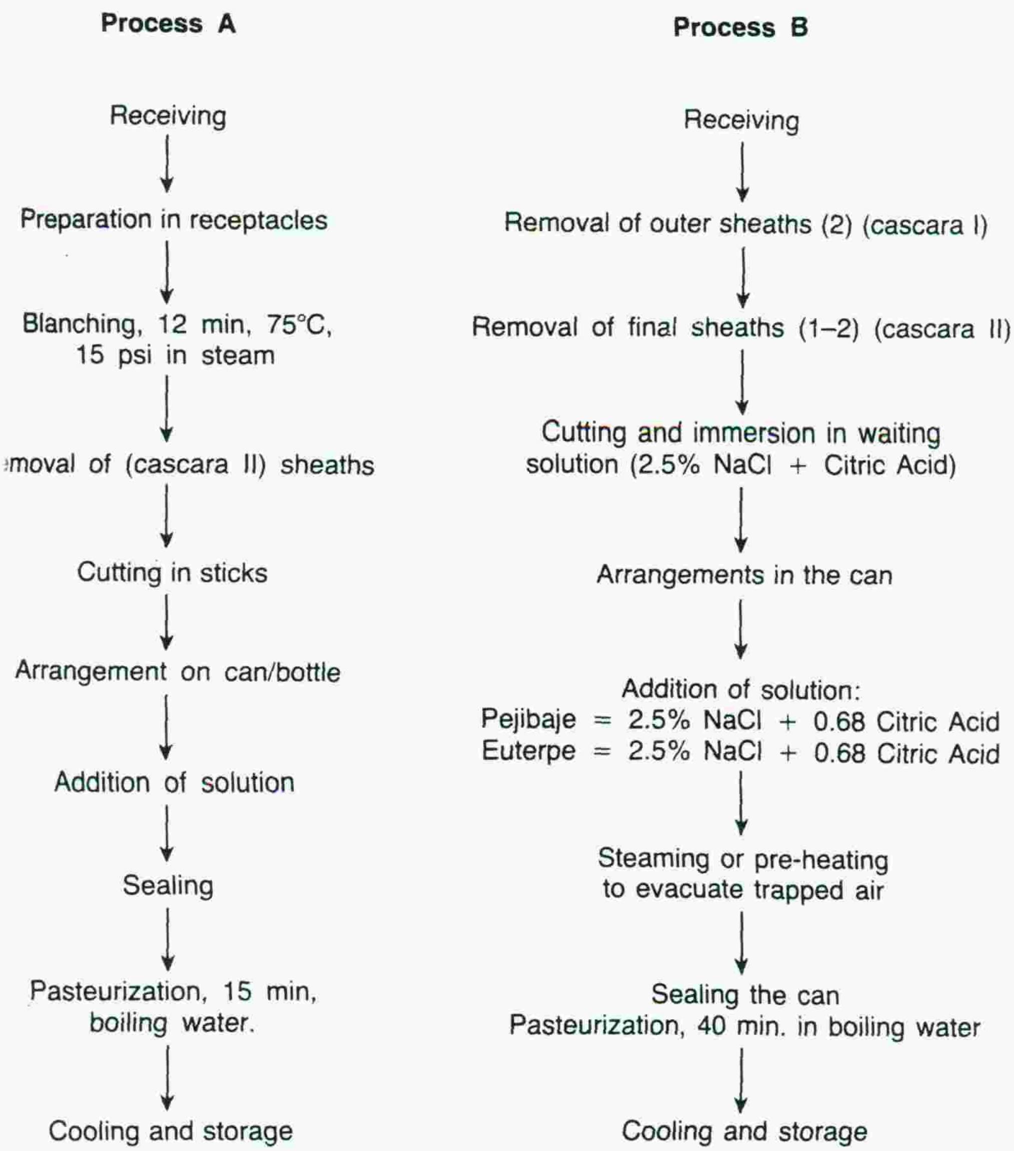

Figure 7.2 Two process flow charts for heart of palm treatment (modified from Ferreira and Paschoalino, 1987).

transport, storage and handling expose them to bacteria and fungi. As the heart of palm for international commerce is canned, pasteurization is carried out to ensure against botulism, a common canning problem (see Figure 7.2).

In Amazonia, small processing plants may have boilers which are fuel-wood fired and while water is being heated tne cleaners and cutters are working. Process A in Figure 7.2 pretreats the hearts at the beginning whereas process B has two heatings at the end of the process.

For bottling, the pre-heating can be missed from the process. The time of heat treatment can vary depending on the portion of the cylinder. In Brazil the cut portions are grouped into the more tender immature and the

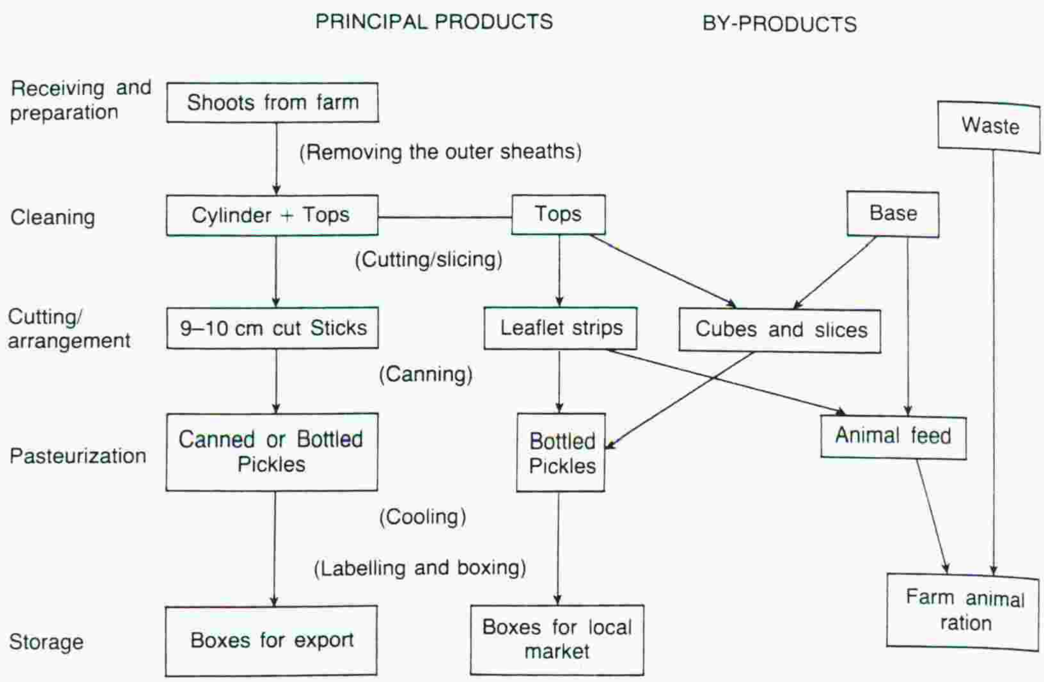

Figure 7.3 Principal products and by-products in processing.

slightly harder and more fibrous parts. The more mature and harder portions receive as much as 40 min in boiling water to soften the fibres. The products and by-products are shown in Figure 7.3.

In Costa Rica the final product is a 24-can box of 12 kg gross weight with a 5.28 kg drained weight of heart of palm. Some bottled hearts are also exported. In Brazil the product could be the same 24-can box of 12 kg gross weight or a 12-can box also of 12 kg heart of palm drained weight. Bottled products of all sorts are sold in the local markets.

Post-harvest and fresh vegetable presentation

Non-pickled heart of palm is widely used in Costa Rica, Southeast Asia, Sri Lanka and India. Thus fresh heart of palm can be obtained in the markets at any time. In C. America, pejibaye cylinders as well as small palm heart bases are packed in plastic bags and refrigerated. Pejibaye can last for 7–8 days in this manner, without any other treatment. In evacuated bags the pejibaye can stay white and fresh for 21 days at 10°C (Tabora *et al.*, 1991). In both cases the fibres progressively develop and palm hearts may become tough.

In Southeast Asia, the coconut is available in the markets as a whole shoot, some very large from mature trees and some very slender from juvenile plants. Restaurants particularly prefer the large ones to use the curved petioles for decoration. In the Philippines the coconut heart is cut into pieces and soaked in brine water to prevent oxidation.

7.1.4 **Trade**

World trade in 1990 reached $65 million. This included Brazil's exports of about $50 million followed by Costa Rica's $6 million (Mora-Urpi *et al.*, 1991). The balance comes from Colombia, Venezuela, Ecuador, Peru, Mexico, Argentina, Thailand and the Philippines. Some 25 000 t are exported from these countries (CECON-OEA, 1977). Trade has been growing erratically due to commercial extinction of jucara in 1985 and 1986 and environmental concerns for the Amazon acai in 1989. Some 85% of all hearts of palm traded come from extraction of primary forest stands. Nevertheless trade has increased in a general pattern since 1972 with shifts into new extraction areas and substitute palm species in Brazil, a gradual increase in plantations in both Costa Rica and Brazil based on pejibaye and an increase in demand. France has been the biggest importer (4500 tonnes), consuming roughly 63% of Brazil's traded heart of palms in 1988. The USA (1000 t), Spain (576 t) and Italy (227 t) are the next big three in growing importance as volumes and value of total imports have tended to increase by about 75–90% annually since 1975. Southeast Asia has decreased its share of the market even though it offers much lower prices. Local markets supply sliced hearts of palm. Many non-exporting countries such as Guatemala, Belize and even the major exporters such as Costa Rica and the Philippines serve basal meristem slices in a myriad of preparations such as sticks, cubes, gratings and decorative slices in pickles, sautées, mayonnaise and vinegar-dressed salads.

Local consumption is high in Brazil, about 80% of its total production or about 80 000 t. All of this is in pickled form, in the cylindrical shape. Local markets in Costa Rica carry the bottled pickled cylinders and also the slices in both bottles and plastic bags. Fresh hearts of palm are neatly packed in transparent plastic bags and show up in supermarket refrigerators. The Southeast Asian markets carry whole fresh shoots, which are used as garnish for local curry and vegetable sautées to substitute for bamboo shoots.

7.1.5 **Farmers' perception of the crop**

Pejibaye farming for palm heart has been increasing, through small and medium-scale farmers, in Costa Rica at a faster rate than with large farms of over 100 ha (Zamora, 1990). The crop's labour intensiveness lends itself to smaller farming schemes. In Colombia (Lozano, 1990; Velasco, 1989), however, large-scale farming is being implemented, using banana farming technologies to transport the stems via cableways to central processing centres.

Brazil, Ecuador and Bolivia have also been increasing their plantations. These are recent plantings (since 1985). Local income compared with coffee and banana puts it in a very attractive position (Tabora, 1987). Its cultural requirements are much less demanding than either coffee or bananas with less problems of pests and diseases as well as less fertilizer needs. The present gross income of $9000/ha/yr is higher than coffee and the market has had less fluctuations. Compared to banana, pejibaye heart of palm show less investment requirement and just as good rates of returns on investment.

There are some problems. Pejibaye needs good drainage and Costa Rican farmers already feel this is a limitation on their farms. It is also estimated that some 76% of the farms have problems with rodents attacking the young shoots.

Juçara and açai farming in Brazil has been recent. The State of São Paulo has already initiated formal plantations. Açai has been growing very well in the São Paulo State (Salles de Aguiar, 1987) and plantations are being developed even while waiting for new hybrids. In the Amazon, açai plantings have been in association with cacao and other crops (Calzavarra, 1987) with açai as a shade tree. Açai has been observed to yield three times more than juçara (Bovi *et al.*, 1987) but this yield has also been superseded by pejibaye (Clement, 1988; Moreira Gomez and Arkcoll, 1987). It seems that heart of palm is quite lucrative in Brazil and both extraction and formal farming are ongoing.

Southeast Asia's coconuts are abundant at all stages. While farming of the juvenile palms for hearts is being done, there is competition of hearts from old plantations under replanting. Thus, farming for palm hearts has not prospered in Southeast Asia except in the vicinities of large urban areas, such as Manila and Bangkok, which provide big markets for the fresh heart of palm.

7.1.6 **Future potential and the role of various palms in different regions**

Heart of palm farming will be a regular feature in the future as palms become scarcer in such places as Brazilian, Venezuelan, Colombian and Peruvian Amazonia where some 85% of all hearts of palm are now being extracted. Farming will also follow the increasing world demand as the heart of palm becomes more accessible. Furthermore as technology is developed palm heart farming could be more productive and lucrative even as prices are reduced. New palms may be brought in for this purpose (Appendix). The royal palm has that potential and recent tests in Honduras show it could yield as much as 5.2 t/ha as a 13 month crop. Granting a 4 ton yield/crop/yr this is more than twice the normal commercial yields of pejibaye. Nevertheless, recent Costa Rican experimental results for pejibaye have also yielded as much as 3 t/yr, twice the present farm yields, and this could already be a competitive crop yield at lower costs (Vargas, 1991). It is expected that pejibaye, juçara, açai and even royal palm will have new technologies as a result of new breeding and cultural managements and they will exceed present yields and profitabilities. Each region will perhaps have a more preferred palm due to edaphic and climatic limitations as well as type of agriculture. In Brazil, an agroforestry scheme combined with the management of existing stands, will become a major need and the model in Santa Catarina may be adapted for this purpose.

It is clear that heart of palm competes with asparagus, bamboo shoots, and certain tubers. While this may be true to a certain extent, the heart of palm has its own distinct appeal. Its slightly astringent taste and crispiness stand out as unique for appetizers. Neither asparagus nor bamboo shoots match it. Asparagus has a chlorophyllous flavour which is not found in the heart of palm. In mixed vegetable salads, the heart of palm will also be useful, but there is no direct substitution function here. Mixing is a matter of form, colour, taste and texture.

New products are expected to increase consumption of heart of palm in the world market, such as slices and juliennes mixed with other vegetables. Fresh rather than canned palm hearts are also expected to enter the world market. Markets in Florida, USA, offer fresh palm hearts and this market can be tapped readily. Florida uses both the royal palm and the sabal palm for this.

The main determinant will be producing the hearts of palm competitively. The Pará, Brazil, industry produces a box of 12kg gross (or drained weight of 6 kg heart of palm) at a cost of $4.20–4.80 for the raw heart of palm, $4.20 for canning (labour, materials and energy), $5.40–6.00 for management overheads and marketing, $3.60 for amortization and about $1.00 for taxes. This brings a total cost of $18.40–19.60 per box. The São Paulo, Brazil, industry pays $6.20–8.00 per box for the raw material and Costa Rica pays as much as $9.33 for the equivalent heart of palm (based on $0.26 per shoot × 1.5 shoots/can of 220 g × 5.28 kg net weight of palm heart/box). Costa Rica trades off with a more efficient and lower cost management due to full integration of production, processing and marketing. No doubt, the future will depend on technological efficiency for Costa Rica and for greater integration for Parã and São Paulo to compete in the world markets. There is also room for improvement in canning and packaging costs. If these happen, hearts of palm can be within reach of a much greater number of people.

7.2 PEACH PALM (PEJIBAYE)

With recent technology development, peach palm has become the pre-eminent heart of palm under cultivation (Zamora, 1989) and has shown agribusiness profitabilities better than those of *Euterpe* sp. trials in Parã

(Moreira and Arkcoll, 1987). Its flavour has been adjusted to customer tastes and as a cash crop it compares favourably with coffee and banana (Tabora, 1987).

7.2.1 **Taxonomy, ecology, and history.**

About eight different species of *Bactris* are recognized at present (Clement, 1988), but full inventory and classification still remains to be done. The pejibayes of Costa Rica are classified as a sub-genus *Guilielma* ($2n = 28$), with four species. It is theorized that the diverse taxa in as many as 11 countries are derived from the Peruvian–Bolivian Amazon's *Guilielma microcarpa*. Clement proposes the following classification:

B. gasipaes Humboldt, Bonpland and Kunth
  Syn. *G. speciosa* Mart.
  Syn. *G. utilis* Oersted
  Syn. *G. chontadoro* Driana
  Syn. *G. microcarpa* Huber = *B. dahlgreniana* Glassman
B. insignis (Mart.) Baillon
B. ciliata (Ruiz & Pavon) Mart.
B. macana (Mart.) Pitter
B. caribaea Kaisten

Peach palm is found in Bolivia (tembé), Peru (pijuayo), Colombia and Ecuador (cachipay and chontaduro), Brazil (pupunha), Panama (pibá), Venezuela (pijiguao), Trinidad (peach palm), Costa Rica and Nicaragua (pejibaye), French Guiana (Paripon) (Pinheiro and Balick, 1987) and Honduras (chúpa o súpa). Most stands occur below 900 m elevation in very humid tropical regions with temperatures above 22°C and rainfall between 2000 and 5000 mm. The palms grow on varied soil types but always with good drainage. They can tolerate acid soils and have high mycorrhiza associations (Clement, 1988).

Peach palm is South America's most utilized native palm and its use is ancient as a source of food (oil and starch) from the fruits and later as a vegetable from the heart of palm. Its multiple use is probably the reason for its widespread distribution and diverse ecotypes (Balick, 1984). Its popularity diminished during colonial times but has recently surged since the 1970s as research proved it to be a good food and the basis for profitable enterprises. New uses have appeared as flour, feedmeal, cooking oil and the trunks have craft value.

7.2.2 **Morphology, growth and development**

The plant is caespitose (clumping) with a fibrous root system and spines cover some internodes but these alternate with nodes without spines.

Table 7.5 Nutrient-removal of heart of palm from pejibaye based on 3200 hills/ha and a production of 9000 heart of palm stems/ha/yr in La Rita, Costa Rica, 1989

	Nutrients removed in kg/ha/yr				*Proportion of nutrients removed*	
Elements	*leaves*[a]	*Gross wt.*[b]	*Total*	*Net wt.*	*Gross wt. (%)*	*Net wt. (%)*
N	503.000	28.000	531.000	8.650	5.270	1.630
P	33.100	4.800	37.900	1.340	12.660	3.530
K	217.300	31.000	248.300	5.760	12.480	2.320
Ca	60.100	4.700	64.800	0.880	7.250	1.360
Mg	39.100	3.900	43.000	0.770	9.070	1.790
Fe	1.200	0.030	1.830	0.006	1.640	0.330
Cu	0.163	0.021	0.184	0.004	11.410	2.170
Zn	0.204	0.050	0.254	0.011	19.680	4.330
Mn	2.189	0.085	2.274	0.014	3.740	0.620
S	43.870	3.360	47.230	0.672	7.110	1.420
B	0.528	0.029	0.557	0.004	5.210	0.720
Cl						
Al						

[a] leaves and outer sheaths
[b] net weight of heart of palm + by-products + inner sheaths.
Stem diameters at 8–9 cm.
Source: Herrera, 1989.

Leaves are large, 2 m in length and with 200 leaflets or more. Every axil gives rise to a shoot or a flower bunch. When cut at the base, shoots are formed. When the tree is left to grow tall, there is no sucker profusion. Thus, when cultivation is for fruits, it cannot be a heart of palm source.

Seedbeds can be used to germinate seeds, but direct planting in bags is also recommended. Germination begins 45 days from seeding and concludes after 60 days. At present tissue culture plantlets are not yet available, thus seeds are used extensively. Sucker separation has been tried (Blaak, 1980) but this is too cumbersome and less successful. Beds and bags must be moist and seeds must have at least 40% humidity. Germination can range from 75%–99% with better results in bags.

Planting distances are at 2 × 1 m or 1.5 × 1.5 m (Mora-Urpi 1989c). At six months plants are ready for transplanting. At 12–18 months after transplanting the first harvest can be done. Subsequently three stems can be harvested per clump/year giving about 15 000 stems harvested/ha/year. Six stems are allowed to grow at any one time.

The first eight months after establishment require rigorous weed control as the field is open. After eight months the leaves begin to close up and weeding becomes minimal. Fertilization depends on soils and climate but as a general guide, heart of palm production requires high nitrogen. The nutrient removal (Table 7.5) and recycling scheme are good bases for fertilizer recommendations.

For the Atlantic coast of Costa Rica where the soil has been analysed (Herrera, 1989; Sancho and Lopez, 1990) the recommendations for fertilizers/ha/yr are 200–220 kg N; 20 kg P_2O_5; 160–200 kg K_2O 50–100 kg Mg; and 400–500 kg Ca.

7.2.3. **Pests and diseases**

The four major pests in Costa Rica are:

1. the sugarcane weevil (*Mitamasius hemipterus*);
2. the basal stem beetle (*Strategeus aloeus*);
3. the foliage mite (*Retracus johnstonii*) (Mora-Urpi *et al.*, 1984);
4. the nibbler (*Orthogeomys cherriei*) (Delgado, 1990).

The best ways to avoid these pests are by ensuring there is no sugarcane or banana nearby (for the weevil), applying a chlorinated insecticide on the holes and closing them (for beetle), and spraying wettable powder of sulphur (3–4 lbs/50 gal water) for the mite.

The diseases of pejibaye are:

1. *Pestalotiopsis* sp., oval or round yellow spots on leaves having a necrotic appearance;
2. *Mycosphaerella* sp., round light brown spots surrounded by dark brown borders and by a well-marked yellow border on young and old leaves;
3. *Colletotrichum* sp., irregular spots surrounded by small yellow borders for young seedlings and these lesions open up the way for *Erwinia* sp., which cause rotting of medula and give a bad odour; and
4. *Phytophthora* sp., rotting of the base of leaves which turn yellow at the tips and also produce a bad smell (Mora-Urpi *et al.*, 1984; Vargas, 1989).
5. A nursery disease of seedlings in Brazil is *Ceratocystis paradoxa* (Bovi *et al.*, 1987).

7.2.4 **Yields and economic profile**

Recent advances have shown that pejibaye can yield 1.76 t/ha (Mora-Urpi *et al.*, 1991) in commercial fields. As younger shoots and smaller hearts are now preferred, cultivation is also changing. With higher densities, experimental yields have gone up to 3 t/ha/yr (Zamora, 1990), beginning the third year. Cannable yields have been only 30%, but it is only a matter of time for better cannable yields with improvement in cultural management. If this happens, pejibaye for heart of palm will be a very lucrative crop.

In 1984 the estimates on gross income for pejibaye heart of palms was $4400/ha. This had doubled to $9000/ha in 1992 even when prices dipped

40%. The increase is due to new technologies allowing the harvesting of thrice more stems from the same area. With $9000 per ha/year gross income, heart of palm is already earning more than coffee.

7.2.5 **Genetics and breeding**

Three major germplasm collections exist in Brazil (Manaus), Colombia (Vallecuacano) and Costa Rica (Guapiles) and they should be good bases for breeding. Costa Rica has organized an intensive research programme breeding palms for greater vigour (faster growth) and longer cylinders for hearts of palm. The Putumayo race (Mora-Urpi, 1989b) with less spines is close to the ideal, but its suckering has to be improved. At present there are data on allozyme variation of pejibaye which should be a basis for breeding. The University of Costa Rica and the Organization for Tropical Studies have a collaborative project with the University of Washington for this purpose.

7.3 *EUTERPE EDULIS* (JUÇARA) AND *EUTERPE OLERACEA* (AÇAI)

7.3.1 **Taxonomy, ecology and history**

There are 29 species of the genus *Euterpe* (Bovi *et al.*, 1987). Three are important ones for palm hearts. *E. edulis* Mart. is a single-stemmed palm distributed along the southern seacoast of Brazil (São Paulo, Santa Catarina and Paranà). *E. oleracea* Mart. occurs in the Amazon region of Brazil and *E. precatoria* occurs on the Peruvian–Brazilian–Colombian borders (Calzavarra, 1987 and personal communication).

The two most important Euterpes are juçara and açai. Juçara has been decimated in its natural stands in Brazil due to over gathering for commercial purposes and the extreme popularity of the heart of palm that led to such excessive extraction (Arkcoll and Clement, 1989). Juçara plantations have been slow in coming as juçara is a slow grower. Its need for shading means that it cannot be grown alone in plantings but needs a form of agroforestry not yet developed. In natural vegetation in 1987, *E. edulis* had a density of 0.66 palms per m^2 in different stages of development (Bovi *et al.*, 1987) with some 620 harvestable shoots/ha (Kirchner *et al.*, 1987). The palm can live up to 50 years (Bovi *et al.*, 1987) and produce 3000 seeds from three inflorescences per year beginning in the sixth to eighth year. The most critical period for survival seems to be to the first 50 cm stage when young plants compete for sun, water and nutrients.

The climate of the São Paulo seacoast, where there are large juçara populations, has high rainfall (1400–2800 mm), with temperature ranging from 20–23°C. On the more elevated (700–900 m) ranges of São Paulo State, the rainfall is 1300–1500 mm, but is well distributed, with temperature about 18–20°C. In places with high humidity some populations exhibit 6–11 palms per m^2 density. The soils where these palms are located are low in phosphorus, K, Ca and Mg with pH 4.1–5.6 and high organic matter.

7.3.2 **Morphology, growth and development**

Juçara germination takes up to six months to complete. The seeds have a hard endocarp that inhibits the penetration of water to the embryos. Depulping and soaking the seeds for two days reduce the germination time to 35 days and increase the percentage of germination from 53.19 to 91% (Bovi *et al.*, 1987). Açai is faster to germinate (30 days) and loses viability fast (Calzavarra, 1987). Seed storage is possible for juçara up to five months by bringing down the temperature to 5–10°C and raising humidity. Best results are obtained by using hermetically sealed containers with seeds fully imbibed at 5–10°C (Bovi *et al.*, 1987).

Seeding is done directly in plastic bags or in shaded beds for germination, and transplanting is done before or after one leaf has developed (Nodari *et al.*, 1987). Direct planting is not recommended (Calzavarra, 1987). The germination beds are made of four parts organic matter, three parts compost, one part fine sawdust and one part ash, mixed together.

Recent techniques using somatic embryogenesis in tissue culture have shown that it is possible to mass propagate clones of *E. edulis* (Guerra and Durzan, 1992), but there is still a long way to go before the technology is down-streamed (Guerra *et al.*, 1987). General protocols for the establishment of *E. edulis* were proposed by Guerra and colleagues in 1987.

Phosphorus and potassium fertilization increase the number of leaves, girth and height of palms. Foliar nitrogen fertilization is not recommended as it accentuates leaf enlargement which makes plants susceptible to water stress. Apparently, mycorrhizas are involved in juçara seedlings and they are of the vesicular-arbuscular type; although this is not readily observed in açai (Bovi *et al.*, 1987), they are important (Balick, unpublished).

Larger plants 50–100 cm in height survive better than 10–20 cm (two-leaved) plants during transplanting. Bare root planting of large seedlings does not do as well as roots with soil. Plants with pruned leaves survive better than those with full leaves. Shaded plants have a higher survival (99%) than those with half shade (89%). Planting distance is recommended at 1.5 × 1 m and 1 × 1 m to obtain yields of 2.905 tons and 2.496 t/ha respectively (Bovi *et al.*, 1987) after three years.

Temporary shading is provided through temporary intercropping; permanent shading means an associated crop or a mixed culture system. Bananas are a good temporary shade for juçara for three years. *Gmelina arborea* and *Mimosa scarabella* are good permanent shades. Interplanting with *Hevea brasiliensis* also seems viable (Bovi *et al.*, 1987). For *Euterpe oleracea* shading does not seem to be a major requirement.

7.3.3. **Pests and diseases**

The most important insect pest is *Rhyncophorus* sp. which deposits it on the young unopened leaves. The larvae eat the tender leave proceed toward the meristematic apex, killing the plant (Bovi *et al.*, A fungus disease, *Colletotrichum* sp., attacks açai seedlings and loss be up to 70% in nurseries. Hybrids have demonstrated resistance disease (see below).

7.3.4. **Breeding**

At present a breeding programme at Campinas, São Paulo, has achi hybrid between *Euterpe oleracea* and *E. edulis.* (Bovi *et al.*, 1987). This i being evaluated and initial results point to improved hybrids, wit susceptibility to anthracnose (*Colletotrichum gloeosporioides*) especia the seedling stages; however, anthracnose is easy to control with fung such as Bentlate and Dithane.

7.3.5 **Yields**

The yield from plantings of juçara, açai and the hybrid, in São Paulo years after planting, are shown in Table 7.6.

A yield of 2.95 t/ha at three years for juçara means 1 t/ha/ye commercial heart of palm. The hybrid (also three years old) has twi yield with 6.15 t/ha or 2.05 t/ha/year. Açai yield is not easy to calcul suckers and needs more time to allow the suckers to be harvested c long period.

7.3.6 **Exploitation of wild stands and agroforestry**

With the rapid decimation of juçara in Southern Brazil, the estuary (Amazon has given rise to the new palm heart industry based or (Calzavarra, 1987; Strudwick and Sobel, 1988). Açai has long been us

Table 7.6 Yield indicators of 3-year-old *Euterpe* at Campinas, San Paolo

Indicators	*Juçara*	*Açai*	*Hybrid*
Gross weight of stem (kg)	9.07	4.14	12.59
Net weight of cylinder (g)	443.00	132.43	923.29
Weight of base (g)	146.57	100.85	437.57
Length of cylinder (cm)	41.42	33.57	51.29
Diameter at middle (cm)	3.51	2.25	5.00
Number of cylinders/ 0.5 kg can	1.01	3.04	0.48

Adapted from Bovi *et al.*, 1987.

produce a popular beverage and the Indians of the estuary collect the fruits from protected palms around their houses and concessions. Thus, fruiting trees are not felled. Açai has suckers which are collected when 3–5 years old and big enough to produce 100–150 g cannable cylinders. The buyers normally tell the local people that they wish to buy the açai palm shoots and will pick them up for delivery, usually the following morning, to transport to the processor. (When the tide is low the delivery is postponed until the river swells.) As the shoots can be already three days old, portions tend to become fibrous and this has led to complaints of 'hard' palm hearts. This is corrected by segregating the harder portions for more heat treatment to soften the fibres.

This exploitation of açai by the Amazon natives for dual use has become more stable (Anderson and Jardin, 1989) but the increase in demand and number of processors poses a threat to the fragile ecological balance. A sudden rise in prices of the palm heart shoots could mean the felling of older trees meant for fruit production and general scarcity for a number of years. Thus there is a need to develop schemes for sustainable exploitation and renewal of the populations using agroforestry schemes. There are some trials being done near Florianópolis in Brazil to regulate harvesting and to incorporate some replanting under forest conditions. The scheme is now over 16 years old and seems to be working, but the model is built on a large (5000 ha) hacienda.

Schemes for smallholders need to be developed. Anderson (1988) studied the commercial products sold in a year by a simple family living in the Ilha das Onças region near Belem, Brazil. He found that some 35 026 hearts of *E. oleracea* were extracted during this time, representing $US 2917 in income. At the same time the family harvested $15 533 worth of fruits from this same species (78 885 kg of product). Together these two products accounted for 75% of the product sold by the family. Management systems derived by local people allow for the sustainable production of palm heart in this region of the world.

7.4 COCONUT (*COCOS NUCIFERA*)

Pickled, canned hearts enter international commerce. These are hearts from very old palms (100 years or so) being replaced with new plantings in the Philippines and Thailand (Tabora, 1976). Much of the information on agronomy and yield is available in the literature and is not repeated here.

7.4.1 **Taxonomy, ecology and history**

Cocos nucifera is a single species with many variants and is an ancient cultigen. The most preferred hearts of palm are from the green varieties which are sweeter, whiter and oxidize less. Yellow varieties are less sweet, have an off-white colour and oxidize more. In Southeast Asia the coconut covers large tracts of lands (3 million ha in the Philippines and another 3 million in Indonesia) on diverse soils and varying climates, normally along seacoasts. Some coconuts are even found in swamps, but water-logging makes coconut unproductive for fruits, the reason they were domesticated.

7.4.2 **Growth and Development**

Near large urban areas of Manila and Bangkok, coconuts can be found as small dense plantings of plants very close to each other: 25 × 100 cm or to 50 × 200 cm. The large seednuts are pre-germinated. The ground is simply cleared (no other land preparation) and the nuts lined up one after the other with the shooting edge upwards. It is not necessary to bury the germinated nuts, but, to secure them, they are half-buried by opening a 12 cm trench and lining up the coconuts at spacing of 25 cm.

Experimental plantings at FHIA in Honduras showed that coconut can produce 2.24–3.63 tons of heart of palm (Zantua *et al.*, 1989) in one year taking into account both the cylinder and the basal heart. About 40% of the weight is the industrial cylinder but this does not possess a structure useful in canning.

In La Lima, Honduras coconuts fertilized with 400 kg of N/ha/year respond significantly better than those with 200 kg of N/ha/year. The palm with 600 kg/ha/year did no better than those with 400 kg/ha/yr (Table 7.7).

Table 7.7 Yield (t/ha) of 18-month-old coconuts, 12 months from transplanting with nitrogen fertilization, La Lima, Honduras, 1989, at three densities

	Nitrogen (kg/ha/yr)			*Effect of density*
Plant density/ha	*200*	*400*	*600*	*(average)*
	Aerial parts (t/ha)			
10 000	110.5	103.0	126.0	113.2[a]
20 000	136.5	161.5	161.0	153.0[b]
30 000	187.5	207.0	210.0	201.5[c]
Effect of N	144.8[d]	157.2[e]	165.7[e]	
	Heart of palm yield (t/ha)			
10 000	1.68	1.99	2.44	2.04[a]
20 000	2.35	2.77	2.77	2.63[b]
30 000	3.05	3.53	3.63	3.40[c]
Effect of N	2.36[d]	2.77[e]	2.95[e]	

Randomized block with four replicates. Interaction of density and nitrogen not significant; averages with the same superscripts are not significantly different (0.05).
Source: Tabora and Ramirez, 1991.

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Randomized block with four replicates. Interaction of density and nitrogen not significant; averages with the same superscripts are not significantly different (0.05).
Source: Tabora and Ramirez, 1991.

7.4.3 **Utilization**

Coconut hearts are used as a fresh vegetable slice with flavoured dips in the Philippines. They are also julienned in Indonesia for the peanut-flavoured gado-gado. In Thailand the petiole base is used to carve designs for sautéed vegetables. In Malaysia slices go into curried vegetables. A favourite dish in Southeast Asia, the eggroll, can be filled with heart of palm julienne mixed with shrimps and other vegetables (called lumpia in the Philippines) and served as 'the millionaire's salad' (Jones, 1984).

APPENDIX: OTHER PALMS USED AS HEART OF PALM

(a) **The royal palms (*Roystonea* sp., previously *Oreodoxa* sp.)**

In Florida, the Caribbean and northern South America, local people have used the royal palm as a source of palm heart (aside from the sabal palm) in traditional preparations (Jones, 1984; Uhl and Dransfield, 1987) for clan gatherings. There are many wild growths of royal palms in Florida.

Experiments in La Lima, Honduras, show the royal palm with high net cannable yields 4.0–5.2 t (cylinder) under high densities of 20 000, 40 000 and 60 000 palms per ha, harvesting the juveniles in 13 months. This is a yield record already and could still be improved, possibly up to 6 t per ha of 10–11 months juveniles. The heart does not oxidize and is very white and the cylinder weighs between 80–250 g, with 2 cm diameters and about 23–42 cm length. Its texture is firm, very much like that of pejibaye, and also has a neutral taste. The apical meristem has a faint astringent flavour like that of pejibaye which, if included in pickling, imparts that particular flavour to even the neutral portions. The hearts are glossy and have an appealing neat presentation.

The architecture of juvenile *Roystonea elata* allows it to be an excellent industrial source of heart of palm. Its disadvantage is that it grows so fast it has to be harvested on time before its diameter grows too big. It is also a non-suckering plant and has to be planted as an annual crop, unlike pejibaye and açai, which are suckering perennials and have smaller diameters. The royal palm's excellent colour, processing properties and precocity make it a very good addition to the palm heart alternatives (Tabora *et al.*, 1991).

Another species of royal palm, *Roystonea oleracea*, from Central America is also a good candidate. It has perhaps greater adaptability in areas with poorer drainage as it normally grows robustly even in water-logged areas in Honduras. It also grows in sandy soils near coastal areas of the Caribbean Islands, Honduras and Costa Rica.

A mature fruit bunch of the royal palm can contain as many as 10 000 seeds which germinate in 30–60 days if seeded immediately. Dried seeds can be stored for two years, but take 6–8 months to germinate. The seedlings have deeper roots than most other palms (Tabora and Ramirez, 1991) and the seedlings grow rapidly.

The most common diseases are those of *Helminthosporium* sp. which attacks the seedlings and *Colletotrichum gloeosporioides* (anthracnose) which attacks the juveniles. Spraying regularly with copper fungicides helps to control the spread of infection. Tilt has been effective to clean off the fungus at this stage. Pests are few, but rabbits are known to attack small seedlings, so protection is necessary.

In fertilizer experiments in Honduras on royal palm, there were no significant differences between 200 kg/ha, 400 kg/ha and 600 kg/ha of N. This is attributed to the extensive root system of royal palm.

As the royal palm stems are smooth, they are easier to harvest, clean and process. On the whole they are also easy to cut. The leaves are upright and there are no suckers that interfere in the operations. In the experiment the yield indicators were as follows:

Plants/ha	*Green mass (t)*	*Weights removed from field (t)*	*Net heart of palm (t)*	*Length (cm)*	*Diameter (cm)*
20 000	138.9	31.7	4.0	31.1	25
40 000	162.0	31.1	4.5	23.8	2.0
60 000	155.0	40.4	5.2	21.7	1.8
cv	11.3	10.3	11.0	8.6	6.3

cv, coefficient of variants.

(b) *Archontophoenix alexandrae* Wendl

This is also a fast-growing palm with a more slender structure than the royal palm. The heart oxidizes slightly, but not much and also has the characteristic astringency very much like the juçara. The dimensions are also just like the juçara, and it is also single stemmed. This palm is much more adapted to drier soils in high rainfall areas, but it is profuse on river banks of Australia and New Zealand.

(c) **The rattans (*Calamus* sp. and *Daemonorops* sp.)**

These are among the most astringent hearts of palms. Nevertheless they are eaten as specialities in the Philippines and Malaysia. The scarcity of the rattans have also made the hearts scarce, but rattans are beginning to be cultivated and the heart may become a by-product. Because of its strong astringent flavour, the rattan hearts may have restricted usage.

Table 7.8 Other palms with edible heart of palm (palm cabbage)

Species	*Origin*	*Taste*
Acanthophoenix rubra	Mascarene Island	Sweet
A. alexandrae	Australia	Neutral
A. cunninghamiana	Australia	–
Acrocomia mexicana	Mexico, C. America	Sweet
A. vinifera	C. America	Sweet
Areca catechu	Asia	Astringent
Arecastrum romanzoffianum	S. America	–
Arenag ambong	Philippines	Sweet
A. listeri	Christmas Island	–
A. pinnata	Indonesia	Sweet
Astrocaryum javari	Brazil	Neutral
A. murumuru	Brazil	Neutral
A. vulgare	Brazil	–
A. standleyanum	Honduras	Sweet
A. tucuma	Brazil	–
Borassodendron machadonis	Malaysia	Sweet
Borassus aethiopium	Tropical W. Africa	–
Brahea brandeegei	Mexico	–
B. serrulata	Texas and Florida	Sweet
Carpentaria acuminata	Australia	–
Chamaedorea elegans	C. America	Astringent
Chamaerops humilis	Italy	Sweet
Corypha elata	Asia	Neutral
C. gebanga	Asia	Sweet
Deckenia nobilis	Seychelles	–
Gronophyllum ramsayi	Australia	–
Gulubia palauensis	Palau Islands, Carolinas	–
Heterospathea elata	Amboina	–
Hyophorbe lagenicaulis	Mascarene Islands	–
H. verschaffeltii	Mascarene Islands	–
Jessenia bataua	Brazil	Neutral
Juania australis	Juan Fernandez	–
Licuala paludosa	Malaysia, Thailand	–
Linospadix monostachya	Australia	–
Livistona australis	Australia	–
L. benthamii	Australia	–
L. humilis	Australia	–
L. rotundifolia	Malaysia, Philippines	Neutral
L. speciosa	India, Myanmar, Malaysia	Neutral
Lodoicea maldivica	Maldive Islands	–
Maximiliana martiana	Brazil	Sweet
Metroxylon sagu	Melanesia, SE Asia	Sweet
Normanbya normanbyi	Australia	–
Oenocarpus bacaba	Brazil	–
Oncosperma horridum	Malaysia, Indonesia	–
O. tigillarium	Malaysia	–
Orbignya cohune	C. America	Neutral
Phoenix canariensis	Canary Island	Sweet
Pritchardiopsis jennencyi	New Caledonia	–
Raphia vinifera	Tropical Africa	Sweet
Ravenea madagascariensis	Madagascar	–
Rhopalostylis sapida	New Zealand	–
Sabal palmetto	USA	Sweet
S. texana	USA	Sweet
Satakentia liukiuensis	Ryukyu Islands	–
Scheelea martiana	Brazil	–
Syagrus siagrus	Brazil	Bitter

(d) **The fish tail palms (*Caryota mitis* Lour, *C. urens* L. and *C. cumingii* Lodd.)**

These have slightly astringent flavours too strong for most people but they are eaten in some regions of India, Malaysia and the Philippines. *C. urens* is a favoured cooking heart of palm. The caryotas are very fast growing and have ideal sizes and length. The cylinders are long and even. Aside from the slight bitterness the caryotas oxidize very rapidly upon exposure to air. Thus they are generally blanched prior to processing. As they are also cooked again during pasteurization, the end result is a mushy heart of palm.

Caryota mitis is a suckering species.

(e) **Sago palm (*Metroxylon sagu* Rottb.)**

This is a large palm which suckers. Often the suckers are pruned and these give hearts of palm with a very sweet taste. The conical architecture of the heart does not lend itself to major industrialization, but its particular flavour may give it a special place among hearts of palms.

(f) **The other palms**

There are probably as many as 60 other palms which can be useful for heart of palm production; some of these are shown in Table 7.8, adapted from Jones, 1984; with additions from Balick, 1982, 1985, 1986, 1987, 1989; Blombery and Rodd, 1982; Dickson, 1978; Dransfield *et al.*, 1988; Johnson, 1986; Martin, 1984; Schery, 1956; Tabora, 1989; Tucker, 1988 and by the authors.

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