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ABIU

A BOTANICAL AND AGRONOMIC REVIEW

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A BOTANICAL AND AGRONOMIC REVIEW

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INTRODUCTION

Abiu, or *Pouteria caimito* Radlk. (Syn. *Lucuma caimito* Roem.) is a delicious, nutritious, exotic fruit which is little known. It is a member of the family Sapotaceae, and is native to the Western Amazon basin in South America where it was cultivated by Indian tribes about 10,000 years ago and vernacularly called "abi", "caimo", or "cauje". Clement (1989) proposed that the centre of diversity of abiu is located largely between the confluence of the Napo and Ica rivers with the Amazon (Fig.1). Abiu has two infraspecific taxa or landraces defined by fruit shape and size : an ovoid, small fruit which is more primitive and more widely distributed than a spherical, larger fruit which is more advanced and more modifed in shape but more restricted in distribution (Calzavara, 1970 as cited by Clement, 1989). Also, the more primitive smaller fruit has moderate rind latex while the more advanced larger, spherical fruit has lower rind latex. A landrace is a primitive cultivar of a crop plant and is genetically very heterogenous, containing numerous alleles that contribute to the survival of the crop in its natural ecosystem. Thus, landraces are rich sources from which plant breeders can selectively reintroduce alleles into highly bred cultivars. Besides countries in South America, the fruit is also grown in Florida and Northern Australia. It grows well, flowers and fruits prolifically around Darwin and northern Queensland. It bears an attractive, bright yellow fruit with a sweet, caramel-flavoured, creamy-white pulp. Abiu has good potential for commercial development with more promotion and publicity.

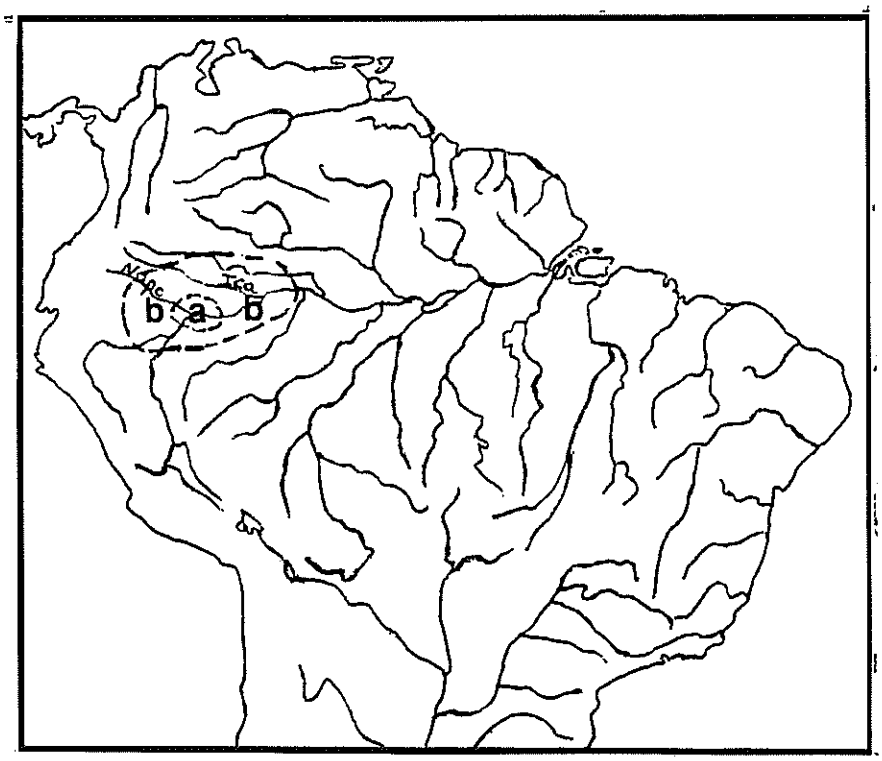

Fig 1. Distribution of Abiu's landraces
a) advanced spherical, b) primitive ovoid

PART 1

BOTANICAL AND NUTRITIONAL CHARACTERISTICS

The genus *Pouteria* Aubl. (Syn. *Calocarpum* Pierre, *Lucuma*) comprises about 50 species of shrubs and trees in the family Sapotaceae which has 800 species distributed among 35-75 genera.

Abiu can be taxonomically classified as follows:

Division:	Spermatophyta
Class:	Angiospermae
Subclass	Dicotyledoneae
Superorder	Caryophyllidae
Order	Ebenales
Family	Sapotacae
Genus	*Pouteria*
Species	*caimito*

Habit: The abiu tree is evergreen, medium-sized and grows to 5-15m high.

Leaf: Its leaves are short-petioled, green, glabrous, leathery, oblong-lanceolate, 100-250mm long by 40-55mm wide in its broadest width, alternate, with a wavy entire margin and an acute apex which is often curved. The petiole is light-green, about 15-20 mm long and broader at the base (2-3 mm). The mid-rib and veins are more prominent on the underside and are sub-opposite to alternate; the mid rib has 13-18 pairs of laterals. The leaves are arranged alternate spirally on the branches and are formed towards the upper ends of the twigs and branches.

Flower: The flowers are axillary, small, white and hermaphrodite and are formed in clusters (up to 8 flowers) or singularly in the leaf axils of new growth or on leaf scars along the branches (Fig.2), i.e. ramiflorous. A flowering terminal branch can bear from 20-280 flowers usually with a greater preponderance of flowers towards the distal apical foliage portion than on leaf scars along the proximal portion of the branch. The flower cluster is initially enclosed by two bracts. The flowers are short-pedicellate, 1-1.5mm long to almost sessile. The calyx consists of four overlapping, light-green sepals, 5mm long, spirally arranged. The corolla tube is cylindrical, 5mm in length, light-green when young and creamy-white to white when mature with 4 white, 2mm long free lobes at the top of the corolla tube.

The androecium consists of four free epipetalous stamens which are inserted on the corolla tube near the base and alternates with four staminodes. The filaments are curved, 4-4.5mm long, white, with a dorsifixed, extrorse, bilobed, yellow-brown anther (0.5-1mm long with a tapering apex). The style is thicker than the stamens, white with a four-lobed stigma at the apex. The style arises from a small, greenish-white, pubescent, superior ovary which is

covered by very fine, 2mm long, white papillae. The style and stamens elongate above the hairs. At anthesis, the sepals open and the style (7-8 mm long) pushes through the creamy white petals and extends 2-3mm above the corolla tube and the stigma becomes receptive. The petals never open completely as in most sapotaceous flowers.

Fruit : The fruit is a berry, green when immature and turns a bright yellow when mature (Fig.3), elliptical to round, spherical or compressed, often pointed at the stigma end (Fig.4), 60-100mm diameter and weighs 100-600gm but often up to 1500gm. The leathery pericarp (rind) is 5mm thick and contains latex which coagulates on exposure to the air when unripe. This latex can irritate the lips or taste buds. The edible pulp is soft, gelatinous, translucent and white. Each fruit has 1-4 large, ellipsoidal, 14 mm diameter and 37.8 mm length, dark brown seeds which have a large, distinct hilum along the lateral and distinct micropyle at one end. The seeds germinate readily when fresh with germination occuring from 2-10 days. The seed can germinate while still in the fruit. The seeds retained their viability for 1-2 days in dry conditions indicating that they may be recalcitrant in nature and difficult to store for long periods without losing their viability.

FLORAL BIOLOGY AND PHYSIOLOGY

Abiu is usually an allogamous (cross-pollinated) species but occasionally can be autogamous i.e. self-pollinated (Clement, 1989). The number of flowers which open in any one day during the first week of flowering is about 10-15% of the total in a flowering terminal. Usually the larger flower buds in a cluster open first, and the flowers along the proximal end of the flowering branch tend to open earlier than those clusters nearer the tip of the branch. In subsequent weeks more of the flower buds open irrespective of their position on the flowering terminal. A day or two before flower opening, the sepals enlarge first, exposing a tiny slit of 0.5mm at the top. The style carrying the stigma protrudes through the slit and extends 2-3mm above the slit, by which time the petals enlarge and elongate and the aperture of the slit reaches 2.5mm. The petals never open fully as in other flowers. Once out of the corolla tube the stigma becomes receptive. The filament also elongates slightly above the ovary hairs but never above the mouth of the corolla tube as does the style. Anther dehiscence occurs before the petal opens and before the stigma becomes receptive, thus favouring cross-pollination. Pollination has been reported to be dependent on high relative humidity and insects like flies, ants and various kinds of butterflies (Fig.6a & b) which are yet to be identified and studied. Nectar has been detected in the flowers (Moncur, 1988). Generally, the flowers open from 0730 to 1200 in the morning, and from 0830 to 1030 insect activity is high around the flowers, tapering off after 1100. Thirty to forty hours after flower opening, the petals start to wither, and turn brown. In cases of successful pollination and fertilisation, the ovary develops into a young fruit about 2-3mm in diameter and is covered in the fine hairs. The hairs are shed when the fruit reaches about 6-8mm diameter and the stigma begins to shrivel and dry up.

Generally, the fruit is available most of the year in Australia, especially from December to June. In Queensland, three crops can be obtained per year and flowering overlaps with fruit set which is reported to be most abundant during the warmer months. In the NT, there appear to be two crops with the earlier crop in June-July resulting from a flowering in

February-March and another crop in November-December from a flowering in July-August. In its native Iquitos, Peru, flowering occurs in October and the crop is harvested in April the following year (Heinz, 1983). Abiu appears not to have any photoperiod requirements for flowering and requires no specific dry duration to trigger flowering unlike many tropical fruit crops. Flowering and fruiting of abiu are quite prolific in the NT and pose no constraint. Abiu fruit takes over three months to develop to maturity. At three years, a yield of 10 kg/tree can be obtained in Queensland and up to 200 kg/tree for older trees.

OTHER POUTERIA SPECIES

Two closely related species with edible fruit are the canistel and the lucmo. The canistel is also known as eggfruit, Ti-es, sapote borracho, sapote amarillo or tiessa (*Pouteria campechiana* (HBK) Baehni (Syn. *Lucuma nervosa* A.DC., L. *salicifolia* HBK). The fruit can be found in Cuba, Mexico, Panama, the Carribean Islands and now in the Philippines. The canistel resembles abiu in being round to oblong but is more pointed at the stigma end, pale yellow to orange when ripe with a musky flavoured, deep yellow pulp which resembles hard-boiled egg yolk. The tree is a prolific bearer and the fruits split if allowed to ripen on the tree. The fruit is a rich source of carbohydrates (25.0-39.1 %) especially sugars, protein (1.14-2.5%), vitamin A (2060 IU), niacin 2.5 mg, ascorbic acid 43 mg, and minerals like calcium (40mg), phosphorus (30mg), iron (1.1mg), and 154-160.7 cal, all per 100g edible portion (Francisco and Wester, 1930). The fruit is easily bruised and has poor keeping quality and is more suitable for processing for use with ice-creams, cakes, etc.

The lucmo, *Pouteria obovata*, also known as "lucuma", "lugma" and "lucma", originates from the Andean foothills of Peru and Chile. It is a popular fresh fruit in Chile and is widely used for flavouring ice-cream. It bears a round to oblate fruit with greenish-yellow pericarp covered with white pores and has a sweet, dry, mealy, orange-coloured flesh. The lucmo is more adaptable to the high altitude or subtropical areas where the temperature is warm around noon and cool the rest of the day.

Other *Pouteria* species yielding edible fruits are:

P. *domingensis* C.F. Gaertn. Baehni (L. *serpentaria* HBK)
P. *duclitan* (Blanco) Baehni. - duklitan
P. *hypoglauca* Standl. Baehni (L. *hypoglauca* Standl.)
P. *mammosa* L.) Cronq. (syn. *Calocarpum mammosum* Pierre - sapote, mammey zapote, chico mammey
P. *sapota* (Jacq.) Moore & Stearn (*Calocarpum sapota*) - chico mammey
P. *tovarensis* (Klotsch and Karst.) Engl. golden, yellow, edible fruit, Columbia and adjacent countries.
P. *ucuqui* edible, consumed by native Amazon Indians but little known, pear-shaped fruit acrid when eaten raw but excellent when cooked (Schultz, 1989);
P. *viride* (Calocarpum viride) Pittier - green sapote

Other species of *Pouteria* and their uses are:

P. *anibifolia* - timber, Brazil
P. *guyanensis* Aubl. Jan Snijder - timber, Surinam
P. *izabalenisi*
P. *macrocarpra*
P. *moluccana* - timber in Indonesia
P. *multiflora* (A.DC.) Eyma. Jacana - timber, West Indies
P. *pariri*
P. *pentasperma* -timber, Brazil
P. *speciosa*
P. *striata* - timber, Brazil

Two *Pouteria* species, namely P. *sericea* (Aiton) Baehni and P. *unmackiana* (Baillon) Erlee are native to tropical Queensland, Australia.

Other important members of the sapotaceae with edible fruits are:

Chrysophyllum cainito L. - star apple
Manilkara zapota L. van Royen (syn. Achras zapota L.) - chiku, chico, sapodilla, sapote, chico zapote, naseberry, briapfel, sapotille
M. *kauki* (L) Dub.

Star apple and sapodilla also have commercial significance in the NT.

CULTIVARS

Several popular varieties have been recorded in Queensland viz. Inca Gold, Cape Oasis, Gray, Z1, Z2, Z3, Z4, etc. The cultivar Gray has been reported to perform poorly under Darwin conditions. Cultivars Z2, Z4, and two CPRS seedling selections designated T25 and T31 have given large, excellent tasting, fruits but their yield potential has yet to be realised. Cultivar Z3 also gives tasty fruits but the fruits are too small. Selection and breeding for varieties adaptable to the NT needs to be pursued further, and promising varieties need to be vegetatively propagated. Little success to date has been obtained with vegetative propagation of abiu because of the inherent latex production in the stem. More studies using newer improved approaches are needed to propagate promising cultivars. Cultivars with the following characteristics should be selected:-

* early, regular and good bearer, yielding about 20 t/ha;
* round or rotund fruits with or without small nipple for ease of packing;
* mean fruit weight greater than 180 g;
* absence of water-soaked areas on pericarp when undamaged;
* few (1-2) small seeds or seedless;
* low rind latex;
* rind thickness greater than 4 mm, thus more resistant to bruise injuries;

* firm, sweet (13-18% brix), translucent but not glassy pulp;
* little or no physiological browning of the pulp (Fig.5);
* good shelf life of 10-12 days.

NUTRITIVE COMPOSITION

The vitamin and mineral composition of abiu is shown in Table 1. Abiu is an excellent source of vitamin C, containing 49mg per 100g of edible portion which will provide the daily requirement. It is also a good source of vitamin A and niacin (vitamin B3), energy - 588 kJ (140 Cal)/100g edible portion, carbohydrates and a fair source of dietary fibre (Anon., 1961).

Table 1. Nutritive composition of Abiu per 100g edible portion

Protein	1.8 g	Calcium	22 mg
Fat	0.4 g	Phosphorus	41 mg
Carbohydrate	36.3 g	Iron	1 mg
Fibre	0.9 g	Thaimine	0.02 mg
Ash	0.9 g	Riboflavin	0.02 mg
Energy (Cal)	140 (588kJ)	Niacin	34 mg
		Vitamin C	49 mg
		Vitamin A	130 ug

Source: Anon. 1961. Food Composition Table for use in Latin America. The Institute of Nutrition of Central America & Panama, Guatemala City and National Institute of Health, Bethesda, Maryland U.S.A. Joint Research Project.

Fig.2. Small, white axillary flowers of abiu.

Fig. 3. Ripe , yellow and unripe, green abiu fruits.

Fig. 4. Variation in fruit shape and size

Fig. 5. Ripe abiu fruit. Left shows internal browning of pulp. Right shows a clean external appearance.

Fig. 6a. Butterflies pollinating abiu.

Fig. 6b. Butterflies pollinating abiu.

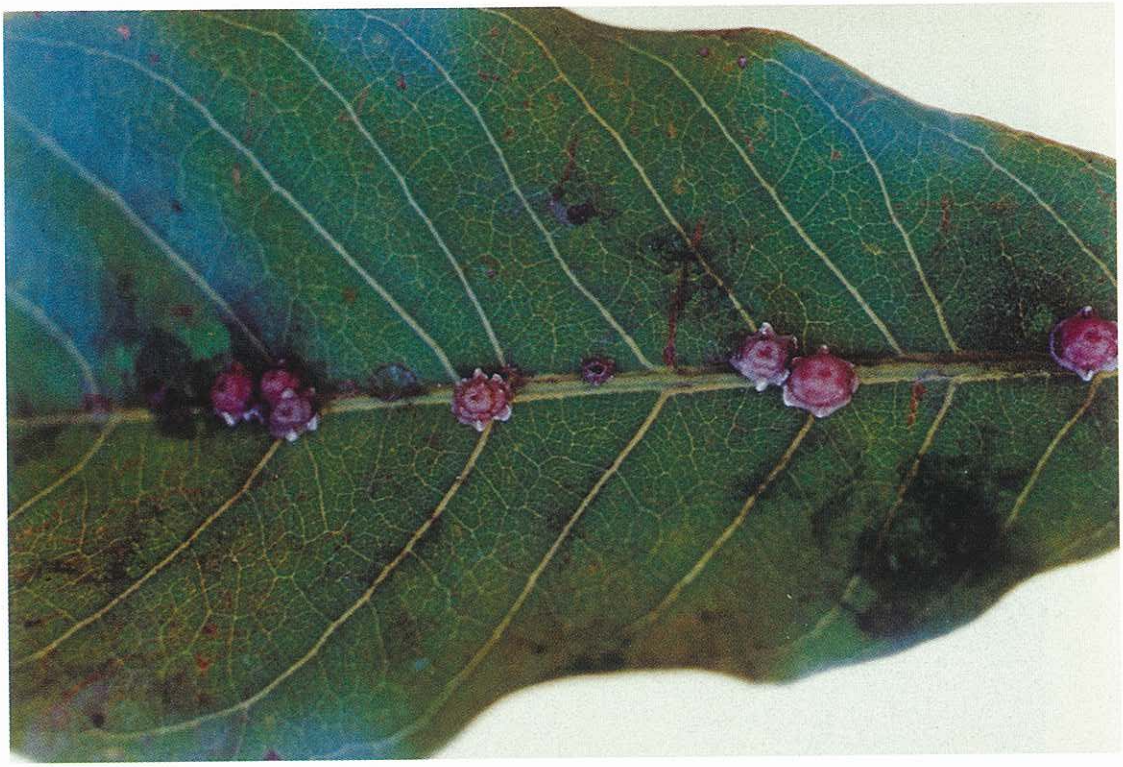

Fig. 7. Pink wax scales and sooty mould infestation on an abiu leaf.

Fig. 8. Developing abiu fruit showing symptoms of injuries caused by *Amblypelta sp.*

PART 2

AGROECOLOGICAL AND MARKET REQUIREMENTS

Abiu thrives well in a humid tropical climate with 1000-3000 mm rain evenly distributed throughout the year, 20°N and 20°S of the equator up to an altitude of 500m. It is rather frost tolerant, withstanding temperatures down to -2°C without appreciable damage. Under NT conditions, no defoliation occurs when temperatures dipped below 10°C during the dry period. It likes full sun, and can be grown on a wide range of soils particularly deep clay loams with good drainage, tolerating a wide range of soil pH with an optimum of 5.5 to 7.5. It is quite drought tolerant and it does not shed its leaves when the weather becomes dry and hot, with temperatures hovering above 37°C. However, it is sensitve to saline conditions which can kill the tree. Irrigation is required to sustain good growth and fruiting during the dry periods especially on the light, sandy soils.

AGRONOMY

Cultural Practices: The agronomy of the crop with regards to planting densities, fertilisation, and irrigation needs to be rationalised. In Queensland, a planting distance of 10 X 8 m is recommended but at CPRS, abiu appeared to be thriving well at a much closer intra-row planting distance of 2-3 m. Planting should be carried out during the warmer months just before the wet season sets in. The tree should be lightly pruned when young to develop a good framework of well spaced branches instead of a central leader. It is recommended that the tree be pruned to a height of 3 m to facilitate harvesting and the branches are allowed to develop at 1 m from the ground. When young, the tree should be well protected from frost and cold winds by establishing good windbreak trees.

Fertiliser Application: In Queensland, fertilisers are split-applied in August, December and April, with an annual total of 10g N, 2g P, and 17g K per tree per year of age up to 10 years. Fertilisers are applied immediately after harvest together with organic manure and dolomite. In the N.T., efforts are now underway to rationalise the fertilisation program for abiu based on the crop's phenology, crop requirement (nutrient removal), foliar analyses, soil analyses and weather fluctuations. A sound interpretation of foliar analyses is dependent on a good standardised procedure of foliar sampling. In the N.T., a standard procedure has been developed for Abiu. Sampling of leaves is carried out during fruit development when the fruit are half their mature size. Two leaves are collected from the middle of each of 10 vegetative terminals randomly selected around the tree and bulked for nutrient analyses. In addition, 4 soil cores are taken up to a depth of 20 cm around the tree and bulked for soil analysis which is recommended every two years. Depending on the variability of the tree stand, 5-10% of the population are sampled.

Pending the completion of such rationalisation procedures, a fertiliser schedule adapted for Abiu at Coastal Plains Research Station, Middlepoint is as follows:

Planting hole: 200g single superphosphate, 200g dolomite and 2-3kg well-cured organic manure.

Non-bearing tree: A fertiliser containing $N:P_2O_5:K_2O$ (10:10:10) applied in 4-6 applications commencing 3 months after planting out. The amount employed is as follows:

Year 1 0.5kg
Year 2 1.25kg
Year 3 2.00kg

Bearing tree: For a bearing tree the NPK fertiliser is changed to $N:P_2O_5:K_2O:MgO$ (12:12:17:2) plus trace elements. It is applied as follows:

Year	Total kg	Late December	Early April	Mid July	Late September
4	2.75	0.825	0.55	0.825	0.55
5	3.50	1.05	0.7	1.05	0.7
6	4.25	1.275	0.85	1.275	0.85
7	5.00	1.500	1.00	1.500	1.00
8	5.75	1.725	1.15	1.725	0.85
9	6.50	1.95	1.30	1.95	1.3
10	7.25	2.175	1.45	2.175	1.45
11	8.00	2.40	1.60	2.40	1.60

Zinc, iron and boron deficiencies are common in abiu grown on soils around Darwin. These can be ameliorated by separate soil or foliar application of compounds containing the respective nutrient. Two or three applications per year during the flushing periods are recommended. Zinc deficiency is rectified by foliar sprays of zinc sulphate heptahydrate or a zinc chelate at the rate of 1-2g/l. Zinc sulphate monohydrate is used if soil application is desired and the rate recommended is 10g per metre ground surface per tree. Iron deficiency is corrected by soil treatment or preferably foliar applications of iron sulphate or chelate at 1g/l. Boron deficiency can be remedied by borax (2g/l) or the more soluble solubor (1g/l) by foliar sprays. For soil application, 2.5-3.5g of borax per square metre is spread evenly

over the soil.

Harvesting, Pests and Diseases: The fruit is harvested when the fruit is almost fully bright yellow; full ripeness is attained after 1-5 days at room temperature storage and harvested fruit should be kept away from the sun. The skin is reported to be resistant to fungal attack, but the fruit is susceptible to fruit spotting bug, fruit fly and thrips, and the foliage is prone to infestations by thrips, mealy bugs, scales (pink wax scales (Fig.7), *Ceroplastes rubens* Maskell, (Hemiptera:Coccidae) and green scale, (*Coccus* spp.) damage and sooty mould infestation. The hemiptera bug, *Amblypelta* spp. attacks young, developing, green fruit as early as the marble size stage, causing 1-12 black sunken roundish spots (1-3 mm diameter) (Fig.8). These later become dry, necrotic cankers and the fruit splits as it develops. Thrips cause superfical russet scarring of fruit and deform young foliage. The incidence appears to be higher during the dry period. The flowers are often damaged by the webbing Tortricid caterpillars. Insects can be controlled by regular sprays with chemicals such as endosulfan and dimethoate. Losses due to bird damage by their pecking ,scarring and devouring of developing unripe fruit at Coastal Plains Research Station and at growers orchards can be extremely devastating and could be the major limitation to its viability as a fruit crop. Studies are needed on the control of birds by electronic scaring devices, bird repellants, and other cultural and physical methods such as light weight plastic "Birdban" netting or growing the crop under permanent cyclone-proof netting. These need to be investigated from the standpoint of efficiency and economics. Sun scorching of foliage, causing bleaching of chlorophyll, and fruit can be quite common during the hot, dry period in the NT. The crop is relatively hardy and except for sooty mould infestations on the foliage and fruit which are associated with honey dew secretions of scale insects and mealy bugs, no serious disease threatens the crop.

POSTHARVEST AND MARKET REQUIREMENTS

The fruit has a shelf life of 7-14 days when cool stored at 10°C. In Queensland the fruits are tray-packed in shredded paper (Fig. 9) to prevent bruising and a tray of 12 large fruits costs about $10-16 in the Brisbane market. More work should be done on extension of shelf-life, and grading and packaging of the fruit to enhance market appeal. More effort is needed to promote abiu as a nutritious, health fruit. Abiu is best eaten when slightly chilled, the fruit halved and the sweet pulp scooped out with a spoon or cut into segments. The pulp can be pureed for use as a fresh juice or in mixed fruit juice, cocktails, fruit salads, sauces, ice-cream, sherbets, yoghurt, etc.

PART 3

CONCLUSION AND RECOMMENDATIONS

Abiu's attractive bright yellow colour and its sweet caramel flavour and nutritive content appeals to Europeans and Asians alike. With more promotion and publicity, and perhaps with a name change, abiu's market potential can be realised. Besides its potential for interstate export, abiu may have export potential to Southeast Asian countries like Singapore, Malaysia, Brunei, Hong Kong, South Korea, New Zealand, Europe and the Middle East countries.

Issues that need to be emphasised are summarised below:-

a) Varietal selection and vegetative propagation;

b) Pollination;

c) Fertilisation and irrigation (fertigation) requirements;

d) Planting densities and pruning practices;

e) Pests (insects and birds) and their control;

f) Postharvest handling and storage;

g) Grading, packaging, shelf life and market development.

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References

Anon. 1961. *Food Composition Table For Use In Latin America.* The Institute of Nutrition of Central America & Panama, Gautemala City and National Institute of Health. Bethesda, Maryland, U.S.A. Joint Research Project.

Calzavara, B.B.G. 1970. Abieiro, Abricozeiro, Bacurizeiro, Biribazeiro, Cupuacuzeiro. *Culturas da Amazonia* 1:45-84. IPEAN, Belem, Para, Brazil (cited by Clement, 1989).

Clement, C. R. 1989. A center of crop genetic diversity in western Amazonia. *Bioscience* 39 (9): 624-631.

Francisco, A.D. and P.J. Wester, 1930. Analysis and food value of some unusual Philippine fruits. *Philip. J.Sci.* 43(4):655-633.

Heinz, H. 1983. Some field observations on *Pouteria caimito, P. campechiana, Diospyros digyna* and *Solanum topiro* under humid tropical conditions (Turrialba, Costa Rica). *Proc. Amer. Soc. Hort. Sc. Tropical Region,* Vol. 27 (part A): 111-116.

Lim, T.K. and Ramsay, G. 1991. Abiu - a new fruit with potential for the Northern Territory. Paper presented at the *International Symposium on Tropical Fruits, Pattaya, Thailand, May 20-24, 1991.*

Moncur, M.W. 1988. *Floral Development of Tropical and Subtropical Fruit and Nut Species - an atlas of scanning electron micrographs.* CSIRO, Australia, 181 pp.

Parker, G.H. 1986. Abiu. *Rare Fruit Council of Australia Inc.* Fact Sheet No. 13.

Popenoe, W. 1920. *Manual of Tropical and Sub-tropical Fruits*, Macmillan, New York, 347 pp.

Rogers, J. 1990. *What Food Is That?* Wildon Publishing, Willoughby, NSW.

Scholfield, P.B. 1984. Canistel, lucmo and abiu. In: *Tropical Tree Fruits for Australia.* (Compiled by C.E. Page), Queensland Dept. Primary Industry, Brisbane, pp 216-217.

Schultes, R.E. 1989. *Pouteria ucuqui* (Sapotaceae), a little-known Amazonian fruit tree worthy of domestication. *Econ. Bot.* 43 (1): 125-127.