

The Potential of Tapping Palm Trees for Animal Production

Christophe Dalibard

Animal Production Officer, Feed Resources Group, FAO

Abstract

Palm trees have proved to be efficient converters of solar energy into biomass in most agro-ecological zones of the tropical world. Most tapped palm trees gives a sap very rich in sugar (10 to 20%). For several millennia, many species of palm trees (including coconut) have been used for sugar production. Highly sophisticated techniques of tapping were developed through the centuries in Asia, Africa and America. High yields of sugar were obtained from palms that could continue for up to a hundred years of production. One of the main constraints on production in recent times has been the increasing lack of fuel needed for processing palm sap into sugar and the price thereof. Nevertheless, since trials of feeding pigs with fresh sugar palm sap were successfully initiated in an FAO project in Cambodia, there has been renewed interest in tapping palm trees for sap to be used as feed. A thorough review of the literature has shown that intensive pig rearing based on palm sap has already been practised by the Indonesians for centuries and was found to be a very efficient system for intensifying agriculture in some highly populated islands. In today's economy, developing animal production using palm sap as the main source of energy in the diet looks very promising: the land could sustain higher population densities through the intensification of crop and animal production within sustainable integrated systems for small farmers.

KEY WORDS: sugar palm, tapping, sap, livestock, feed

Introduction

For centuries, many palm species have been tapped throughout the tropical world in order to produce fresh juice (sweet toddy), fermented drinks (toddy, wine, arak), syrup ("honey"), brown sugar (jaggery) or refined sugar. Most tapped palm trees do not only produce sap but are multipurpose (edible fruits, building materials, fibres, wax, etc.) and their socio-economic importance can be critical for the rural poor. Palm trees are also often associated with crops and pastures.

Rationale

Theoretically, the advantages of taking the sugars from the sap before it goes to the fruits are obvious. These sugars are intercepted before being used in the production of the non-edible parts such as husk in coconut, which represents 35% of the fruit (Rangaswami, 1977), and in the production of edible material through chemical reactions which imply a loss, mainly a conversion of sugar into oil as for coconut and oil palm. It is therefore more profitable from the point of view of edible energy production to tap a palm for the sap rather than allowing the palm to produce fruits. Similarly, it was demonstrated that, in the context of harvestable energy from the coconut palm, the amount of energy harvested in the sap (through production of ethanol) could be 5 to 7 times higher than from the oil of the nuts (Banzon, 1984).

Physiology

It is possible to obtain a sugary solution by the excision of the meristem in nearly all palms (Tuley, 1965). Basically, starch reserves from the trunk are converted to sugar and are transported upwards to the stem apex (Fox, 1977). Although this is true in the case of *Corypha*, other explanations are needed for palms such as coconut which does not accumulate starch in its trunk (Reijne, 1948, cited by Van Die, 1974). Pethiyagoda (1978) describes the upward stream as a watery liquid containing dissolved salts absorbed from the soil, and the downward stream as a comparatively rich mixture of food (principally sugars) manufactured in the leaves. The sap flow is intercepted by injuring fibro-vascular tissues of the apex or of the inflorescence. Nevertheless,

this author recognizes that the large volume of exudate produced during tapping and the high sugar concentration clearly indicate that the material is drawn from stored resources and is in excess of currently synthesised sugars. The origin of the large flow of sap that occurs in a tapped tree is not yet clearly demonstrated. This is also the case for *Borassus flabellifer* where water from root absorption appears quite insufficient (Kovoor, 1983). Pethiyagoda (1978) suggests that there is a steep rise in respiration which occurs whenever there is a rapid solubilisation and movement of materials from sites of storage to the points at which they are needed such as during seed germination, flower opening and fruit ripening. This phenomenon can be fostered, heightened and sustained by manipulative processes, the use of generally young growing sites (merismatic tissues) and the act of freshening the wound. Preliminary studies (not published) cited by Pethiyagoda (1978) show a considerably increased respiration by fragments of coconut inflorescence drawn from stimulated spadices.

Location, Products and Tapped Parts of Palms

Table 1 lists nearly 30 different palm species that are traditionally tapped in parts of the tropical world. The major part of the information was found on palms that are tapped in the Old World, with more or less as many different tapped species in Asia and in Africa. It has been possible to identify only three tapped palm species in the New World (*Carnauba cerifera*, *Jubaea spectabilis* and *Mauritia flexuosa*) and very little literature seems to be available on tapping these trees. In America and Africa, it seems that tapping palms has been practised exclusively or mainly for wine production, whereas in Asia the sap is used either as fresh juice or processed into a large array of products (wine, arak, sugar, vinegar, etc.). Table 1 also shows that there are tapped palm species adapted to almost all agro-ecological zones of the tropical world from tidal areas and swamps to deserts and mountains.

Table 1: Location and management of tapped palm species

Latin name	Regions and management
<i>Areca catechu</i>	Tropical rain forest S & SE Asia; Improved cultivated palm [1]
<i>Arenga pinnata</i> or <i>saccharifera</i> <i>Arenga undulatifolia</i>	Tropical rain forest into dry forest SE Asia; Unimproved cultivated or managed palm [1]
<i>Beccariophoenix</i> <i>madagascariensis</i>	Central Madagascar (1,000m)
<i>Borassus aethiopium</i>	Tropical savanna Africa; Semi-wild or wild palms [1]
<i>Borassus flabellifer</i> <i>Borassus sundaicus</i>	Tropical forest into savanna Asia; unimproved cultivated or managed palm [1]
<i>Borassus</i> <i>madagascariensis</i>	Along rivers Madagascar [2]
<i>Carnauba cerifera</i>	Brazil
<i>Caryota urens</i>	Tropical rain forest Asia & S Pacific; Unimproved cultivated or managed palm [1]
<i>Cocos nucifera</i>	Coastal tropical rain forest E Africa, Asia & Pacific; Improved cultivated palm [1]
<i>Corypha elata</i>	SE Asia Unimproved cultivated or managed palm [1]
<i>Corypha umbraculifera</i>	Tropical rain forest S & SE Asia;

Table 1: (Continued)

<i>Elaeis guineensis</i>	W Africa, Madagascar [2], Indonesia [4]; Improved cultivated palm [1]
<i>Hyphaene coriacea</i>	SE Africa
<i>Hyphaene thebaica</i>	Semi-deserts & deserts of E Africa; Unimproved cultivated or managed palm [1]
<i>Hyphaene shatan</i>	Madagascar
<i>Jubaea spectabilis</i>	Chile
<i>Mauritia flexuosa</i>	Tropical rain forest Peru; Semi-wild or wild palms [1]
<i>Nypa fruticans</i>	Tidal areas Asia; Unimproved cultivated or managed palm [1]
<i>Phloga polystachya</i>	Madagascar [2]
<i>Phoenix dactylifera</i>	Semi-desert N. Africa; Improved cultivated palm [1]
<i>Phoenix reclinata</i>	Coast W & SE Africa [5][3][4][6]
<i>Phoenix sylvestris</i>	Trop. rain forest to 1,500m [1]; India, Bangladesh, Ivory Coast; Unimproved cultivated or managed palm [1]; Bangladesh: plantations [7]
<i>Raphia hookeri</i> , <i>R. vinifera</i> , <i>R. sudanica</i> , <i>R. ruffia</i>	Tropical rain forest W Africa, Madagascar [2]; Semi-wild or wild palms [1]

References: [1] Johnson, 1987; [2] Decary, 1964; [3] Giffard, 1967; [4] Blanc-Pamard, 1980; [5] Cunningham, 1990; [6] Adand , 1954; [7] Annett, 1913.

Methods of Palm Tapping

The techniques for tapping palms are numerous and can vary drastically from one continent to another, as demonstrated by the case of *Borassus aethiopium* in Africa and *Borassus flabellifer* in Asia. Refined techniques of tapping the inflorescence of the latter are compatible with production in the long term. Destructive techniques are usually practised on the terminal bud of *B. aethiopium* and are often responsible for the death of the tree within a few months. The African oil palm is used in Africa for producing wine mainly through two different techniques: one is destructive (incision of stem apex of felled palm) and is preferred in Ghana; the other is not destructive (excision of male inflorescence) and has been developed where economic considerations have forced the people to preserve their palms, e.g. in eastern Nigeria (Hartley, 1977). The excision of the terminal bud of standing trees is quite harmful since tapped palms never resume vigorous growth. If the terminal bud is only perforated, then the trees will show malformation in subsequent leaves, flowers and trunk growth (Kovoor, 1983). Nevertheless, it has been observed that multi-stemmed trees such as *Hyphaene coriacea* and *Phoenix reclinata* in south-eastern Africa generally recoppice after tapping, although tapped stems die unless tapping is stopped before the apical meristem is totally destroyed (Cunningham, 1990). The very low yields of sap from these trees are interpreted as a result of over exploitation. Cunningham (1990) suggests that if palm size classes shifted to the extent that there was again a high proportion of mature fruit-bearing palms in the population, then inflorescence tapping could be practised.

The most advanced method of tapping is that applied to the inflorescence spadix which guarantees a high yield for long periods without affecting the well-being of the tree. It only entails a sacrifice of a bunch of fruit in the case of tapping female inflorescences. Tapping the inflorescence is practised throughout S.E. Asia on all species of tapped palm trees (Kovoor, 1983). Two features are common in tapping: manipulative treatment or preparation (application of chemicals and substances of plant origin, twisting, distortion, kneading, pounding, bruising, beating or tapping) necessary as a prelude to copious and

sustained sap flow, and renewing the exuding wound by shaving off a thin slice of tissue once or twice a day (Pethiyagoda, 1978). Tapping is an art: sap yields depend on the skills of the tapper (Khieu, 1996; Coconut Research Institute, 1967).

Except for *Nypa fruticans*, which is trunkless and develops its inflorescence at a height of about 1m (Hamilton and Murphy, 1988), other palm trees have to be climbed for tapping as their inflorescences are located at the summit of their trunk which is often over 10m high. Various methods are used to climb the tree (six recorded by Kovoor, 1983), using ankle-loops, aerial ropeways between trees, hoop-belt, rivetted bamboo, mobile 4-9m long ladders and fixed ones on the upper part of the trunks, notches in the trunk, etc.

Management of Tapped Palm Trees

The management of palm trees for sap production varies very much according to species. *Nypa fruticans*, *Phoenix sylvestris*, *Elaeis guineensis*, *Raphia hookeri* and *Cocos nucifera* can be tapped at a rather early age, respectively when the trees are 4, 5, 6, 7 and 7 years old (Crevost and Lemari, 1913; Abedin *et al.*, 1987; Essiamah, 1992; Profizi, 1988; Levang, 1988). On the other hand, many years are needed before tapping *Caryota urens* (10 to 15), *Borassus flabellifer* (15 to 30) or *Corypha elata* (20 to 100) (Redhead, 1989, Fox, 1977).

The number of years a palm tree can be tapped is also very different depending on the species. *Corypha elata* and *Raphia hookeri* flower just once. They will produce sap only for a few months before dying (Fox, 1977; Profizi, 1988). *Arenga pinnata* and *Caryota urens* will produce sap for several years, with large interruptions in the case of *Caryota urens* as it flowers only every two or three years (Redhead, 1989; Dissanayake, 1977). Other palm trees will produce sap for much longer periods: 10 to 15 years for *Elaeis guineensis*, more than 20 years for *Cocos nucifera*, 50 years for *Nypa fruticans* and *Phoenix sylvestris* and 30 to 100 years for *Borassus flabellifer* (Adand, 1954; Levang, 1988; Magalon, 1930; Abedin *et al.*, 1987; Lubeigt, 1977).

Some species are able to produce sap all year round: *Arenga pinnata*, *Cocos nucifera*, *Elaeis guineensis* and *Nypa fruticans* (Mogea *et al.*,

1991; Rangaswami, 1977; Tuley, 1965; Kiew, 1989). *Borassus flabellifer* and *Phoenix sylvestris* produce only seasonally (Crevost and Lemari, 1913; Annett, 1913).

Yields of Sugar

Most tapped palm trees give a sap very rich in sugar (10 to 20% according to species and individual variation). The yields are highly variable according to the species and their management. Under proper management, the main tapped palm species (*Arenga pinnata*, *Borassus flabellifer*, *Cocos nucifera* and *Nypa fruticans*) can reach yields of about 20 tonnes of sugar per hectare (Van Die, 1974; Watson cited by Kiew, 1989). Compared to sugarcane production (5-15 tonnes of sugar/ha/year), the *Borassus flabellifer* tree can reach 18 tons/ha/year under rain-fed conditions (Khieu, 1996) and the coconut tree 19 tons/ha/year (Jeganathan, 1974). According to estimates, *Elaeis guineensis* produces much less sugar (1.2 tonne per hectare, Udom, 1987) but, as it has never been exploited for sugar production but only for wine production, there are good prospects for obtaining much higher yields in a production system oriented towards sugar production.

Multipurpose Uses and Role in Sustainable Integrated Production Systems

Most palm trees have multipurpose uses. Nevertheless, they are not always compatible. Sap production is at its maximum just before or during fruit formation. Tapping the tree competes with the production of the ripening fruit (Redhead, 1989). Tapping can also stimulate fruit production: a young coconut palm tapped during 6-12 months for sugar production will then produce more nuts (Magalon, 1930; M.F., 1925). A technique called sequential coconut toddy and nut production has been developed in the Philippines at the Davao Research Centre. The first half of the spathe is tapped and the second half is left for fruit production as female flowers that develop to mature nuts are situated in this lower portion. Nut and copra yields are about 50% lower than non-tapped palms; however, this technique has been demonstrated to be very feasible and highly profitable for small producers (Maravilla and Magat, 1993).

Arenga pinnata can be tapped when they are between 12-15 and more than 30 years old; then they can be cut for sago production (Sumadi, 1988). Nevertheless, in West Java, where sago is obtained from trees 10-12 years old, no tapping will be done previously, farmers arguing that it would reduce the quantity of starch in the trunk (Mogea *et al.*, 1991). In Eastern Nigeria, oil palms that have been abandoned as uneconomic bunch producers usually give good economic returns for wine production before old plantings are cleared and replanted (Tuley, 1965).

There are various types of palm-crop associations in Bangladesh. *Phoenix sylvestris* and *Borassus flabellifer* can both be associated with several of the following crops: rice, wheat, chickpea, mustard, jute, lentil, potato, linseed, winter vegetables and sugarcane (Abedin *et al.*, 1987).

Palm trees often have advantages compared with other crops as far as sustainability is concerned: in parts of west Java where *Arenga pinnata* is still tended in groves, soils appear much more stable and productive of other crops than where cassava is cultivated (Dransfield, 1977). Furthermore the advantages of this tree are its great ecological tolerance, its ability to grow and stabilize unproductive erosion-prone sites such as steep dryland slopes (e.g., coffee orchards in North Sulawesi, Mogea *et al.*, 1991), its potential to grow on almost any type of soil, to increase soil fertility and water conservation, its great tolerance of accidental burning (the only surviving tree in the Minahassa, Sulawesi after volcanic activity), the relatively fast growth rate, the fact that it needs almost no maintenance and usually does not suffer from any serious pests or disease, and the wide range of secondary or alternate products obtainable (Mogea *et al.*, 1991).

Borassus flabellifer is often planted on paddy fields boundaries in Cambodia and India. The effect of shading on understorey crops are likely to be negligible due to the small-sized crowns and to the large space (10-15m) between trees (Jambulingam and Fernandes, 1986). Like *Arenga pinnata*, this tree thrives in reputedly the poorest, infertile and arid regions. It also suffers remarkably little from prolonged flooding. It is extraordinarily pest and disease-resistant, requiring limited means of cultivation if any. As it grows in sandy plains, it is used for blocking erosion and fixing dunes, thanks to its deep root system (Kovoor, 1983).

It is also, like *Corypha elata*, a fire resistant palm that is a pioneer species on regularly burnt land such as those exploited by the slash-and-burn technique (Ormeling (1956), cited by Fox, 1977). It is used in Burma as a wind-break in areas cropped with groundnut (Lubeigt, 1977). It plays a major role in Savu and Roti islands (Indonesia) where the soil fertility is a crucial constraint. Traditional slash-and-burn system which is currently practised in neighbouring islands (Timor and Sumba for example) has been replaced by semi-permanent gardening through the use of large amounts of old *Borassus* leaves that are burnt in the fields. This permits fertile gardens to be kept in the vicinity of the houses (Fox, 1977). *Borassus* forests possess a potentially unique pattern of nutrient cycling, which enables them to support relatively productive and stable forms of agriculture as well as to contribute to recovery of disturbed sites (Anderson, 1987).

In the Peruvian Amazonia, *Mauritia flexuosa* constitutes dense populations in seasonal swamp forests on waterlogged or sandy soils, which are generally considered as unfit for agriculture (Kahn, 1988). Unlike sugarcane, *Nypa fruticans* does not compete with other crops for agricultural land except where total reclamation is undertaken on mangrove land (Hamilton and Murphy, 1988).

Origin of the Decline in Palm Tree Tapping Activity

One of the main reasons for the decline of sugar production from palm trees is the increasing lack of fuelwood and its increasing price. In the case of wine-producing palm trees, the decline often occurred under religious or colonial pressure. In Africa, some destructive techniques of tapping were responsible for the disappearance of the trees in entire areas. The important moves of population in the fifties (settlers setting up coffee, cocoa, rubber trees and oil palm plantations) were also responsible for loss of traditional codes of managing the trees and less long term concerns. Thus the traditional technique of tapping only male trees and keeping females for regeneration was abandoned (Port res, 1964; Blanc-Pamard, 1980). In Sri Lanka, widespread cultivation of coconut as an exported-oriented crop drastically changed the local economy and imported sugar became cheaper (Dissanayake, 1977). In

Peninsular Malaysia, the swamp areas were drained for coconut plantations where *Nypa fruticans* was before predominant (Kiew, 1989). Fishponds developers also found great profits in various fishpond operations made possible by converting mangrove swamps, including *Nypa fruticans* areas, for fish production (Encendencia, 1985).

Tapping sugar palms is very labour intensive. It must be done daily otherwise the sap flow rapidly diminishes as tissue healing occurs and restarting the sap flow requires long and hard work. Whenever easier and better paid jobs were available, tapping was given up. During the colonial period in India, *Borassus* tappers were recruited in the British plantations abroad, particularly on the rubber and oil palm estates where their skills could be easily adapted to those required for these trees (Fox, 1977).

In many countries, in comparison to other crops or commodities, there is a general lack of interest shown by the decision makers about the socio-economic potential of tapping palms. None or little research, selection of higher yielding varieties or training and extension services are funded and the tappers are seldom exposed to technological innovations if they do not generate them by themselves.

Origin of the New Interest for Palm Tree Tapping Activity

In today's economy, the profitability of tapping palms for sugar has improved: this is the case for coconut and *Caryota urens* in Sri Lanka. In the mid-seventies, with continuing foreign exchange crises, a reduction in the import of sugar occurred and was immediately followed by a sudden rise in its price and palm sugar again became a low-cost source of sugar (Dissanayake, 1977). In parts of South Sumatra (Sriwangi), tapping coconut for sugar production is 8 to 10 times more profitable than selling nuts (Levang, 1988). In the Philippines, a sequential coconut toddy and nut production system can provide the small scale coconut farmers with incomes nearly 10 times higher per hectare and per year (Maravilla and Magat, 1993). In Nigeria, an oil palm estate is likely to be better off devoting all its resources to the production of 9,770 litres/ha/year of oil palm wine than producing 10 tonnes of fresh fruit bunch per hectare per annum. Furthermore, as oil palm wine production is more labour-intensive than fresh fruit bunch production, tapping oil

palm trees for wine is likely to create more jobs than harvesting fruit bunches (Udom, 1987).

Producing sugar from palm trees that can be tapped all year round (like coconut and *Nypa fruticans*) is an advantage compared to the seasonal production of sugar from sugarcane. Palm trees that produce sugar seasonally, like *Phoenix sylvestris* from November to March (cold weather) and *Borassus flabellifer* from April to September (hot weather) would grow very well side by side, as suggested by Annett (1913) in Bangladesh, and would ensure continuous sugar production all year round.

Prospects for Increasing Sugar Yields

Indigenous knowledge is available in countries that have had a long experience in tapping palm trees. The tapper generally makes a selection before starting tapping: he chooses the trees that, according to his experience, should fulfill the following objectives: high sap yield, reduced time between commencement of working an inflorescence and the first flow of sap, maximum volume of sap sustained for as long as possible; health and well-being of the tree maintained during tapping (Pethiyagoda, 1978).

Different management techniques permit increased sugar production from palm trees. *Nypa fruticans* produces more inflorescences (and potentially more sap) when the stands are kept thinned of old leaves. Sap production can be improved by wider spacing between trees than in wild almost pure stands of *Nypa fruticans*: from 2,500/ha down to 500 or less (Hamilton and Murphy, 1988). In the Philippines, Quimbo (1991) developed a new, highly profitable method of tapping that increases the sap yield from less than 60,000 litres/ha to more than 100,000. Daily *Borassus flabellifer* sap yields average between 6 and 10 litres per tree but can be as low as 1 litre or as high as 20 litres per tree (Paulas (1983); Tjitrosoepomo and Pudjoarinto (1983) cited by Kovoov, 1983). This can be explained by genetic and environmental factors. More sap per tree can be obtained if each inflorescence produces more, over a longer period (skill of the operator), if there are more inflorescences in a given time, if flowering starts on younger trees and lasts longer (genetic factors) and if

the response to tapping is higher (genetic factors) (Kovoor, 1983). Tall varieties of coconut trees yield twice as much sap as dwarf palms and are also more resistant to pests and to droughts and winds because their root system is more developed (Jeganathan, 1974). The impact of manuring trees on sap yields is reported to be great for coconuts but scientific results are scarce. In Sri Lanka, through hybridization work to identify the most promising species with regard to nut production, an hybrid between a tall variety (Typica) and a dwarf one (Pumila) was found to be the best. Selection and breeding of the African oil palm for high sap yields and high concentration of sugar have not yet started. It is likely that yield improvement research will produce varieties that will yield more than 100 litres of sap per palm and more than 14,800 litres per hectare per annum (Udom, 1987). It is absolutely essential for most tapped palm species in Asia to have a sophisticated preparatory phase, sometimes continued throughout the tapping period, in order to ensure high yields of sap. Such a preparatory phase has not been reported in Africa for the African oil palm and it is likely that south-south transfer of technology could permit a major increase in sap production from this tree.

Prospects for Facilitating Sap Collection

For most non-destructive tapping techniques, a high degree of traditional expertise is needed and where this technique is not traditionally practised, great difficulties might be encountered in training people. In the case of the high sugar producing palms, reduced height would be a much appreciated quality decreasing labour time, effort and risks. Unlike the coconut, dwarf mutants and races have not been reported to occur in the case of *Borassus flabellifer* (Kovoor, 1983). This may be attributed to the lack of systematic research. An alternative would be to select the most precocious trees (that starts flowering at a very low height) as precocity is a genetic trait (Kovoor, 1983). Devices for safer and more efficient ways of climbing palm trees have been invented: one by Davis (1984), cited by Davis and Johnson (1987); another was developed by the Palmyra Development Board of Sri Lanka and using it, the tapper would be able to tap about 100 trees a day, more than twice the present average

(Dissanayake, 1986). Hybridization of the African oil palm with the American species, *Elaeis oleifera*, which has a creeping trunk and better resistance to disease (Kahn, 1988) could produce a productive variety, easy to tap because of low and stable height.

Prospects for Animal Production

Storage of sap at local level is not possible as fermentations rapidly occur even if delayed by some chemical agents. Fermented sap is not suitable for the production of good quality sugar and this usually limits the expansion of palm sugar making at village level. Processing sap into good quality jaggery is also a difficult and time-consuming task: up to 16 hours per day in Cambodia (Khieu, 1996). It also requires an experienced and skilled worker, often a woman (stirring, removing of froth and maintaining the appropriate temperature). This is also a major bottle-neck which limits sap processing (Dissanayake, 1986). Furthermore, in many countries, production and sale of toddy is prohibited by regulations and some raw material is wasted (Dissanayake, 1986).

On the other hand, meat demand is increasing in many developing countries as population grows and living standards improve: in the case of Cambodia, the pig population is increasing at a rate of 16.6% per year (Devendra (1993) cited by Khieu, 1996). Instead of preparing sugar from the sap of sugar producing palm trees, the sap can be directly fed to the animals and provide most of the energy needed in the diet. This has been done for centuries in two Indonesian islands, Roti and Savu (Fox, 1977). They have a complex diverse economy that has *Borassus* as the centre and which includes a small-scale semi-intensive or intensive pig-rearing component (7-8 pigs per household). In a *Borassus* economy, pigs are a prime means of converting palm products to protein. Pigs are fed fresh sap throughout most of the tapping season and therefore fatten during the dry season while other livestock lose weight. In addition, pigs always receive the residue and spill from the syrup-cooking process. During the rainy season they are frequently fed syrup mixed with water. Fox concludes in these words: "*Borassus* syrup and fruit constitute the primary food for pigs; pigs in turn are a principal means by which Savu's palm economy is able to support its dense population; pigs and palms go

together and one can view pigs as a reasonable indicator of palm utilization". This is further demonstrated by the strong correlations (much higher than for other livestock species) between pig and human populations in the different areas of these two islands. The areas where the population densities are highest, are the areas of most intensive pig rearing; pigs also representing the highest proportions of the total livestock (Fox, 1977). Captain James Cook, sailing west from New Guinea stopped at the Savu island from 17 to 21 September 1770, at the high point of the tapping season. He reported in his book "Voyages" detailed information on the use of Borassus. In this particular year, the crops were reported to have failed. Therefore the maximum harvest of sap was taking place in order to secure 6 to 8 months food supply. Despite this threatened food security situation, Cook witnessed that syrup was given to pigs and used even for other animal production: "I have already observed, that it is given with the husks of rice to the hogs, and that they grow enormously fat without taking any other food: we were told also, that this syrup is used to fatten their dogs and their fowls..." (Cook, cited by Fox, 1977).

Trials on feeding pigs with palm juice have been initiated recently in Cambodia by T.R. Preston, FAO consultant, within the framework of an FAO Technical Cooperation Project (FAO, 1995). Pigs were reared from 20 to 80 kg, with ADG of 356g using the following daily diet: approximately 8 kg of palm juice, 156g CP (soya bean), lime, salt and 500g of fresh water spinach per day. Twelve farms were studied. Taking into account the price of fuelwood, the profit per tree per day was nearly 14 times higher when the juice was used for feeding pigs instead of making sugar syrup (Khieu, 1996). Using fresh sap for feeding animals will avoid burning large quantities of fuel. Nevertheless, as part of this fuel generally comes from the palm tree itself, it might be possible to make syrup or sugar that will be easy to preserve and that will be later fed to the animals when the sugar production season is over. If this is not possible, sap production can be entirely used as fresh juice for feeding fattening animals and the fattening cycle can coincide with the sometimes rather short tapping season. This can easily be done with pigs and ducks. Sap, syrup or sugar could also be used as emergency feeds, replacing

other feeds whose production has been compromised by droughts or other calamities, whenever necessary. There is a huge potential for capitalising on under-exploited sugar palm trees which are not used because of the lack of fuelwood for making sugar or the limited marketing possibilities (Mogea *et al.*, 1991). In Sri Lanka, only about 2% of the total area suitable for tapping is reported to be actually tapped (Sivilingam (1983) cited by Dissanayake, 1986). Therefore, there is a niche for diversification. In these cases, the sap could be used for animal production. Present labour constraints can be overcome through the use of climbing devices that enable the tapper to tap twice as many palm trees (Dissanayake, 1986).

To balance monogastric diets based on sugar palm juice or syrup, a good source of protein is required. As soya bean is hardly available at a reasonable price in many tropical areas, some alternative sources of protein are needed: cassava leaves, sweet potatoes leaves, fodder tree leaves, aquatic plants (duckweed, Azolla, etc.), whole soya plant at milky grain stage, fish wastes, etc. Proper use and management of these different alternative sources of protein can contribute to reducing pollution, increasing carbon sinks and decreasing erosion. Animal feeding systems based on palm juice/syrup favours keeping the animals in confinement instead of grazing or scavenging systems. This protects the environment, limits the dissemination of contagious diseases and also optimizes the integration of livestock within an intensive farming system. Manure can be processed through a biodigester, producing the energy for family cooking needs, and the effluent can be used as a fertilizer either for crops or for fish ponds. The potential of feeding goats and cows with palm sap as the main source of energy for milk production should be investigated as well as the source of nitrogen (non-protein nitrogen and by-pass proteins), minerals and fibre to complete the diet. Incidentally, tapping palm trees will also always offer an easy source of sugar for bees which will tend to spontaneously harvest all wasted sugar. Honey production is therefore increased in areas where palm trees are tapped (Fox, 1977).

Conclusion

Borassus palms are the most numerous palms in the world after the coconut palm (Fox, 1977). Despite this, they are among the least studied of all the palm species in the world. This lack of interest can be explained during colonial history by the fact that, from the colonizer's point of view, it was much easier to set up, manage and control large sugarcane plantations to produce sugar than to use existing scattered palm trees that had been managed for centuries by the local people, often within a subsistence economy. Beside this, these trees are often associated with the poor. The fact that their juice quickly ferments and makes alcohol made tapping activities undesirable to governments, and also for the Hinduist, Buddhists and Muslims orthodoxes (Fox, 1977).

Nevertheless, there are many good arguments for revitalizing knowledge and research on sugar producing palm trees. Considering their multipurpose uses, they can contribute in many ways to the sustainability of integrated farming systems. As these trees are often the main subsistence resource for the poorest people (*Borassus flabellifer*), improving the way these trees are used will contribute to the alleviation of poverty. Palm tapping, especially as far as wild and semi-wild species are concerned, is an activity that does not require capital to start. In highly populated rural areas, it can be a major source of self-employment for the poorest people and avoid major drifts from the land. In the case of coconut (in Sri Lanka for example) or African oil palm (in Colombia and Nigeria for example), with the low and unpredictable world prices of copra and palm oil, it has become increasingly difficult for small farmers to depend on their production. This encourages attempts to find other ways of using these trees, including diversification for better sustainability of the system. Sugar production and animal production are alternatives to consider if markets can be developed for these products.

Future research on using palm tree sap for animal production should consider the following issues:

- Assessment of existing stands of wild palms (*Nypa fruticans*, *Borassus* sp., etc.) and the economic prospects for tapping these trees.
- Assessment of the economic potential of palm trees selected over centuries for sap production to be used in other regions.
- Identification of criteria for proper selection of individuals to be

tapped and for recognizing the proper plant stage for initiating successful tapping operations.

- Physiology of the production of sap flow and precise significance of the various acts that constitute the art of tapping in order to develop improved technologies for increasing sugar yields (techniques of tapping, frequency, fertilization, tree spacing) and to optimize the use of labour.
- Improved technologies for safely tapping trees.
- Techniques to preserve the juice and avoid fermentation.
- Identification of production systems with palm trees, crops and animals: according to the present economic and environmental changes
- Assessment of the relevance of tapping sugar palm trees for animal production in comparison with energy production (ethanol) or other products (copra from coconut or oil from oil palm).

What is needed is a thorough field survey reviewing in detail all indigenous knowledge related to tapping palm trees for sugar and animal production. This would permit a major breakthrough for assessing all the future potential of these trees and for sharing techniques and experiences between regions and countries. Once the potential of tapping palm trees for sugar and animal production has received the full attention it deserves from decision makers through funding research, selection, technology improvement, training and extension and small credit for farmers, many rural areas are likely to benefit from a new source of self-employment and sustainable income.

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