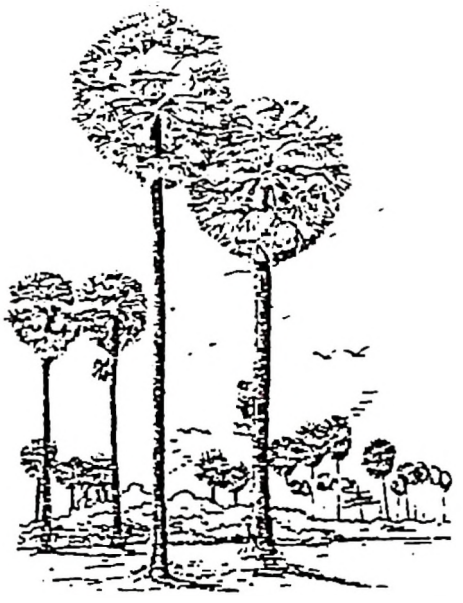
A STUDY ON THE USE OF THE SUGAR PALM TREE *(Borassus flabellifer)* FOR DIFFERENT PURPOSES IN CAMBODIA

by

Borin Khieu



Institutionen för husdjurens utfodring och vård

Swedish University of Agricultural Sciences
Department of Animal Nutrition and Management

M.Sc. Thesis

Uppsala 1996
ISSN 0347-9838

Tryck: SLU/Repro, Uppsala 1996

DEDICATION

This thesis is affectionately dedicated to my beloved parents, Khieu Yoeun and Tun Ponn, Khlok Peng Thol, my wife and Khieu Mayouty, my son.

PREFACE

This thesis is based on the following papers which are referred to by their Roman numerals:

I. Borin, Khieu; Preston, T. R. and Lindberg, J. E., 1996. Juice production from sugar palm tree (Borassus flabellifer) in Cambodia and performance of growing pigs fed sugar palm juice (manuscript).

II. Borin, Khieu; Lindberg, J. E. and Preston, T. R., 1996. A study on Multipurpose Sugar Palm tree (*Borassus flabellifer. L*) and its product as animal feeding in Cambodia (manuscript).

CONTENTS

A STUDY ON THE USE OF THE SUGAR PALM TREE (Borassus flabellifer) FOR DIFFERENT PURPOSES IN CAMBODIA

Borin Khieu
Department of Animal Health and Production (DAHP), Ministry of Agriculture, Forestry and Fisheries (MAFF), Phnom Penh City, Kingdom of Cambodia.

ABSTRACT

This thesis is based on two studies carried out in two different districts of the Kandal and Takeo provinces in Cambodia where a dense populations of the sugar palm (Borassus flabellifer) are found. The aim of the studies was to understand the sugar palm tree and the traditional pig production systems .The studies comprised quantification of sugar palm juice production and the use of palm juice as an energy feed for pigs. A participatory study was conducted in five villages to determine the profitability of sugar syrup production and of pig production based on sugar palm juice. The further study consisted of a feeding trial in which the growth performance of crossbred pigs fed diets consisting of palm juice and boiled whole soya beans with a supplement of water was evaluated.

Sugar palm is considered as one of the high potential multipurpose trees in the tropics, and produces valuable carbohydrates without any agronomic inputs. A total of 105 male and female sugar palm trees were studied during a period of five months, the results demonstrating that a palm tree produces seasonally an average of 5 kg of juice per day with a Brix value (approximate sugar content) of 13.3%. Assuming that the canopy of a palm tree is 50 m², a hectare of 200 trees will seasonally produce approximately 150,000 kg of juice per year.

Sugar palm syrup production is one of the two main activities of most rural Cambodian farmers after rice growing. The activity commences in December with the preparation of materials for sugar syrup production. The most expensive component in the cost of sugar syrup production is fire wood which is difficult to get today. It was clearly shown during the present study that when fire wood was purchased from the market four of seven farmers lost an average 27 Riels per day (1 $US =2,350 Riels).

There were no significant differences between days in the yield of juice and Brix value (approximate sugar content) (P=0.390 and P=0.534), respectively. However there was a highly significant difference in the yield of juice and Brix value (approximate suagr content) between families, months and sex of the palm tree (P<0.001) and a significant difference in Brix value (approximate sugar content) between male and female trees (P=0.005).

Seventy two crossbred pigs comprising Yorkshire, Landrace and local pigs raised from 20-80 kg on 12 farms. The main energy source was palm juice fed restrictly. A daily amount of 400g soya beans of protein source were and daily supplement of 0.5 kg of water spinach and lime and salt were given. The average daily weight gain of the pigs of the twelve farmers was 356 g (range 320-417 g) and there were no statistically significant differences in live weight gains between fams (P=0.735).

The demand for meat increases as the population grows, and the living standards improve. Therefore, the new technique to feed pigs with sugar palm juice is an alternative and interesting source of income for rural communities in Cambodia. In addition, it will create work for the farmers and reduce the migration to the cities and simultaneously improves the use of local resources increasing the sustainability of agriculture.

Keywords: **Borassus flabellifer; Multipurpose; Pigs; Palm juice; Fire wood; Brix value; Sugar palm; Soya beans, Sustainable production.**

INTRODUCTION

Devendra (1993) reported that there was an average annual growth rate of 16.6% of the pig population in Cambodia and that was the highest rate among the countries of South-East Asia. The production of meat from non-ruminants (pigs and poultry) will increase faster than that of meat from ruminants, which tends to increase the demand on energy and protein to support the production. The most common feeds used for pigs in the country are rice bran as a dietary basis and kitchen waste, banana stems and sweet potato leaves. There are also other feed resources like water spinach, water hyacinth, cassava and small fish. The latter are accessible in the regions near to the rivers, lagoons and lakes.

Fattening pigs is one of the sources of farm cash income for the rural farmers in Cambodia. Generally, piglets are purchased after rice harvest. The reason for buying piglets at this time is that farmers will have enough money and feed available from rice by-products. The traditional feeding practices depend on the available feed resources in the region. The low performance of pigs in the traditional production system is basically a result of the poor quality, the availability of feed resources and the insufficient feed supplement. There are also other important factors that affect the production system, such as management, breeds and mortality caused by infectious diseases and parasites.

As Preston and Sansourcy (1987) and Preston and Leng (1988) have suggested, one way to achieve sustainable animal production systems is to match them with the available local resources. This approach requires studies on the animal production system as a whole, including socio-cultural, economic and environmental aspects, instead of individual animal productivity as a unique paradigm.

Cambodian farmers have demonstrated their capability of improving their living situation partly by using new methods in agricultural production, so also to improve pig production. An important part of this thinking is the strategy to increase animal production based on local resources. The use of sugar palm juice as an energy feed for pigs could be an interesting possibility for the small farm. The diversification of palm juice for growing and fattening pigs will help to stabilize the environment and conserve the biodiversity by decreasing fuel wood consumption for sugar production. However, in order to ensure the technical and economic feasibility of pig production, it is necessary to either utilize conventional feeds or develop new alternatives based on non-conventional feeds for pigs.

Studies on the use of sugar palm juice as an animal feed is scanty. However, a number of researchers have shown that sugar cane juice or sweet feeds can be successfully used as substitutes for cereals in pig diets (Fernandez, 1988; Mena, 1987 and 1988; Elliot and Kloren 1987; Preston, 1991; Beech et al. 1991; Speedy et al. 1991; Phuc et al. 1994a and b, etc). In order to evaluate sugar palm juice as pig feed, scientific data are needed. However, in addition it is very important to evaluate the farmers' opinion, and the economic feasibility of using this feed resource.

This research project was focussed on the use of sugar palm juice as the main energy source in diets for pigs. The main objectives were to determine the variation of yield and the Brix value (estimated by the refractometric method determining the sugar content) from each

individual palm tree (male and female) at different times during the production period (Paper I) and to determine the growth performance of pigs fed diets based on restricted quantities of juice from the sugar palm tree (*Borassus flabellifer*) supplemented with soya beans as the major protein source plus supplements of water spinach and minerals (Paper I). The aim was also to study the use of the multipurpose sugar palm tree (*Borassus flabellifer. L*) and its products as animal feed and alternative uses in rural areas in Cambodia.(paper II).

GENERAL DISCUSSION

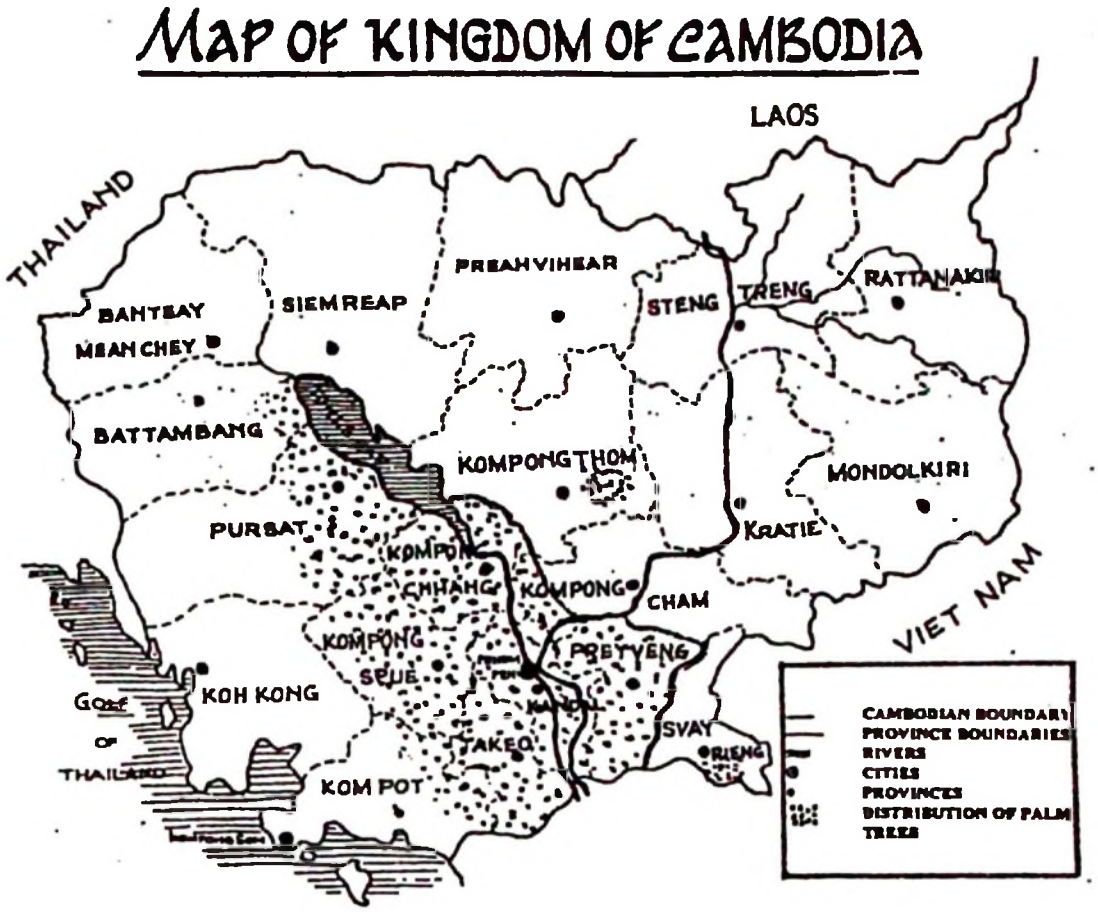
1. Distribution of the Sugar Palm tree (*Borassus Flabellifer L.*)

1.1 General

According to Kovoor (1983) the genus *Borassus* is made up of seven species, although present day taxonomists recognize no more than four (Uhl and Dransfield 1987). Whatever the true number of species, the genus *Borassus* is one of the most widely distributed palm trees, found in a broad belt from western Africa to eastern Indonesia. It is a genus adapted to tropical wet/dry climates. The three economically most important species are *B. aethiopum Mart.* (occurring in Africa), *B. flabellifer L.* (found in coastal areas of India, northern Sri Lanka, and mainland southeastern Asia) and *B. sundaicus Becc.* (restricted to Indonesia). In each of these geographic areas *Borassus* palms are of significant value to the local populations (Davis and Johnson 1987). There are other palm trees which provide also valuable product for people in different countries in Asia, Africa and South America. (See Annex 1).

Romera (1968) estimated a total population of 1.8 million palm trees in Cambodia, while at present the estimated population is approximately 6 million trees (local press and Ministry of Industry 1995). The most dense populations of *Borassus flabellifer* are found in the provinces of Kandal, Kompong Speu, Takeo, Kampot and Kompong Chhnang (See Figure 1).

Figure 1. The distribution of the sugar palm tree in Cambodia.



1.2. Ecology

In April 1983, five soil samples were taken in different sites at Kandoeun Commune in Takeo province. The average pH of the samples was 5.5 (range 4.9- 5.8) which agrees with Romera (1968) who reported a soil pH of 5.5 in the palm tree regions of Cambodia. The average rainfall is approximately 1,200 mm per year and the humidity ranges from 55 to 75%. Tkatchenko (1948) noted that the sugar palm tree in Cambodia is quite drought resistant and that it also suffers remarkably little from prolonged flooding.

2. Different domestic uses of the sugar palm tree

2.1. Juice (sap)

The main product of the palm tree is juice (teck thnot) for sugar syrup (skor thnot) production. The Brix value (approximate sugar content) of juice is about 13% and it has been increased to approximately 80% by evaporation (sugar syrup). The palm tree reaches maturity in terms of juice production at an age of 15-20 years, depending on the fertility of the soil (Borin, personal communication). Davis and Johnson (1987) discovered that the first flowering takes place when the palm is 12-20 years of age and Morton (1988) considered that the palm starts to bloom when about 20 years old. The male palms begin to give inflorescences early in the dry season (November-December), while female trees gives

inflorescences approximately one to two months later. The female inflorescences can be used for juice production for a longer period (about three to four months) than the male inflorescences. The sugar palm juice is mostly protein free, but it is rich in some minerals and vitamins (Paulas and Muthukrishnan 1983).

2.2. Leaves

Approximately 80-90% of rural houses in Cambodia are constructed with leaves and trunks from palm trees. The leaves are mainly used for thatching and matting. According to farmers in Bati and Punhear Leu Districts, 25-36 leaves are annually collected from a tree that is not exposed for juice production, and similar figures (25-40 leaves) were reported by Morton (1988). The leaf is separated from the petiole and sun-dried for 2-3 days. The hard part of the branch is used to strengthen the thatch. However, a bamboo stick would be a better alternative material to use for this purpose. The fresh thatch is soaked in water for 3 days and redried for approximately 2 days. This procedure is used in order to prevent the leaves from being attacked by insects. The thatches last for 3-5 years after this treatment, depending on the form of thatching. Palm leaves were also used in the past, especially by monks, to write upon with an iron stylus. Some leaves from the young tree can be made into fans for domestic use. Hats or boxes are also made from the third and fourth of the top leaves.

2.3. Fruit

Each palm may bear 8-15 bunches of fruits with a total of about 80 fruits per year. The immature fruits are sold in the market for human consumption. The soft-shell at the top of each fruit is chopped in slices to be used in soups with fish or meat and other vegetables called in the Cambodian language "*Kako* and *Praheu*". The kernel is eaten fresh or prepared as a sweet with some sticky rice which is commonly sold along the roadside. The rest of the fruit after kernel extraction, and tender fruits that fall prematurely, are chopped for cattle feeding. The mature fruit is soaked in water and then the wiry fibres sucked out. The yellow pulp of the fruit is mixed with rice starch. The mixture is put in a banana leaf folder and later steam cooked. The fresh pulp has been reported to be rich in vitamins A and C (Morton 1988).

2.4. Trunk

The palm trees are cut for timber when they are over 10 m high and are about 70-100 years old. The whole trunk is used by sawing out the middle (soft part) of the trunk and the strong, hard outer wood is used for house construction. This part of the trunk is more durable than other kinds of wood when used in the shade and protected from rain. The whole trunk can also be made into a small boat which is able to carry at least 3 persons for fishing or for transportation on the lakes. The terminal bud (palm cabbage) is edible. Usually it is used in a soup with fish or meat and vegetables.

2.5. Brush fibre

The most important fibre product comes from the bifurcated portion of the leaf base. The leaf bases of the mature tree are beaten with a piece of wood until the outer covering and the

white soft material surrounding the fibre are removed. The fibre extracted from the base of the leaf stalk has valuable qualities such as resistance to chemicals, termites, water etc. (Jaganathan and Mohanadas 1983). The raw fibre with a black and brown colour called *Chhourk thnot* has the best quality and is commonly made into brushes and ropes to tie animals.

3. Sugar palm juice production

3.1. General

The palm tree is one of the valuable plants in the tropics that is grown without agronomic inputs. The tree is considered to be a very important multipurpose tree and it is also the national symbol of Cambodia. The whole tree is used for many purposes, especially the juice for sugar production, leaves for thatch, trunk for timber and fruit for human or animal consumption. According to Paulas and Muthukrishnan (1983) the sugar palm juice has a high nutritive value due to it high soluble carbohydrate content (98.4 %) of dry matter content (Table 1).

Table 1.
Composition (% of dry matter) of sugar palm syrup

Crude protein	0.24
Fat (ether extract)	0.37
Mineral matter	0.50
Carbohydrate by difference	98.89
Carbohydrate (direct polarimetry)	98.40
Calcium	0.08
Phosphorus	0.064
Iron (Fe)	0.3
Nicotinic acid	0.04

Paulas and Muthukrishnan, 1983.

The sugar palm juice can be proceeded in 3 types of sugar in the small farm level, the liquid sugar (sugar palm syrup), the solid palm sugar and the block sugar. The most common type for the consumption in the countryside is sugar palm syrup which is about 80% of dry matter content. The later proceedure is refined sugar which is made at the small artisans. (Annex 2)

3.2. Effect of the skill of the tapper on juice production

The most important technique for tapping palms is the manipulation of the inflorescence. Juice production from the inflorescences is stimulated by crushing of tissues of the inflorescences. However, the cells of the crushed tissues should not be completely destroyed in the process. The interval from the commencement of tapping to the dropping of the juice depends on the experience of the tapper. The time interval of 5 to 8 days is used to crush and massage the flowers (farmers in Bati District, Takeo province). The juice is then collected twice daily in highly productive trees (morning and afternoon). It is usually possible to continue tapping a single spathe till it is reduced to a stump of about 10-15 cm in length.

When the palm trees start giving many inflorescences at the same time, the tappers are not able to collect juice from all. The inflorescences are therefore sliced and crushed for 5-8 days and then preserved (3 to 5 months) for juice collection some months later.

The daily production of palm juice will mainly depend on the skill of each tapper. When a tapper is replaced for a short period, the sap flow often diminishes on the following day of the replacement. Kovoor (1983) reported that the flow of juice results from the stimulus produced by the manual operation of tapping, and thus depends on the physiological response of the palm. There is enormous variability in daily yield per tree and tree-to-tree juice production. Depending on the tree, weather and location, from one to seven inflorescences may be tapped at a time. As shown in the present study (Paper I) juice flow is reduced as the process continues ($P<0.001$) but the Brix value (approximate sugar content) increases ($P<0.001$).

3.3 Juice collection technique

The inflorescences of the male and female palms are bound, beaten and then sliced for approximately 5 to 8 consecutive days before juice can be collected. The tapping process is repeated every 2-3 days during the production season. The inflorescences can also be preserved for later use after being prepared according to the above mentioned procedure (3.2). A pair of rounded wooden or bamboo mallets are used for female inflorescences and flat wooden tongs are used for the male inflorescences (Annex 3 and 4). The small fruits around the female inflorescences should not be crushed during the preparation. The juice is chanelled into a bamboo or plastic collector. The bamboo collector is called an *Ampong* and has a diameter of 10-15 cm, a height of about 30-40 cm, and can contain 2-4 kg of juice. For each tree an average of 4-6 collectors are used according to the number of inflorescences coming up at the same time. The collection is done twice daily (morning and afternoon) in order to limit the exposure of juice to contamination by yeast and other fermenting micro-organisms. Farmers believe that pruning negatively affects the juice production.

3.4. Juice yield and Brix value (Approximate sugar content)

Pethiyagoda (1979) accordingly refers to a 'climacteric' of respiratory phenomena which could be associated with juice flow in the palm. The interview with groups of farmers in Punhear Leu District showed that there is a great variation of yield according to night time temperature. Under the cool conditions (around 20-25°C), the juice flow increases and the juice can be kept for a long time without fermentation. Rain might also positively influence on the yield of juice in the following days. Paulas (1983) and Tjitrosoepomo and Pudjaorinto (1983) reported that low yielders may produce only about one litre of juice per day, while at the other extreme, individual palms are known to give up to 20 litres per day, while the average yield was 6-10 litres. In the present experiment an average yield of juice of 5 kg per day per tree was found (Paper I). The drought that occurred in Cambodia in 1995 might have affected the juice yield during the experimental period. There were no significant differences in the daily yield ($P= 0.390$), but there were highly significant differences according to farm, month and sex of palm tree ($P<0.001$). This agrees with Porteres (1964) and Lubeigt (1979) who reported that female palms are supposed to yield more juice on tapping than males, either from the terminal bud as practised on the Ivory Coast or from the inflorescence as

practised in Burma. In the present study, the Brix value (approximate sugar content) of female and male palms had a significant difference (P=0.005), which were 13.4 and 13.2%, respectively (Paper I). In contrast, Sivalingam et al, (1983) reported that the juice of male inflorescences was 13% richer in sugar than the juice from female inflorescences. Normally female inflorescences are tapped for a longer period than male inflorescences (about 3 to 4 months), although male trees start giving inflorescences one to two months before female trees.

3.5. Rural experience of conserving sugar palm juice

The fresh juice without fermented agents starts to deteriorate naturally within a few hours after sunrise, especially in hot weather. When the juice is collected for sugar production, fresh juice for human consumption and animal feeding, fermentation should be avoided as far as possible.

The normal procedure is that the collectors are fumigated with the smoke of palm leaves or are cleaned with boiling water before every collection time in order to kill the microflora. In order to achieve this in the juice a piece of the bark from *Shorea cochinchinensis* is put into the collector. The bark is left in the collector during juice collection (about 15 hours). There are also other anti-fermenting agents such as lime (calcium hydroxide) that is available in local markets, but farmers do not use it. They think that lime has a negative effect on the quality of sugar and the fresh juice for drinking. Tkatchenko (1948) found out during his systematic study in Cambodia that commercial formalin at 5 ml/l of juice or 7 to 10 g of lime/l of juice conserves the juice quite satisfactorily for more than a day against fermentation. Larrahondo and Preston (1989) in their experiments found that sodium metasilicate (Na2SiO3) at 5-7g/l of cane juice was effective for up to 96 hours.

The natural fermented palm juice (*Teck thnot chhu*) is also a common alcoholic beverage in the countryside, and vinegar is also made from fermented juice. Davis and Johnson (1987) reported that when the juice is allowed to ferment through the action of air-borne microorganisms, an alcohol content of 5 to 6% may be reached. The upper limit of alcohol is set not by the quantity of sugar available in the juice, which always is in exccess. However, the natural fermenting organisms are killed at an alcohol concentration of 5-6% leaving a lot of fermentable substrate. Rogers et al. (1982) mentioned that the most efficient yeasts are therefore mutants of Zygomonas mobilis (strain ATCC 29191) with increased tolerance to extracellular ethanol.

3.6. Climbing technique

Cambodian tappers use long bamboos poles with the stumpy remnants of leaf bases at the nodes which serve as rudimentary steps for climbing. These are rivetted permanently to the base of the trunk (Annex 5). When palm trees are close to each other, one to two long bamboo stairs are used to keep the investments down and to save time for climbing. Most tappers collect juice only once daily (in the morning), because according to their experience during the day time the temperature is too high for the palm to produce quantities of juice. Tappers are capable of tapping more than 20 palm trees twice a day when one assistant is available at the base of the trunk.

4. Sugar palm syrup production

4.1. General

In sugar production technology a simple direct refractometric measurement of the percentage of total solids in juice is possible and isexpressed as degrees Brix value (approximate sugar content). Total sugars represent about 95% of this value (Gooding 1982).

One palm tree produces an average of 5 kg of juice daily, containing 13.3 % of Brix value (approximate sugar content) which makes approximately 90 kg of solid sugar per tree per season. Assuming that the canopy of a tree occupies 50 m², one hectare with 200 palm trees will produce 150,000 kg of juice per year which is equivalent to 18 tonnes of solid sugar per hectare.

The most important component for sugar syrup production is fuel. Today fire wood has become the main constraint in this production system. Farmers are not allowed by the local government (Kandoeung Commune, Bati District, Takeo Province) to cut trees in the forest any more, as the area is now preserved as a National Park. The yield of rice in this area used to be 3-5 tonnes per hectare per year, but from 1979 after the disappearance of the forest, the yield of rice drastically dropped down to about 1.5 tonnes per hectare per year. This means that not only yields of rice but also other agricultural activities have negatively changed after deforestation. The forests have been destroyed to produce fire wood for boiling palm juice and also for other domestic uses.

4.2. Traditional sugar palm syrup production practices

Usually people in the rural areas start preparing their tools for palm syrup production early in the dry season, such as bamboo to make rudimentary steps, containers, bamboo ropes, clay stoves, pans of 50-60 kg capacity, stores of fire wood, sharpe knives and especially bark to prevent fermentation of the juice (bark of *Shorea cochinchinensis*). Husbands and young men are the climbers and tappers while the women do the rest of work, such as collecting fire wood, cleaning and preparing collectors, boiling juice, mechanical crystallization and sometimes selling sugar palm at the market (Annex 6). Families without the man power to climb the tree rent out a palm tree for 5 kg of sugar per palm per season, that is equivalent to 3,000 Riels.

4.3. Fuel consumption for sugar production

In the traditional routine of sugar production, fuel consumption has not been included in the cost of production. Farmers could in theory obtain fire wood in the common forest or around their households, but at present, as fire wood is scarce, palm trees are cut to boil juice for sugar. Some farmers who do not produce sugar sell a palm tree for 5,000 to 10,000 Riels. The whole trunk of a palm tree lasts for about 15 days making approximately 150 kg of sugar (Ang Snoul District, Punhear Loeu District, Kandal province, 1993 and 1995, respectively). During the present study (Paper II) seven farmers were chosen to determine the fuel consumption for sugar palm production. It was found out that 4.6 kg of fire wood was needed

to produce 1 kg of sugar from 6.1 kg of palm juice, which means a total of 460 kg of fire wood per tree per season. Dolbert (1991) estimated that 3-4 kg of fire wood was needed to produce 1 kg of sugar. The consumption of fire wood for sugar production can vary as it depends on the quality of the fire wood, type of stove (Annex 7) and sugar contents of the juice. Dolbert (1991) reported that modification of stoves has been introduced in which rice hulls was used as fuel for boiling juice. However, in a hectare of rice, the yield of rice hull is about 240 kg) which covers only 4.5% of the total fuel consumption for condensing the juice of 20 trees.

5. Traditional and alternative animal feeding systems in rural areas

5.1. General

Livestock and poultry actively contribute to the livelihood of the small farms in the rural areas in Cambodia. Cattle are raised as source of draught power for rice production and manure as fertilizer, as source of meat for consumption at ceremonies and/or sale when they are not capable of working (too old or sick). The main source of feed for cattle is rice straw, while in the rainy season cattle grazed along the roadsides and dykes. Chickens are commonly raised as scavengers and are supplemented with only a little paddy rice in the morning. They are kept for home consumption and sale. However pigs are mainly raised as a source of seasonal income for the family. Most animals in the rural areas in Cambodia are kept as scavengers, it could be the cheap ways of management, but it is also a risky system as diseases can spread out from one animal to the others.

5.2. Traditional pig feeding and management systems

Pigs in the rural areas are commonly raised by allowing them to run free (scavengers) especially in the dry season. Pigs are fed with kitchen waste, sometimes supplemented with banana stems or sweet potato leaves and rice bran. The composition of the diet will depend on the money available to buy feeds and the availability of by-products from the farmers' own paddy rice mill. Generally, pigs grow slowly due to the use of feed supplements with a very low content of crude protein and high fiber content. Solarte et al. (1994) found that the growth rate of pigs under the traditional management system was only 60 g/day, while when supplemented of 200 g of crude protein daily, the weight gain increased and ranged from 243 g to 445 g/day. The performance of pigs in the rainy season seems to be somewhat better than in the dry season, as the pigs are able to find supplementary feeds to eat, like earth-worms or green leaves which improves the protein supply. Normally, however the pigs are tied during this period because it coincides with the rice cultivation time. When pigs are set free, they are usually affected by parasites and diseases.

Piglets in the rural areas are sold with an average live weight of 4 to 6 kg at an age of about 40 to 50 days. A high mortality rate is observed at this stage. Cunha (1977) recommended that piglets should be supplemented with a diet containing 22% CP of a good quality. In contrast, piglets in the rural areas of Cambodia are offered the same quality of diet as given to adult pigs or even worse.

5.3 Alternative pig feeding systems

The sustainability of pig feeding systems in Cambodia as well as in other developing countries is aimed at making the best use of local feed resources. Feed accounts for about 60 to 80% of the total costs in pig production, which means that the efficient use of locally available feeds plays a major role in a profitable and sustainable pig production.

The unavailability of high quality feeds and the lack of money to import certain ingredients such as vitamin/mineral premixes which are commonly produced in the developed countries, make it very expensive to adhere to the standard nutritional recommendations. However, feeding pigs with expensive rations will not mean profitable production for the small farmers. Instead the cost of feed per kilogram of meat produced should be considered.

Sugar palm juice can be a good source of cheap energy in diets supplemented with high fibre vegetable protein and water plants, as reported by Mena (1988). Sugar palm juice is similar to cane juice in chemical composition and is characterised by being free from fibre and having a low lipid content (ether extract 0.4%). Preston and Murgueitio (1992) mentioned that leaves and water plants are the complementary sources of tropical biomass, providing protein to balance the carbohydrate in sugar cane and fruit crop by-products. The advantages of these natural resources are that they require minimum inputs, are long time members of the tropical flora, and help to protect the environment.

6. Protein supplement

6.1. General

The principal objective of modern pig production is to maximize the daily lean gain. It is important that the maximum rate of body protein deposition is achieved with as little wastage of the ingested protein as possible. It is therefore advisable to provide feed to pigs with the necessary amount of protein containing a well balanced profile of essential amino acids. However, it should be pointed out that local breeds of pigs reared in the tropics have a much lower potential of lean tissue deposition than modern hybrids, so their requirements for protein will be much lower than the recommended in the text books. It is known that if any one amino acid is lacking in the proper amount, this will limit the utilization of the other amino acids in the diet. The reasons for avoiding an excessive intake of protein are that this results in an inefficient use of protein that is expensive and that the excretion of nitrogen contributes to environmental pollution. Holness (1993) confirmed that surplus of protein or excess of amino acids to the requirement of pig, cannot be utilised by pig, they are deaminated in the liver. The nitrogen is excreted in the urine and the remaining deaminated fraction is used as an energy source. Therefore, it is not recommendable to provide this expensive nutrient in a higher quantity than needed or what corresponds to the energy supply chosen.

6.2. Conventional protein resources

Soya beans are used throughout the world as a protein supplement, and are grown locally in

the red soil of the north-eastern part of Cambodia in the provinces of Kampong Cham, Kandal and part of Kampong Chnang. The harvest time is between October-November when the price is reasonable for animal feeding. Soya beans however are mostly earmarked for export. Soya beans are the richest source of protein of all the common seeds used for animal feed, but contain trypsin inhibitors, which block the activity of the digestive enzyme trypsin (Göhl, 1994). To destroy the trypsin inhibitors, whole soya beans should be heated thoroughly before feeding to monogastric animals. Industrially, toasting is the standard method for neutralizing these compounds. Toasting can also be done at farm level but it is not always reliable. Too high or prolonged heating will make the essential amino acids less available. It is better to boil the beans for 30 minutes after soaking in water the previous 24 hours (Preston, 1995). Although this method consumes fuel, at least it avoids the need to grind the beans, as the soaking and boiling soften them to the point where they are easily digested.

The price of soya beans fluctuates in the different seasons of the year because of the regional market demands. In January 1995 the price was $US 265 per tonne of soya beans and a few months later was $US 520 per tonne. Cunha (1977) recommended the use of whole soya beans in swine feeding if the economic considerations warrant this.

Another source of cheap protein is small fishes which are caught between December-March from the Mekong river. The price of fresh small fish is about 100-150 Riels per kg during the above mentioned period, which will reduce the cost of pig diets if they replace soya beans.

The fish can be preserved by different methods, but the cheapest and most common method for Cambodian conditions is sun-drying. The small fishes which can not be sold for human consumption are sun-dried and ground to a fish meal for livestock feeding. Göhl (1994) reported that fish meal has become a standard ingredient in monogastric rations to make up for deficiencies of essential amino acids and the maximum recommended inclusion in pig diets is 10%. Small fish should be a good protein supplement for pigs in the rural areas of Cambodia. McDonald et al. (1992) reported that fishmeal has high contents of lysine, methionine and tryptophan. In addition, fish meal has a high mineral content, about 210 g/kg, which is of value nutritionally since this is made up of a high proportion of calcium (80 g/kg) and phosphorus (35 g/kg). Fish meal is also a good source of vitamins of the B complex. The price is about 100-150 Riels per kg, which is equivalent to $US 40 to 60 per tonne fresh fish. Ensiling is another alternative way to preserve fish. This could be a profitable way to preserve fish, as sugar palm juice is available at the farm in this period and could provide a carbohydrate source to facilitate the ensiling process. Ensiling is a simple and inexpensive way of utilizing waste from fish which are difficult to preserve by sun-drying.

6.3. Alternative sources of protein

A cheap alternative source of protein could be green leaves and water plants. The water plants and leaves (table 2), such as sweet potato leaves (*Ipomoea batata*), water spinach (*Ipomoea aquatica*) and water hyacinth (*Eichhornia cressipes*) are used by small scale pig producers in Cambodia. However there are other resources that are available in the rural areas such as cassava leaves (*Manihot esculenta*), duckweed (*Lemna spp*) and azolla (*Azolla filiculoides*).

Cassava is grown along the Mekong river and is harvested before the water in the river rises. After harvesting the tubers, cattle are allowed to eat the leaves. Cassava leaves are a good source of vegetable protein, and it is possible to obtain more than 6 tonnes of CP from cassava leaves per hectare per year with the proper agronomic practices directed toward foliage harvesting (Göhl, 1994). Phuc et al. (1995) reported that nitrogen balance in growing pigs fed a cassava root meal diet was unaffected when cassava leaf meal replaced up to 35% of the protein from soybean meal.

Duckweed grows wild in the ponds and canals close to farmer households during the rainy season. In Cambodia duckweed is mainly used as duck feed. Elliott et al (1987), Preston et al. (1992) and Bacerra (1991) argued that water plants represent a highly productive source of protein-rich biomass which appears to make an ideal complement for fibre free basal diets such as molasses and sugar cane juice in pig and poultry diets. When effectively managed duckweed yields 10-30 tonnes DM per ha per year, and contains up to 43 % CP, 5% fat and highly digestible dry matter which can be used as a protein source for pigs with only slightly less efficiency than soya bean meal (Leng et al. 1995).

Another complementary source of tropical biomass, providing protein to balance the carbohydrate in sugar cane and food crop by-products, are trees (Preston and Murgueitio 1992). Foliage from legume trees and water plants are a cheap and excellent source of protein for animal feeding . However, studies reported up to now have been focused on a few species, especially the legumes due to their diversity in the tropics and sub-tropics and nitrogen fixation capacity. Solarte et al. (1994) found out that there are other potential candidates in the tropical flora which have a high protein content (17- 23% CP in DM) such as *Urera baccifera (L) Gaud, Ipomea batata L., Eupatorium acuminatum* etc. Not all the non-conventional feeds support high daily weight gains, but they often give high economic profitability.

Table 2.
Chemical composition of unconventional protein supplement

		---- As % of dry matter ----				
	DM	**CP**	**CF**	**Ca**	**P**	**Ref.**
Sweet potato leaves	8.7	21.9	15.0	1.8	0.2	1
Whole water spinach	9.6	27.1	16.4	1.1	0.5	2
Water hyacinth	7.8	12.8	24.6	2.1	0.4	1
Cassava leaves (8 months)	16.1	24.1	26.0	1.0	0.5	1
Duckweed	4.7	38.6	18.7	0.7	0.6	3
Azolla	5.6	26.7	8.4	0.4	0.5	4

1.Göhl (1994), 2. Naren et al. (1994), 3. Men et al. (1995), 4. Becerra et al. (1995).

6.4 Vitamin supplements

Vitamins are required by animals in very small amounts compared with other nutrients. Nevertheless a continuous deficiency in the diet will result in a disordered metabolism and eventually disease (McDonald et al. 1992). Pigs in the rural areas in Cambodia are supplied with water spinach (*Ipomoea aquatica*) and sweet potato leaves (*Ipomoea batatas*) as sources of vitamins.

Göhl (1994) mentioned that the principal nutritive value of sweet potato vines is as a source of vitamins and protein. Naren et al. (1994) reported that water spinach has been found to contain high levels of protein and vitamins A (carotene), B1, B2 and C and minerals. Both water spinach and sweet potato vines have the important advantage of providing a vitamin supplement in the rural areas where premixes are not available and may be very expensive.

CONCLUSION

The yield of juice and brix varied considerably tree by tree, according to the sex of the tree and between individual farmers. Some trees produced up to 20-25 kg of juice per tree per day, but the other trees produce an average of 4-6 kg within a similar micro-climate. Therefore further studies on this topic are needed.

The scarcity and high price of fire wood at the present time greatly influences the cost of the sugar production from sugar palm juice. This critical situation will make sugar production from sugar palm juice unprofitable. However, it continues to be a valuable product for people who still have access to free fire wood.

Improving pig production in the rural areas appears to be an logical strategy as the demand for meat will be higher while the population and incomes grow. Therefore the sugar palm juice could be an alternative energy source for growing and finishing pigs, as the tree has been shown to have high potential to produce large amount of soluble carbohydrates. The diversification of juice for pig feeding will provide a good profit and improve the living conditions of the farmers. In addition palm juice fed to pigs rather than being used for sugar production will also prevent the deforestation and preventing the immigration to the city.

The protein supplement is the most expensive component in most animal diets, especially pigs and poultry. In order to improve the profitability of pig production other cheap alternative source of protein, such as leaves and water plants should be utilized. In pig production system suggested here it is recommended to keep pigs in pens to prevent infection with parasites and other risks. In addition it will be easy to collect the manure from pigs to feed biodigesters which provide gas for cooking and leads to a cleaner and healthier kitchen environment.

ACKNOWLEDGEMENTS

The studies were carried out during 1995 in the Districts of Bati and Punhear Leu, in Takeo and Kandal provinces, respectively in Cambodia, as a requirement of the Master of Science degree in " Integrated Livestock-Based Systems for the Sustainable Use of Renewable Natural Resources", administered by the Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences. These studies were made possible through the financial support of the Swedish Agency for Research Cooperation with Developing countries (SAREC) and from the Ecumenical Scholarships Programme in Germany (DIAKONISCHES WERK).

I also would like to express deep gratitude to Professor Hans Wiktorsson, Dr Brian Ogle, Dr Peter Uden, Dr Inger Ledin, Dr John Öhrvik, Frands Dolberg, Britta Ogle, Dr Andrew Speedy , Dr Anil Gupta, and other professors and lecturers for their great support and scientific guidance during the course. Thank also due to Mr Börje Ericson for his great assistance in analysing samples. I am also indebted to Dr Rene Sansoucy, Dr Kayouli Chedly, Chistophe Dalibard and Nina Cederpren who provided me with a lot of literature about the palm tree.

I would like to express my deep thanks and appreciation to Norbert Klein and Janet Ashby for their great help and assistance that gave me a opportunity to start this study.

I wish also to thank the Department of Animal Health and Production of the Ministry of Agriculture, Forestry and Fisheries in the Kingdom of Cambodia for granting me permission to pursue this study and use some of its facilities to accomplish my research work.

My study was made possible through my supervisors, PhD. DSc. T. R. Preston and Dr. Professor J. E. Lindberg who freely offered their time and patience for useful guidance, discussion and encouragement at all times. They provided me with an environment which made this period the most enjoyable learning experience, and I am greatly indebted to them.

Thanks are also due to the farmers in the above mentioned villages and the team of the Lutheran World Service Integrated Rural Development Program in Takeo/Kandal, especially to Mr Oscar Paez Casto, Mr. Lor Bunnath and Mr Kim Saran (Dept. of Agronomy) for their great assistance.

REFERENCES

Becerra, M. 1991. Azolla-Anabaena: Un recurso valioso para la producción agropecuaria en el Tropico. Serie de manuales tecnicos #1. CIPAV: Cali, Colombia. pp 1-53.

Becerra, M., Ogle, B. and Preston, T. R. 1995. Effect of replacing whole boiled soya beans with azolla in the diets of growing duck. Livestock Research for Rural Development, 7(3). pp 32-38.

Beech, S. A., Elliott, R. and Betterham, E. S. 1990. Sucrose as an energy source for growing pigs: Digestibility energy content and energy utilization. Anim. Pro. 51:343-355.

Cunha, T. J. 1977. Swine feeding and Nutrition. pp 154 and 241.

Davis, T. A. and Johnson D. V. 1987. Current Utilization and Further Development of the Palmyra Palm (Borassus flabellifer L., Aracaceae) in Tamil Nadu State, India. 1988, by the New York Botanical Garden, Bronx, NY 10458. Economic Botany, 41(2), 1987. pp 248-265.

Devendra, C. 1993. Sustainable animal production from small farm systems in South-East Asia. Charter 3 and 4. pp 23-44.

Dolbert, P. 1991. The Artisan Sugar Palm Syrup Production in Cambodia. Project of GRET (Agricultural Technique and development of Cambodia), translated from cambodian language version. pp 1-9.

Elliott, R. and Kloren, W. R. L. 1987. The use of sugar in diet for monogastrics. Recent Advances in Anim. Nutr. in Australia. pp 290-296.

Fernandez, G. M. 1988. Uso de jugo de cana para cerdos en una finca de mediano productores en la Republica Dominicana. In: Sugarcane as feed: Proceeding of an FAO Expert Consultation held in Santo Domingo, Dominican Republic, 7-11 July 1986. FAO Animal Production and Health Paper No. 72. (Editors: R. Sansoucy, G. Aarst and T. R. Preston,). pp 164-169.

Göhl, B. 1994. Tropical Feeds 5.0 for window. Revised by Andrew Speedy, July 1994. Text, 1994, Food and Agriculture Organization of the UN. Sofware (1994) Oxford Computer Juornals Ltd.

Gooding, E. G. B. 1982. Effect of quality of cane on its value as livestock feed. In: Tropical Animal Production 7:72-91.

Holness, H. D. 1993. PIGS: The Tropical Agriculturist: CTA (The Technical Centre for Agricultural and Rural Co-operation. (Editors: René Coste and Anthony J. Smith. pp 51-53.

Jaganathan, N. and Mohanadas, S. 1983. Palm tree fibre. FAO/DANIDA Palm tree Workshop, Jaffna.

Kovoor, A. 1983. The palmyra palm: potential and perspectives. FAO Plants Production and Protection Paper, 52. Rome.

Larrahondo, J. E. and Preston, T. R. 1989. Control Quimico de la Inversion de Jugos de Cana de Azucar para la Alimentación Animal. Livestock Research for Rural Development. 1(1). pp 55-59.

Leng, R. A., Stambolie, J. H. and Bell R. 1995. Duckweed-A Potential High-Protein Feed Resource for Domestic Animals and Fish. Livestock Research for Rural Development. Volume 7, number 1, October 1995. (16Kb).

Lubeigt, G. 1979. Le palmier à sucre (Borassus flabellifer L.,) ses defferents produits et la technologie associée en Birmanie. J. Ag. pp 197.

McDonald, P., Edwards, R. A. and Greehalgh J. F. D. 1992. Animal Nutrition. 4th edition,

1988 and reprinted 1992. Longman Scientific & Technical. Copublished in the United States with John Wiley & Sons, Inc., New York. pp 58-59 and 470-471.

Men Bui Xuan, Ogle, B. and Preston, T. R. 1995. Use of duckweed (Lemna spp) as replacement for soya beans meal in a basal diet of broken rice for fattening ducks. Livestock Research for Rural Development, 7(3). pp 5-8.

Mena, A. 1987. The utilization of sugar cane by-products as substitutes for cereal in feeds animal feed. In: Proceedings of FAO Expert Consultation on the substitution of imported concentrate feeds in animal production systems in developing countries. FAO Animal Production and Health Paper No. 63. (Editors: R. Sansoucy, T. R. Preston, and R. A. Leng). pp 94-96.

Mena, A. 1988. Utilización del jugo de caña de azúcar para la alimentación animal. In: Sugar cane as feed: Proceedings of an FAO Expert Consultation held in Santo Domingo, Dominican Republic, 7-11 July 1986. FAO Animal Production and Health Paper 72. (Editors: R. Sansoucy, G. Aarts, and T. R. Preston,). pp 153-157.

Moog, F. A., Samiano A. M., Valenzuela, F. G., Raymundo, S. G. and Fementira, E. B. 1994. Utilization of Sugarcanes Juice for Swine in the Philipinnes. Proceedings of the 7th AAAP congress in Bali, Indonesia 1994. pp 129-135.

Morton, J. F. 1988. Notes on Distribution, Propagation, and Products of Borassus Palm (Arecaceae). 1988, by the New York Botanical Garden, Bronx, NY 10458. Economic Botany, 42(3). pp 420-441.

Naren, Tong, Ogle, B. and Preston, T. R. 1994. Optimum protein supply and level of inclusion of water spinach (Ipomoea aquatica) in sugar cane juice based diets for growing ducks. (MSc Thesis in Sustainable Livestock Production, Swedish University of Agricultural Sciences, Uppsala). pp 8-9.

Paulas, D. 1983. Research for exploitation of palm tree. FAO/DANIDA Palm tree Workshop, Jaffna.

Paulas, D. and Muthukrishnan, C. R. 1983. Products from palm tree. FAO/DANIDA Palm tree Workshop, Jaffna, Sri Lanka.

Pethiyagoda, U. 1979. Coconut inflorescence sap. Planter (Malaysia) 55, 390-397.

Phuc Bui Hay Nhu, Ogle, B. and Preston, T. R. 1994. Effect of protein supply in sugar cane juice based diet for growing pigs. (MSc Thesis in Sustainable Livestock Production, Swedish Unversity of Agricultural Sciences, Uppsala). pp 4-10.

Phuc, Bui Hay Nhu, Lai, Nguyen Van, Preston, T. R., Ogle, B. and Lindberg J. E. 1995. Replacing soya bean meal with cassava leaf meal in cassava root diets for growing pigs. Livestock Researsh for Rural Development, 7(3). pp 56-60.

Phuc Bui Hay Nhu, Ogle, B. and Preston, T. R. 1994. Survey on the use of sugar cane juice as energy source for growing pigs on small farms in Vietnam. (MSc Thesis in Sustainable Livestock Production, Swedish Unversity of Agricultural Sciences, Uppsala). pp 3-9.

Porteres, R. 1964. Le palmier ronier (Borassus aethiopum Mart.) dans la province du Baoule Cote d' Invoire. Journ. d' Agri. Trop. & Appl. II. pp 499-516.

Preston, T. R. 1991. Sweet ration: sugar cane as a livestock feed. Ceres Rome. 23:2, 39-40.

Preston, T. R. 1995. Tropical animal feeding: A manual for research workers, FAO Animal Production and Health Paper, No. 126. Charter 7: Technologies for improving use of renewable natural resources. pp 144-145.

Preston, T. R. and Leng, R. A. 1988. Matching Ruminant Production Systems with Available Local Resources in the Tropics and Subtropics. PENAMBUL Books. Ltd: Armidale

NSW, Austalia. pp 1-5.

Preston, T. R. and Murgueitio, E. 1992. Stratedy for Sustainable Livestock production in the Tropics. pp 23-26.

Preston, T. R. and Sansoucy, R. 1987. Matching livestock systems with available feed resources. In: Proceedings of the FAO Expert Consultation on the substitution of imported concentrate feeds in animal production systems in developing countries. FAO Animal Production and Health Paper No. 63. pp 32-41.

Rogers, P. L., Lee, K. J., Skotnicki, M. L. and Tribe, D. E. 1982. In Advances in Biochemical Engineering, volume 23, Ed. A. Feighter, Springer-Verlag, N. Y.

Romera, J. P. 1968. Le Borassus et le sucre de palme au Cambodge. L' Agron. Trop. 8, 801-839.

Sarria, P., Solano, A. and Preston T. R. 1990. Utilización jugo de cana y cachaza panelera en la alimentation de cerdos. Livestock Research for Rural Development, volume 2, number 2. pp 92-102.

Sivalingam, K. and Maheswaran, S. 1983. Palmyra sugar and sugar-based products: Present position and future prospects. FAO/DANIDA Palmyrah Workshop, Jaffna.

Solarte, J. A., Dolberg, F. and Corrales, E. 1994. Experiences from two ethnic groups of farmers participating in livestock research in different ecological zones of the Cauca Valley of Colombia. (MSc Thesis in Sustainable Livestock Production, Swedish University of Agricultural Sciences, Uppsala). pp 10-11.

Speedy, A. W. 1991. A comparison of sugar cane juice and maize as energy source in diet for pigs with equal supply of amino acids. Livestock Research for Rural Development, 3(1). pp 65-73.

Tjitrosoepomo, G. and Pudjaorinto, A. 1983. Study on Palmyra (Borassus flabellifer L.) in Indonesia. FAO/DANIDA Palmyra Workshop, Jaffna.

Tkatchenko, B. 1948. Le sucre de palme de Cambodge. L' Agron. Trop. 3, 563-593.

Uhl, N. W. and Dransfield, J. 1987. Genera palmarum: A classification of palms based on the work of H. E. Moore, Jr. The international Plam Society, Lawrence, KS.

Annex 1

Palm yielding juice used for alcoholic production

Species	Countries
Arenga pinnata	India, Malaysia
Borassus aethiopum	Africa
Borassus flabellifer	Cambodia, India, Thailand
Borassus madagascariensis	Madagascar
Borassus sundaicus	Timor
Caryota urens	India
Cocos nucifera	Polynesia
Elaeis guineensis	Africa
Mauritia flexuosa	South America
Mauritia vinifera	South America
Nypa fruiticans	Philippines
Phoenix dactyfera	North America
Phoenix sylvestris	India
Raphia taedigera	South America
Raphia vinifera	Nigeria
Sabal palmetto	USA

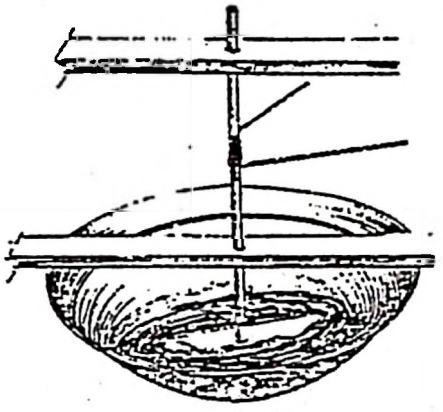
Annex 2

ទឹកត្នោត

1. Palm juice

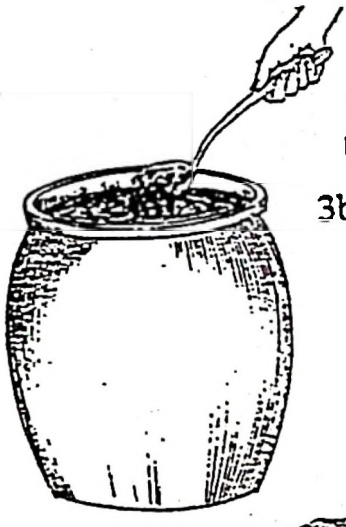
ទឹកស្ករ

2. Crystallization



ស្ករដែង

3a. Solid block sugar



ស្ករកាងរាវ

3b. Liquid sugar (syrup)

ស្ករកាងទឹង

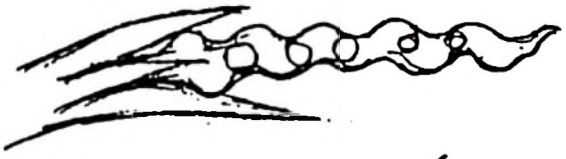
3c. Solid sugar

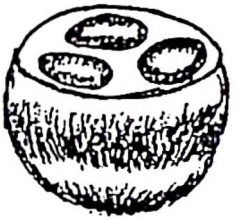
ដែជាស្ករស

4. Refined sugar

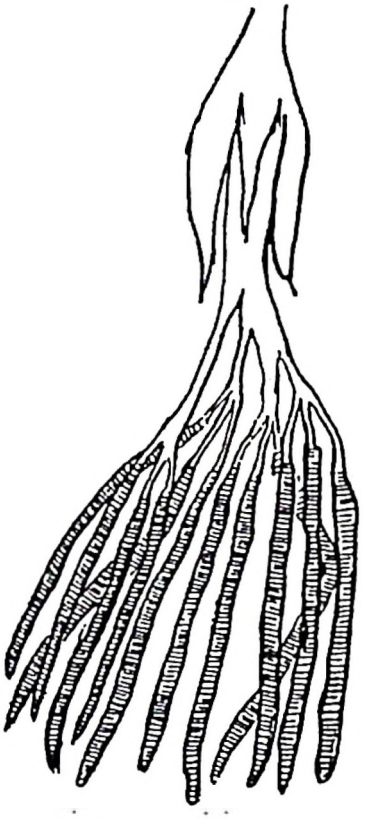
Annex 3

Female inflorescense





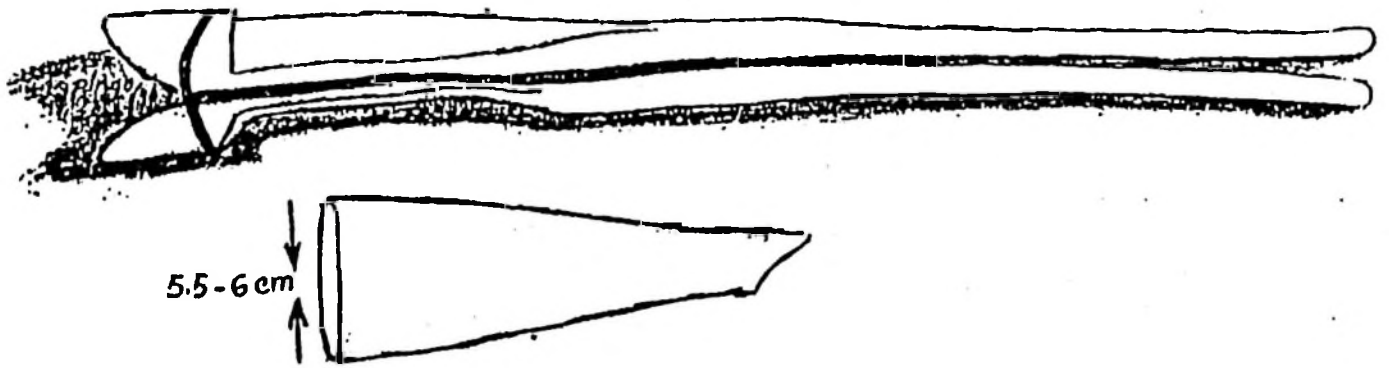
Palm fruit



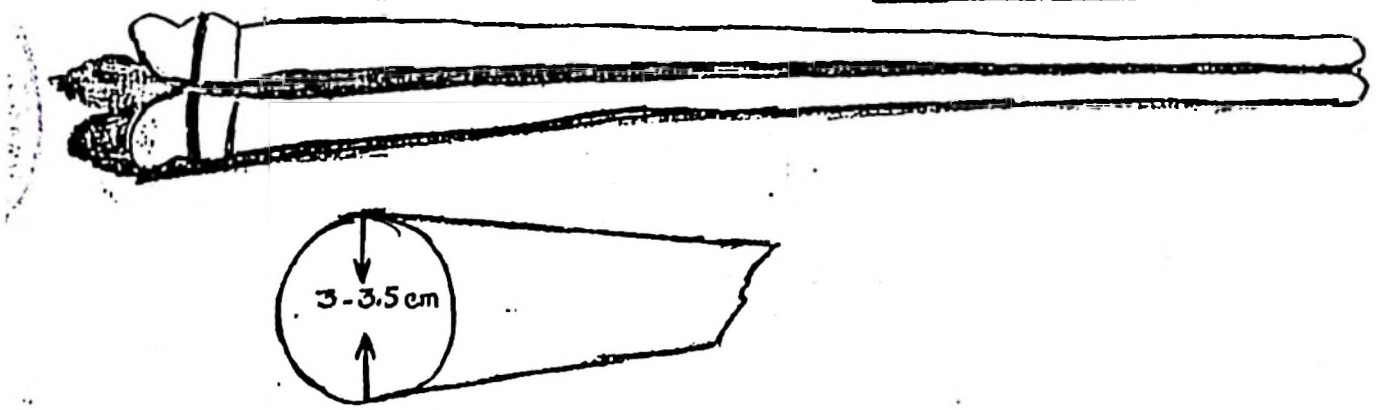
Male inflorescense

Annex 4 TOOLS FOR MASSAGING INFLORESCENSES

1. A pair of flat wooden tongs for male inflorescenses



2. A pair of rounded wooden for female inflorescenses

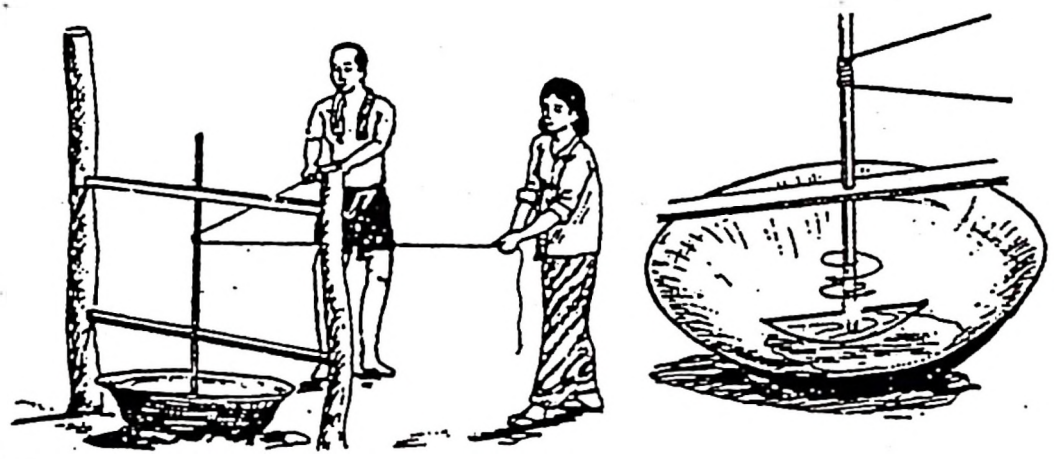


Annex 5

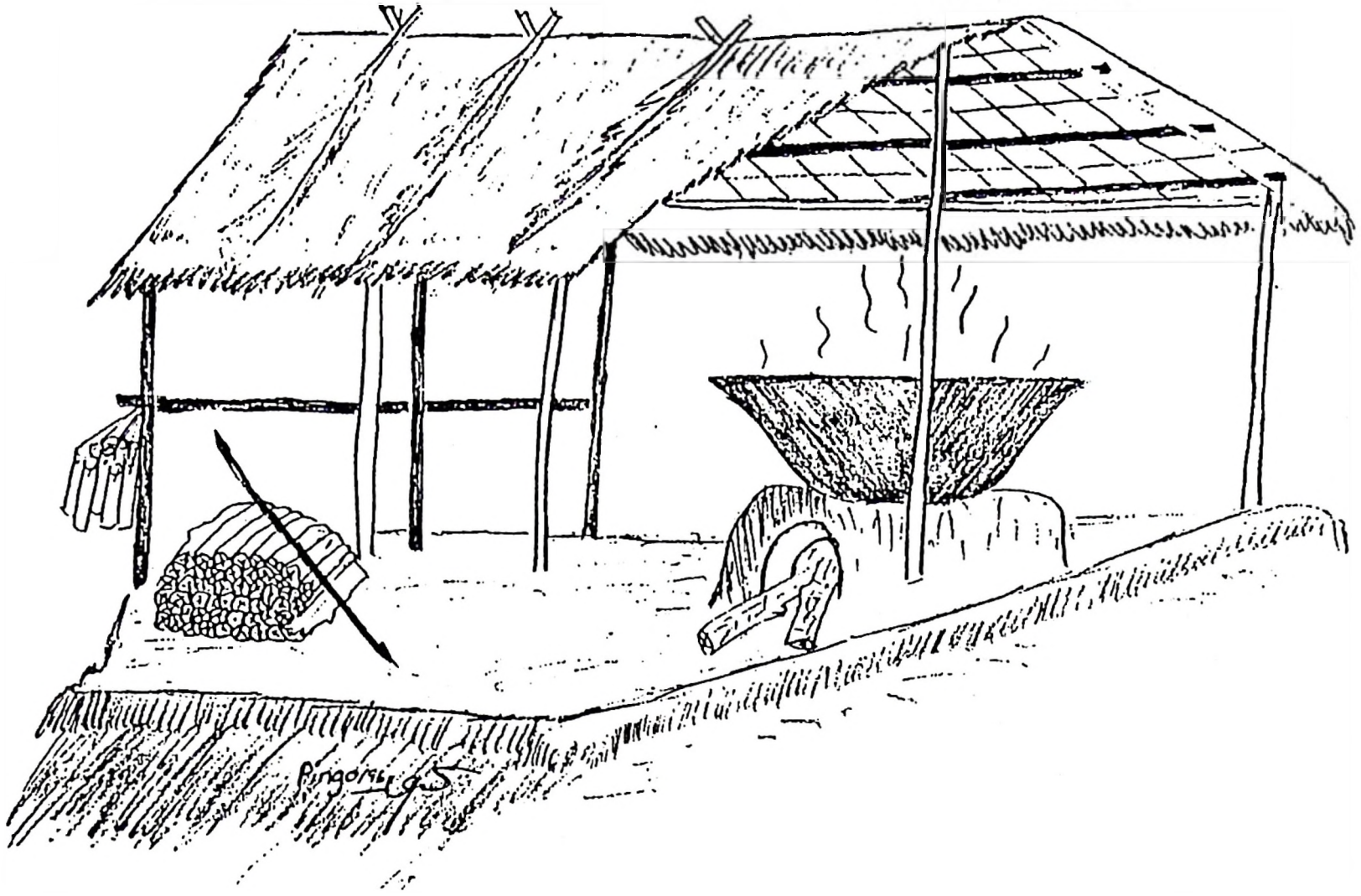
TECHNIQUE OF CLIMBING PALM TREE (FEMALE)

Annex 6

MECHANICAL CRYSTALLIZATION



Annex 7 TRADITIONAL STOVE FOR BOILING PALM JUICE



I

JUICE PRODUCTION FROM THE SUGAR PALM TREE (*Borassus flabellifer*) IN CAMBODIA AND PERFORMANCE OF GROWING PIGS FED SUGAR PALM JUICE.

Borin Khieu[1], Preston[2] T. R. and Lindberg[3] J. E.

ABSTRACT

A total of 105 male and female palm trees were studied during a period of five months in the Bati district, Takeo province (approximately 50 km south of Phnom Penh City) in Cambodia. The yield of juice and the Brix value (approximate sugar content) were measured for three consecutive days every month. The daily average yield was 5.0 kg (SE ±0.20) and the average Brix value (approximate sugar content) was 13.3% (SE ±0.14). There was no significant difference in daily yield of juice (P=0.665) and daily Brix value (approximate sugar content) (P=0.334). However, there were highly significant differences in yield of juice according to families, months and sex of the trees (P<0.001). There were also highly significant differences in Brix value (approximate sugar content) between families and months (P<0.001) as well as between male and female palm trees (P=0.005). Sucrose ranged from 66 to 94% of the total solids in the juice in the samples taken in January and from 51 to 81% in April (P=0.021). In contrast, glucose and fructose levels in juice increased when the harvest season advanced (P=0.021 and P=0.006) respectively.

Seventy two pigs of different crossbreds between Yorkshire or Landrace and local pigs were reared from 20-80 kg on diets composed of approximately 8 kg of sugar palm juice per pig per day with a supplement of 156 g CP daily. Soya beans were used as the mayor protein supplement in the diet. In addition pigs were given lime, salt and 500 g of fresh water spinach per day as a source of vitamins. The average daily weight gain of the pigs was 356 g (SE ±40).

Due to the capacity of sugar palm tree to produce juice with high digestible carbohydrates, sugar palm juice can be used as the main alternative energy source for growing and fattening pigs at the small farms in the rural areas in Cambodia.

Key words: **Cambodia; Diversification; Palm juice; Brix; Palm syrup; Energy; Pigs.**

---

[1]Department of Animal Health and Production, Ministry of Agriculture, Forestry and Fisheries Phnom Penh City, Cambodia. Email address: borin@forum.org.kh

[2]La finca ecologica, University of Agriculture and Forestry, Ho Chi Minh City, Vietnam. Email address: thomas%preston%sarec%ifs.plants@ox.ac.uk

[3]Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, P. O. Box 7024, S-750 07 Uppsala, Sweden.

INTRODUCTION

The sugar palm is a multipurpose tree and a national symbol of Cambodia. The palm tree grows best in sandy soils and Romera (1968) in his studies on palm juice in Cambodia discovered that palm trees are mainly found on soils with a pH of around 5.5. Palm trees are planted traditionally as fences around households, on the dykes between rice fields and along the roadsides. The palm trees mostly grow without any agronomic or human interventions. The palm trees grow wherever the seeds fall or where the cattle drop them. The policy of the former and the present Cambodian government has been that each person must plant a few palm trees in order to increase the population. The sugar palm tree could be one of the important potential carbohydrate producers in the tropics as it has a metabolism that results in accumulation of sucrose. The palm tree provides a cheap form of energy and only requires a small area of land (approximately 50 m^2 per tree) and may not require particularly fertile soil. The palm tree is quite resistant to drought and flooding. The yield of juice varies with weather conditions, the skill of tappers and is affected by the length of the collection period.

The first attempt to utilize the juice was to use the "scums" skimmed off the boiling juice to improve pig feeding in rural communities in Cambodia. The scums are sometimes thrown away or poured on rice straw for cattle feeding. Preston (1995) reported that the scums are composed of juice enriched with the protein and minerals which flocculate and float to the surface due to denaturation of the protein when juice is heated. During the first village visits and the interviews with farmers it was found that the majority of the farmers preferred to feed pigs with palm juice instead of the scums.

No research reports have been found relating to the feeding palm juice to livestock. However, many researchers have demonstrated that sugar cane juice can completely replace cereals as the sole energy source in diets for pigs (Mena, 1987 and 1988; Elliott and Kloren 1987; Figuerao, 1989; Sarria et al. 1990; Preston, 1991; Beech et al. 1990; Speedy et al. 1991; Moog et al. 1994).

Fernandez (1988) demonstrated that it was possible to use sugar cane juice as the principal energy source for growing pigs raised from 16-90 kg. It was more economic for pig producers to use their own sugar cane and avoid more expensive imported grains. Speedy et al. (1991) confirmed that sugar cane juice was a very appropriate basal feed for monogastric animals in the tropics and under sub-tropical conditions.

Elliott and Kloren (1987) reported that raw mill sugar also was an acceptable source of dietary energy for growing and finishing pigs. Moog et al.(1994) showed that sugar cane juice and its derivatives are essentially energy rich feed resources, that must be supplemented with a protein source with a balanced profile of essential amino acids, particularly for pigs and other monogastric animals.

The aims of this experiment were to determine the variation of yield and Brix value (approximate sugar content) at different times (month and day), and between families and the sexes of individual palm trees. The aim was further to determine the growth performance of pigs fed diets based on restricted quantities of juice from the sugar palm tree with soya beans as protein supplement.

MATERIALS AND METHODS

Sugar palm juice (sap) study

Palm trees

A total of 105 (51 females and 54 males) palm trees of unknown age, were used in this study. All palm trees were found in different places in the Or Pheasang village, but most of them were located around the farmer households. Juice was collected two times per day, at 07:00 h and 15:00 h. A piece of bark of Shorea cochinchinensis was deposited in the juice collectors two times a day as an anti-fermentation agent.

Measurements

The palm juice yield from each tree was weighed every month, during the period January-May, and the Brix value (approximate sugar content) was also measured each month on three consecutive days, tree by tree. The juice yield was measured with a hand balance and the sugar content was determined by Brix value using a hand refractometer (Atago N1, Japan). A simple direct refractometric measurement of the percentage of total solids in the juice is possible and expressed as degrees Brix. Total solid sugars in the palm juice represent about 95% of Brix value (Gooding 1982). The juice was measured in the morning from 08:00 h to 11:00 h to fit in with the farmers' routine collection time. Twenty-four samples were taken from individual farmers at the beginning (16-01-1995) and at the end (15-04-1995) of the collection period. The juice was mixed in equal amounts from different trees and from trees with different sexes from the same farmer. Prior to analyses the samples of sugar palm juice were condensated into palm syrup (about 80% DM content) and brought to Uppsala, Sweden. Beyond the sugar content of the palm juice, the content of sucrose, glucose and fructose was also determined. The later analyses were performed according to standard methods at this laboratory.

The twenty four samples of the sugar palm syrup were dried at 103°C for 20 hours and 84 hours, respectively, in order to determine the dry matter content and the chemical composition.

Pig performance study

Experimental design

The trials were carried out at Or Pheasang Village, Kandoeung Commune, Bati District, Takeo Province, between January and May, 1995. Twelve farmers who had annually produced sugar palm syrup participated in the feeding experiment. Each farmer had access to 10-15 palm trees, which guaranteed that juice yield would be sufficient to feed the pigs with the planned quantities. Pigs were distributed to farmers in twelve different locations in the village. Pigs were purchased by individual farmers with the assistance of the researcher. Six pigs of each sex were assigned to each farmer and were divided into two subgroups (replicated groups).

Animals

A total 72 crossbred pigs (35 castrated males and 37 ovarectimized females) were used in the experiment. The main breeds that were crossbred with local pigs, were Yorkshire (22 males

and 24 females) followed by Landrace (9 females and 7 males) and the rest were pure local pigs. The initial weight ranged from 15 to 30 kg and the pigs were of unknown age. All pigs were vaccinated after the 15 days of the pre-experimental period against common infectious diseases in Cambodia such as hog cholera, pasteurellosis, salmonellosis and erysipelas. The pigs were also treated with an anti-parasitic drug (Ivomic injectable) once during the experiment. Each pig was tagged which facilitated registration of the individual pig performance.

Housing and environment

At each farm, the six pigs were divided into two sub-groups within the pen, and were fed as sub-groups. The pens were constructed from palm trunks, with thatched roofs of palm leaves and concrete floors, with an average area of 1.66 m^2 per pig. The feed trough in each sub-group was divided into three small compartments and one water trough with permanent fresh water was shared between the sub-groups. During the experiment, the average daily temperature was 31°C, with a minimum of 20°C and the maximum of 39°C. The temperature was registered twice daily at 07:00 h and at 17:00 h. The humidity was registered two times daily at the meterological unit of the National Cattle Breeding Station, approximately 2 km from the experimental site and ranged from 45% -76% relative moisture. Rainfall was about 1,200 mm per year, mostly concentrated in the months of August-October.

Diets and feeding

Pigs were purchased by farmers individually at the end of December and went into the pre-experimental period during the first half of January 1995. An adaptation period of 15 days was used to change to the experimental feed. The first 5 days all pigs were fed 1.5 kg of rice bran, 150 g of whole soya beans and 3 kg of palm juice. For the second 5 days the pigs were fed 1 kg of rice bran, 250 g of whole soya beans and 4 kg of palm juice and for the final 5 days they were fed 0.5 kg of rice bran, 350 g of whole soya beans and 5 kg of palm juice. After this period, they were given 100% of the experimental feed which on a daily basis consisted of 400 g of whole soya beans (156 g CP), an average of 5 kg palm juice, 5 g of lime and 5 g of salt per day per pig. In addition they were offered 500 g of water spinach per pig per day as a vitamin supplement. The water spinach was given when the pigs had eaten the basic feed. At all stages pigs had free access to fresh water. All feed ingredients were fed in fixed amount after the adaptation period until the end of the trial, however, palm juice that was provided according to the categories of the pigs. Pigs of 20-50 kg live weight were fed with 5 kg of palm juice per pig per day, while 50-80 kg were provided 6-10 kg of palm juice.

The whole soya beans were distributed to the 12 farmers in 15 day intervals. In order to facilitate the operation, soya beans for the daily allowance of the six pigs (2400 g) was weighed and put into small plastic bags. The whole soya beans were soaked in water over night and was boiled in the morning for around two hours.

Measurements

All pigs were weighed individually after the 15 days of adaptation, and this was used as the initial live weight. Pigs were weighed every 15 days throughout the experimental period by using a beam balance. The animal was pushed into a bamboo enclosure connected to the scale and at least three persons were needed to operate the system. Pigs were not given feed until the weighing was completed.

Statistical analyses

The yield of palm juice and growth performance of the pigs were analysed by analysis of variance (ANOVA) using the GLM (General Linear Model) and the Basic Statistic using 1 sample "T"test to calculate the variation of sucrose, glucose and fructose in Minitab Statistical Software (1993).

RESULTS

Sugar palm juice collection

Juice was collected twice daily at 07:00 h and 15:00 h. The average yield of juice of the 105 palms was 5.0 kg (SE ±0.20) per tree per day, while the highest yielders produced up to 22-25 kg of juice per day.

There was a highly significant difference in yield between months, sex of the palm and farmers ($P<0.001$). However, there was no significant difference between the daily yields ($P=0.665$). The average yield in January was 4.7 kg per day per palm, while the maximum yield of 5.7 kg was noted in February after which yield decreased to a mean of 4.2 kg in May (SE ±0.13). The average yield of palm juice varied between farmers and ranged from 2.7 to 7.5 kg per tree per day. The average yield of female palms was 5.3 kg per day compared with 4.7 kg from the male tree (Table 1).

The average Brix value was 13.3% (SE ±0.14) for the whole period. There was no significant difference in Brix value between days ($P=0.534$). However, the Brix value was higher ($P=0.005$) in the juice from the female tree compared with the male. There were highly significant differences in Brix value between farmers and months ($P<0.001$). The Brix value ranged from 12.6% in January to 14.1% in May (SE ±0.09). The yield of juice decreased from the first to the fifth month, while in contrast the Brix value gradually increased.

Chemical analysis of sugar palm syrup

Dry matter values after 20 hours drying at 103°C were choosen, as they gave the most reasonable results, as drying for 84 hours gave too low dry matter values. The sample number 8 and 23 of the samples dried for 20 hours had a higher sum of total carbohydrates than the dry matter content.
The composition of the syrup samples (Table 2 and Figures 1 and 2) showed considerable variation among farmers and harvest period. Sucrose as percent of total solids in the juice ranged from 66 to 94% in the samples taken in January and from 51 to 88% in April. A "T" test of the differences (Table 3), paired by farmer, showed that the mean value decreased ($P=0.021$) from January to April.

In contrast, glucose and fructose levels in juice increased ($P=0.021$ and $P=0.006$), respectively. The levels of glucose ranged from 2.1 to 9.6% in samples taken in January and from 3.5 to 18.2% in April. The fructose levels ranged from 2.6 to 11% in samples taken in January and from 4.6 to 24.5% in April.

Feed intake

The quantity of palm juice fed to the pigs, varied according to the juice production. The palm juice given varied from 5-10 kg per pig per day. Pigs were fed three times per day at 07:00 h, 12:00 h and 17:00 h, respectively. The pigs in each of the 12 households consumed palm juice avidly. As soon as they heard the sound of the bamboo collectors knocking against each other they became restless and crowded to the feed trough in anticipation of being fed. There were only few cases when the pigs were not able to consume the amount of juice which was provided. When the temperature became very high during the day time pigs consumed more water.

Daily weight gain

The daily weight gain of the pigs varied from one farmer to another, and the average daily gain was 356 g per pig per day, with a range from 320 to 417 g (P=0.744) (table 4). There were no significant differences in daily weight gain between sex and breeds (P=0.711 and P=0.283, respectively).

General health

In general, the health of pigs during the experiment was good. It should be noted that there was a drought in 1995 in most parts of the country and the months from March-May are the driest and hottest time of the year in Cambodia. Several pigs showed symptoms of nutritional diarrhoea during the first 4-5 days on juice diet in the pre-experimental period. Two pigs died in April, and were clinically diagnosed as having symptom of the infectious disease erysipelas, and 14 other pigs were affected but recovered after being medically treated with the antibiotic Streptapen for 5 days.

DISCUSSION

Sugar palm juice yield and Brix value (approximate sugar content)

In Cambodia, sugar palm trees grow on acid soils with a pH of around 5.5. The sugar palm trees are commonly found on sandy soils and a small population of palm trees is found on red soils (fertile soils) in the North-East provinces. Kandiah (1983), quoted by Kovoor (1983), reported that in Sri Lanka the sugar palm tree may not prefer acid soils in the wet zones. More research is needed on this topic.

The interval between the commencement of juice collection to the production of juice depends on the skill and experience of the tapper. During the present study it was found that the majority of palm trees took 5 to 8 days from the preparation of the inflorescences until juice production started. Kovoor (1983) reported that in the literature different times have been observed. The interval from the commencement of tapping to the dripping of juice has been reported to vary from 10 to 35 days, while others have found that it does not exceed 12 to 15 days.

Paulas (1983) and Tjitrosoepomo and Pudjaorinto (1983) reported that the average yield of juice was 6 to 10 litres. At the extreme individual palms are known to give up to 20 litres per day. During this experiment, it was found that the average yield of palm juice was 5 kg per day per tree, with the extreme trees producing up to 20-25 kg per day. Female palm trees produced on average 5.3 kg of juice per day compared to 4.7 kg in male trees (Figure 3). This agrees with Porteres (1964) and Lubeigt (1979) who reported that female palms yield more juice on tapping than males, whether from the terminal bud, as practised on the Ivory Coast, or from the inflorescence, as practised in Burma. In the present experiment, it was found that several male trees terminated juice production in March. This corresponded to a juice production of approximately 90 days. Some of the female trees terminated juice production in April (after about 120 days). According to farmers some trees have the potential to produce juice all year around. However, it is a problem to collect juice during the rainy season, as the tree becomes slippery, the winds are strong for working at the top of the tree and it is difficult to protect the collectors from rain.

The average Brix value measured in this experiment was 13.3% which was similar to the values reported by Dolbert (1991) in a survey on sugar palm production in Cambodia. Sivalingam and Maheswaran (1983) found that the juice of male inflorescences was 13% richer in sugar than juice of female inflorescences. In contrast, during the present experiment, the juice from female inflorescences was richer in sugar than from the male inflorescences and there were statistically significant differences in Brix value (approximate sugar content) between the sexes. However, the sex is not the only factor which determines the Brix value. It was shown that the skill and experience of the tapper were also the most critical factors for the Brix value (Borin et al. 1995). There were two farmers in this experiment who got an average Brix value of 14.4% and 15.9%, respectively (see Figure 4). It was also demonstrated that there were significant changes in sucrose and glucose/frutose (reducing sugars). The proportion of sucrose in the juice decreased ($P=0.021$) and that of glucose and fructose increased ($P=0.021$ and $P=0.006$), respectively as the harvesting season advanced from January to April, although the concentration of ash was not affected.

The yield of juice and Brix value also depends on the first weeks of inflorescence preparation (slicing and massaging). Pethiyagoda (1979) reported that the unique feature of tapping the palm juice is the manipulation of the inflorescence, that is the crushing and massaging of young tissues. It is important to emphasise that the crushed tissues are actually not killed in this process. The other factor is the replacement of the tapper. One tapper is used to slice palm inflorescence by moving it to the right hand side, but others move it to the left side and slice it. In addition every tapper applies different pressure to manage the inflorescences. Therefore, juice production often dropped when the tapper was replaced for short time, and it was difficult to recover from such a situation. Farmers also mentioned that different odours from persons may negatively influence the juice production. The sugar palm tree is also very sensitive to changes in the weather. It was noted that when it was hot (Figure 5), with no wind and a cloudy sky, the palm juice production decreased markedly. One of the factors could be that the palm tree does not receive enough solar radiation for photosynthesis.

Fermentation occurs within hours after the commencement of juice collection and results in an alcohol content of 5-6% (Davis and Johnson 1987). To prevent fermentation, the sugar producers normally use the bark of Shorea cochinchinensis. The bark of Shorea

cochinchinensis keeps palm juice for 12 to 15 hours without fermentation, which allows time for the sugar palm producers to keep juice in good condition. Tkatchenko (1948) found out during his systematic study in Cambodia that commercial formalin (5 ml/l) or lime (calcium hydroxide, 7-10 g/l), conserve quite satisfactorily against fermentation for more than a day. Larranhondo and Preston (1989) in their study reported that the sodium metasilicate (Na2SiO3) at 5-7 g per litre of sugar cane juice was effective against fermentation for up to 96 hours.

Pig performance

In this experiment the average live weight gain was 356 g per pig per day (see Figure 6). The daily live weight gains were reasonably good when considering the genetic potential of the pigs. Phuc et al. (1994) in their on-farm survey of growing and finishing pigs in Tuyen Quang province in Vietnam showed that restricted sugar cane juice based diets with a low protein supplement (108 g per pig per day) could support an average live weight gain of 270 g per day. Borin et al. (1993 unpublished data) reported that when a small number of pigs (2) was raised per farmer household and fed sugar palm juice ad libitum and supplemented with 156 g CP per pig per day, pigs had a better performance than those on traditional diets and the average daily live weight gain in that study was almost 500 g per pig. Moog et al. (1993) in on-farm trials in the Philippines fed either fresh sugar cane juice and sugar syrup or muscovado sugar with a supplement of 500 g of soya bean meal per pig per day, and noted an average of live weight gain of 420 to 450 g per pig per day. Despite a low daily growth rate in the present experiment, the profitability was positive in all households, although it was closely linked with the rate of growth. The mean live weight gains of the ovarectomized female and castrated male pigs were similar and there were no significant differences (P=0.711) (Figure 7). In contrast, Phuc et al. (1994) reported that castrated males were significantly fatter and had mean live weight gains around 100 g per pig per day higher than the females. However the non-castrated female, especially local pigs produce in early stage of growth and usually lost appetite during the heat period, which may result in them loosing weight. Therefore, in the present experiment all female pigs were ovarectomized during the pre-experimental period. The statistical analysis showed that there were no significant differences between breeds and farmers (P=0.283, P=0.735, respectively). In fact, there was around 100g difference in the average live weight gain per pig per day between the farmer number 12 (Pauv Pauv) and farmers number (2, 6 and 10). The factors which influenced the performance of those pigs were probably the management practices of individual farmers. The washing the pigs with cool water played an important role when temperatures were high during the hot period. Payne (1990) suggested that during the daytime, particularly in the hottest months adequate shade and roof, and especially fine water sprays or wallows, should be applied in order to improve the production. The initial weight also could be a factor that influences the growth performance of pigs. The average initial weight of pigs of the farmers (2, 6 and 10) was around 20 kg lower than those of farmer (12) which was 30 kg. In this situation, heavier pigs could utilize better sugar palm juice because the enzima sucrase is more developed than small piglets.

The dietary CP supplement of 156 g per pig per day was very low compared with NRC recommendations (1988) and those recommended by Phuc et al. (1994 a) in their on station

trial in Vietnam. In the experiment reported here the amount of 156 g CP (400 g dry soya beans) supplement was fixed during the whole period of the experiment in order to make the operation easy for the farmers. Mena (1988) suggested that from a biological point of view the level of the protein supplement in the diet in the final stage of fattening should be reduced, but the most important consideration is the economical aspect, as the protein supplement is generally the most expensive ingredient of the animal diet. Sarria et al. (1990) demonstrated that the level of protein (soya bean meal) could be restricted to a maximum of 200 g per pig per day without reducing pig performance when pigs were fed diets based on sugar cane juice and its by-products, and the system was economically viable under Colombian conditions.

Wiseman (1987) reported that the availability is only important for those amino acids which may be limiting in the diet. Thus lysine is of particular importance because it is strictly essential, it is generally at low level in the majority of feed proteins (with the exception of soya beans). From a nutritional point of view, the methionine is the limiting amino acid in soya beans, and Göhl (1994) reported that there is only 1.4% of methionine in soya bean protein. However, in the present experiment water spinach was given as a supplement, to the sugar palm juice and soya bean diet, which provided complementary methionine to give diet a better balanced amino acid profile. Animal Husbandry Research Institute, Hanoi, Vietnam, 1979 quoted by Naren et al. (1994), reported that a 100 g of fresh whole water spinach contains 0.14 g of lysine, 0.07 g of methionine, 0.04 g of tryptophan, 0.14 g of threonine. In the present study 500 g of the water spinach given per pig per day which provided a complement of 0.35 g of methionine. This means that approximately 2.55 g methionine was provided per pig per day (see Tables 5 and 6).

A series of trials was undertaken to evaluate the feeding of pigs with the raw juice from the sugar palm tree as it is recognized that the sugar palm tree has the potential to produce juice rich in highly digestible carbohydrates (sugars), and also pig feeding systems based on the juice from the sugar cane has been demonstrated to work successfully in many tropical countries. Dolbert (1991) reported that some of the sugar palm juice was converted from sucrose to glucose during the collecting time. In the present study it was shown that there is a significant variation of sucrose content in palm juice (range from 65.8 to 94.3% of DM), but there was no apparent relationship between sucrose content and pig growth rate (see Figure 8). The present data suggest that sugar palm juice could completely replace cereals as the main energy source in diets for growing and fattening pigs, and this is supported by data from Mena (1987) and Speedy et al. (1991) which demonstrated that sugar cane juice can totally replace the cereal component of the diet for growing pigs. Nguyen Thi Loc et al. (1993) also reported that it was feasible to use sugar cane juice to replace cereals and their by products in the diet of pigs.

Studies of the digestibility of dietary sucrose, fructose or glucose have shown that sucrose and glucose were completely digested in the small intestine with an apparent digestibility of 93.8% at the ileum and 100% at the rectum (Ly, 1992). In the present experiment the allowance of palm juice was estimated from the average daily yield of 2 palm trees per pig per day which gave approximately 10 kg of juice. According to Figuerao (1989) the energy content of DE of sugar cane is 11.6 MJ per kg DM which means, that 5-10 of palm juice (13.3% sugar content) would provide 7.7 and 15.4 MJ, respectively of DE daily for pigs

weighing 20 and 80 kg respectively in the present study. According to McDonald et al (1992, table 13) the daily requirement of DE for improved pigs with live weights of 20 and 90 kg are 16.8 and 31.2 MJ. This means that during the present experiment pigs were fed in all stages under the standard requirement of energy. An increased daily palm juice allowance would probably result in an improved daily growth rate. However, there were exceptional cases where palm juice was given over the estimated quantities and there were also a few occasions when the pigs could not be fed with the planned amounts as juice production decreased when the weather was hot and cloudy. The quantities of juice fed to the pigs in the 3 daily meals was not equal, especially in the afternoon when juice production decreased as temperature rose. Kandiah (1983) quoted by Kovoor (1983) reported that the highest levels of juice flow are registered at night and Pethiyagoda (1979) reported that palm juice flow can be associated with the 'climacteric' of respiratory phenomena. Pigs could not consumed all amount of feed that was provided in the early stage of the experiment. But, entire feed was consumed when pigs were around 50-90 kg live weight.

A vitamin/mineral premix was not used in the diets in the present experiment as it was not available in Cambodia. It is very expensive when it is available, and is not a sustainable way to supply premix in a small on farm trial. It is better to demonstrate to farmers how to use their own local feed resources which in the present study was made by providing 500 g of fresh water spinach per day per as vitamin supplement. Naren et al. (1994) reported that water spinach contained relatively high levels of vitamins A (carotene), B1, B2 and C and minerals. Paulas and Muthukrishnan (1983) reported that sugar palm juice is also rich in some minerals (phosphorus and iron) and some vitamins (C and B1), The anti-fermentation agent that farmers placed in the collectors did not have any affect on the juice after 13-15 hours, and was applied to make sure that juice was collected in a good condition for pig feeding, as juice is fermented within few hours during the collection period at high temperature. However, 5 g per pig per day of lime was given to prevent diarrhoea which could be caused by the fermentable carbohydrates, and also as a source of Calcium.

In general, no deficiency symptoms were observed during this experiment and all pigs looked healthy. The vaccines and anti-parasitic drug were used to treat the pigs at the beginning of the trial in order to ensure that they were healthy as parasites and infectious diseases are the common problems which affect pig production in the rural areas. Payne (1990) reported that the humid tropics provide an almost perfect environment for many parasites which is the major problems confronting pigs producers in the tropics, particularly in the humid regions.

Feeding palm juice to pigs is not only profitable for people in the rural areas but also benefits biodiversity and the environment, as firewood is not required. The farmers also save time when the palm juice is fed to pigs instead of being used to make sugar. It takes 2-3 hours for the husband to climb at least 8-10 palm trees, which is able to feed 4-5 pigs, and it takes 1-2 hours for the wife or children to feed the pigs and clean the shed. At the same time they can be charging the biodigester with manure and waste and the effluent can be used as fertilizer for fish ponds, water plants or rice and fruit trees, with no harmful effects on the environment. For sugar production they spend about 16 hours per day to produce sugar syrup such as collecting firewood, and they must stay close to the stove where they boil the juice. It was stated by Dolbert (1991), in his survey of sugar palm syrup production in Cambodia, that the whole family is occupied almost all the time with sugar production.

CONCLUSION

The experiment showed that sugar palm juice can be used as the main energy source for growing and finishing pigs. Pigs grew satisfactorily without showing any palatability and digestibility problems. They were healthy and had reasonably good rates of daily weight gain with the low protein intake.

Piglets of at least 15 kg initial weight can be reared on diets based on sugar palm juice. In the rural conditions of Cambodia it is recommended to vaccinate pigs against common infectious diseases and also to practise de-worming. Keeping pigs in confinement in a pen is recommended in order to save energy, to facilitate collection of manure and minimize the risk of diseases.

The average yield of juice per tree was 5 kg daily with a Brix value (approximate sugar content) of 13.3%. In a 5 month harvest season this is equivalent to a production of 100 kg of sugar per tree. Assuming that the area occupied by each tree is $50m^2$ this is equivalent to 18 tonnes of sugar per hectare per year compared to 5-15 tonnes from sugar cane, which under rain-fed conditions indicates that the palm tree is both productive and efficient in its use of solar energy. Further research is needed in order to understand more about the sugar palm tree and its potential production capacities. The important issues are to investigate the respiratory phenomena in the juice production period and the interaction between the tapper and the inflorescences.

ACKNOWLEDGEMENTS

The study was carried out in Or Pheasang Village, Kandoeung Commune, Bati District, Takeo Province, Cambodia, during 1995 as requirement for the Master of Science degree " Integrated Livestock-Based Systems for the Sustainable Use of Renewable Natural Resources", administered by the Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences. The study was made possible through the financial support of the Swedish Agency for Research Cooperation with Developing Countries (SAREC) and the Ecumenical Scholarships Programme in Germany (DIAKONISCHES WERK). Thanks are also due to the 12 farmers in Or Pheasang Village, who shared their experience and participated actively in this experiment.

REFERENCES

Beech, S. A., Elliott, R. and Betterham, E. S. 1990. Sucrose as an energy source for growing pigs: Digestibility energy content and energy utilization. Anim. Pro. 51:343-355.

Borin Khieu, 1994. (FAO/TCP/CMB/2254): Feeding Livestock on Local Resources in Cambodia. In: Proceedings of National Seminar-workshop "Sustainable Livestock Production on Local Feed Resources" (Editors T. R. Preston, B. Ogle, Le Viet Ly and Lu Trong Hieu), Ho Chi Minch City, November 22-27, 1993. pp 98-104.

Borin Khieu, Preston, T. R. and Ogle, B. 1995. Fattening pigs with the juice of the sugar palm tree (Borassus flabellifer). Livestock Research for Rural Development, 7(2). 25-29.

Bui Hong Van, Le Thi Men, and Vo Van Son, 1994. Evaluation of a low protein diet based on raw sugar and water spinach (Ipomoea aquatica) for growing pigs. In: Proceedings of National Seminar-workshop "Sustainable Livestock Production on Local Feed Resources" (Editors: T. R. Preston, B. Ogle, Le Viet Ly and Lu Trong Hieu), Ho Chi Minch City, November 22-27, 1993. pp 47-49.

Davis, T. A. and Johnson D. V. 1987. Current Utilization and Further Development of the Palmyra Palm (Borassus flabellifer L., Aracaceae) in Tamil Nadu State, India. 1988, by the New York Botanical Garden, Bronx, NY 10458. Economic Botany, 41(2), 1987. pp 23-44.

Dolbert, P. 1991. The Artisan Sugar Palm Syrup Production in Cambodia. Project of GRET (Agricultural Technique and development of Cambodia), translated from cambodian language version. pp 1-9.

Elliott, R. and Kloren, W. R. L. 1987. The use of sugar in diet for monogastrics. Recent Advances in Anim. Nutr. in Australia. pp 290-296.

Fernandez, G. M. 1988. Uso de jugo de cana para cerdos en una finca de mediano productores en la Republica Dominicana. In: Sugarcane as feed: Proceeding of an FAO Expert Consultation held in Santo Domingo, Dominican Republic, 7-11 July 1986. FAO Animal Production and Health Paper No. 72. (Editors: R. Sansoucy, G. Aarst and T. R. Preston,). pp 164-169.

Figuerao, V. 1989. Experiencias cubanas en el uso de las mieles de caña para la alimentación porcinas. Livestock Research for Rural Development, 1(1). 9-22.

Göhl, B. 1994. Tropical Feeds 5.0 for window. Revised by Andrew Speedy, July 1994. Text, 1994, FAO. Software (1994) Oxford Computer Juornals Ltd.

Gooding, E. G. B. 1982. Effect of quality of cane on its value as livestock feed. In: Tropical Animal Production. 7:72-91.

Kovoor, A. 1983. The palmyra palm: potential and perspectives. FAO Plants Production and Protection Paper, 52. Rome.

Larrahondo, J. E. and Preston, T. R. 1989. Control Quimico de la Inversion de Jugos de Cana de Azucar para la Alimentación Animal. Livestock Research for Rural Development. 1(1). 55-59.

Lubeigt, G. 1979. Le palmier à sucre (Borassus flabellifer L.,) ses defferents produits et la technologie associée en Birmanie. J. Ag. pp 197.

Ly, J. 1992. Studies of the digestibility of pigs fed dietary sucrose, fructose or glucose. Arch. Anim. Nutr. 42. 1-9.

McDonald, P., Edwards, R. A. and Greehalgh J. F. D. 1992. Animal Nutrition. 4th edition, 1988 and reprinted 1992. Longman Scientific & Technical. Copublished in the United

States with John Wiley & Sons, Inc., New York. pp 470-471.

Mena, A. 1987. The utilization of sugar cane by-products as substitutes for cereal in feeds animal feed. In: Proceedings of FAO Expert Consultation on the substitution of imported concentrate feeds in animal production systems in developing countries. FAO Animal Production and Health Paper No. 63. (Editors: R. Sansoucy, T. R. Preston, and R. A. Leng). pp 94-96.

Mena, A. 1988. Utilización del jugo de caña de azúcar para la alimentación animal. In: Sugar cane as feed: Proceedings of an FAO Expert Consultation held in Santo Domingo, Dominican Republic, 7-11 July 1986. FAO Animal Production and Health Paper 72. (Editors: R. Sansoucy, G. Aarts, and T. R. Preston,). pp 153-157.

Minitab Statistic Software version 9.0, 1993. Minitab release 9.2. Minitab Inc., 3081 Enterprise. Drive, State College, PA 16801-3008, 814: 238-3280, USA.

Moog, F. A., Samiano A. M., Valenzuela, F. G., Raymundo, S. G. and Fementira, E. B. 1994. Utilization of sugarcanes juice for swine in the Philipinnes. Proceedings of the 7th AAAP Congress in Bali, Indonesia 1994. pp 129-135.

Naren, Tong, Ogle, B. and Preston, T. R. 1994. Optimum protein supply and level of inclusion of water spinach (Ipomoea aquatica) in sugar cane juice based diets for growing ducks. (MSc Thesis in Sustainable Livestock Production, Swedish University of Agricultural Sciences, Uppsala). pp 8-9.

National Research Council, 1988. Nutrient Requirementof Swine, Ninth Revised Edition. Nutrient Requirement of Domestic Animals. Washington.

Nguyen Thi, Loc, Ngo Thi Bich, Doung, Nguyen Kim, and Preston, T. R. 1994. Feeding sugar cane juice to growing pigs. In: Proceedings of National Seminar-workshop "Sustainable Livestock Production on Local Feed Resources" (Editors: T. R. Preston, B. Ogle, Le Viet Ly and Lu Trong Hieu), Ho Chi Minch City, November 22-27, 1993. pp 115-117.

Paulas, D. 1983. Research for exploitation of palm tree. FAO/DANIDA Palm tree Workshop, Jaffna.

Paulas, D. and Muthukrishnan, C. R. 1983. Products from palm tree. FAO/DANIDA Palm tree Workshop, Jaffna, Sri Lanka.

Payne, W. J. A. 1990. An Introduction to Animal Husbandry in the Tropics. Fourth edition. Tropical Agriculture Series. Longman Scientific & Technical. Copublished in the United State with John Wiley & Sons, Inc., New York. pp 660-666.

Pethiyagoda, U. 1979. Coconut inflorescence sap. Planter (Malaysia) 55, 390-397.

Phuc Bui Hay Nhu, Ogle, B. and Preston, T. R. 1994 a. Effect of protein supply in sugar cane juice based diet for growing pigs. (MSc Thesis in Sustainable Livestock Production, Swedish Unversity of Agricultural Sciences, Uppsala). pp 4-10.

Phuc Bui Hay Nhu, Ogle, B. and Preston, T. R. 1994 b. Survey on the use of sugar cane juice as energy source for growing pigs on small farms in Vietnam. (MSc Thesis in Sustainable Livestock Production, Swedish Unversity of Agricultural Sciences, Uppsala). pp 3-9.

Porteres, R. 1964. Le palmier ronier (Borassus aethiopum Mart.) dans la province du Baoule Cote d' Invoire. Journ. d' Agri. Trop. & Appl. II. 499-516.

Preston, T. R. 1991. Sweet ration: sugar cane as a livestock feed. Ceres Rome. 23(2). 39-40.

Preston, T. R. 1995. Tropical animal feeding: A manual for research workers. FAO Animal Production and Health Paper, No. 126. Charter 4: Feed Resources for non-

ruminants. pp 51-62.

Romera, J. P. 1968. Le Borassus et le sucre de palme au Cambodge. L' Agron. Trop. 8. 801-839.

Sarria, P., Solano, A. and Preston T. R. 1990. Utilización jugo de cana y cachaza panelera en la alimentation de cerdos. Livestock Research for Rural Development, 2(2). 92-102.

Sivalingam, K. and Maheswaran, S. 1983. Palmyra sugar and sugar-based products: Present position and future prospects. FAO/DANIDA Palmyrah Workshop, Jaffna.

Speedy, A. W., Seward, L., Langton, N., Du, Plessis, J. and Dlamini, B. 1991. A comparison of sugar cane juice and maize as energy source in diet for pigs with equal supply of amino acids. Livestock Research for Rural Development, 3(1). 65-73.

Tjitrosoepomo, G. and Pudjaorinto, A. 1983. Study on Palmyra (Borassus flabellifer L.) in Indonesia. FAO/DANIDA Palmyra Workshop, Jaffna.

Tkatchenko, B. 1948. Le sucre de palme de Cambodge. L' Agron. Trop. 3, 563-593.

Valenzuela, F., Moog, F., Samiano, A., Raymundo, R., Fementira, E. and Galaraga, A. 1993. Use of Sugarcanes Juice as Feed for Pigs in the Philippines. In: FAO International Workshop " Increasing Livestock Production through Utilization of Available Local Resources". Beijing, China 15-23.

Wiseman, J. 1987. Feeding of Non-Ruminant Livestock. Translated and Edited by Julian Wiseman. pp 14-16 and 40-45.

Table 1.
Mean yield of juice and Brix value (approximate sugar content) according to farms, month, sex of tree and day when harvested.

No		Juice (kg/tree/d)	Brix value (%)
	Farmers		
1	Hay Yang	4.6	13.4
2	Huy Kiel	4.9	12.5
3	Pring Houy	2.7	14.3
4	Map Chreb	5.9	13.5
5	Sim Hen	4.0	15.9
6	Pauv Pauv	5.5	13.3
7	Tha Khorn	5.5	13.5
8	Thol Onn	6.0	12.2
9	Thorn Pun	4.4	12.8
10	Yem Khnol	7.5	11.6
11	Chhan Mak	3.9	13.0
12	Thorn Chreb	4.9	13.3
	Mean	5.0	13.3
	SE	±0.20	±0.14
	Prob.	0.001	0.001
	Month		
1	January	4.7	12.6
2	February	5.7	12.6
3	March	5.2	13.5
4	April	5.1	13.6
5	May	4.2	14.1
	SE	±0.13	±0.09
	Prob.	0.001	0.001
	Sex		
1	Female	5.3	13.4
2	Male	4.7	13.2
	SE	±0.09	±0.06
	Prob.	0.001	0.005
	Days		
1	First	4.9	13.2
2	Second	5.0	13.3
3	Third	5.0	13.3
	SE	±0.10	±0.07
	Prob.	0.665	0.534

Table 2.
Chemical composition of sugar palm syrup

		-------As % of dry matter----------				
	DM	**Ash**	**Sucrose**	**Glucose**	**Fructose**	**Total Carb.**
16 Jan.1995						
Hay Yang	84.8	1.4	65.8	9.6	10.6	86.7
Huy Kiel	86.5	1.3	85.7	5.8	6.6	98.0
Pring Huy	84.3	1.7	74.1	9.4	11.0	94.8
Map Chreb	82.7	1.2	88.2	4.8	5.5	98.6
Sim Hen	87.8	1.0	93.1	2.1	2.6	97.9
Pauv Pauv	84.1	1.4	81.7	5.7	7.5	95.5
Tha Khorn	88.1	1.5	94.3	2.1	3.3	99.7
Thol Onn	90.2	0.6	98.1	3.6	1.5	103.8
Thorn Punn	89.9	1.8	74.3	6.8	8.3	91.1
Yem Khnol	84.2	1.8	72.9	9.1	10.6	93.6
Chan Mak	88.4	1.0	93.1	2.5	2.9	98.5
Thorn Chreb	78.6	1.7	85.7	4.8	2.9	96.9
15 Apr. 1995						
Hay Yang	85.8	1.7	69.8	7.3	12.5	89.6
Huy Kiel	88.9	1.5	68.5	11.2	13.4	93.5
Pring Huy	82.9	1.6	51.0	18.2	24.5	91.2
Map Chreb	82.3	1.5	57.4	15.7	18.1	92.7
Sim Hen	85.0	1.3	74.9	8.7	9.9	96.2
Pauv Pauv	79.7	1.6	68.0	10.6	12.2	92.2
Tha Khorn	82.2	1.1	87.6	5.5	5.9	99.0
Thol Onn	86.9	1.2	73.5	8.0	11.0	92.6
Thorn Punn	87.4	1.5	87.1	3.5	4.6	96.1
Yem Khnol	92.0	1.5	62.6	9.4	15.8	90.0
Chan Mak	96.9	0.4	100.1	0.7	1.1	102.8
Thorn Chreb	75.6	1.6	76.4	9.8	9.5	95.7

Table 3.
T test analysis of changes in sucrose, glucose/frutose (reduced sugar)and ash in sugar palm juice with advance of harvesting season.

	16 Jan. 95	15 Apr. 95	Mean difference	"T" value	Prob.
Sucrose	81.6	70.4	11.2	2.79	0.021
Glucose	6	10	-4.0	-2.78	0.021
Fructose	7.2	12.3	-5,1	-3.56	0.006
Ash	1.4	1.4	-0.02	-0.19	0.86

Table 4.
Average daily weight gain of pigs of 12 farmers fed sugar palm juice in the experiment.

	Init. LW (kg)	Final LW (kg)	DWG g/day
Farmers			
Pauv Pauv	30.0	81.7	417
Tha Khorn	18.9	75.6	404
Chhan Mak	21.2	75.4	372
Thol Onn	20.9	71.8	365
Huy Kiel	22.8	69.8	363
Map Chreb	19.5	70.0	355
Hay Yang	19.6	69.5	350
Thorn Chreb	21.3	71.2	345
Sim Hen	19.2	66.7	330
Thorn Punn	22.6	69.3	330
Pring Houy	21.2	67.6	320
Yem Khnol	21.1	64.6	320
Mean	21.5	71.1	356
SE			±40
Prob			0.735
Breed			
Yorkshire x local			379
Landrace x local			373
Local			315
SE			±26
Prob			0.385
Sex			
Female			360
Male			351
SE			±19
Prob			0.711

Table 5.
Recommended nutrient allowances (g/kg diet) for pigs

	(20-65 kg)	(50-90 kg)	(65-120 kg)
Crude protein	160-170	140-150	120
Lysine	8.5	7.0	5.5
Methionine/cystine	4.6	4.1	3.4
Threonine	5.4	4.6	4.0
Tryptophan	1.7	1.4	1.2

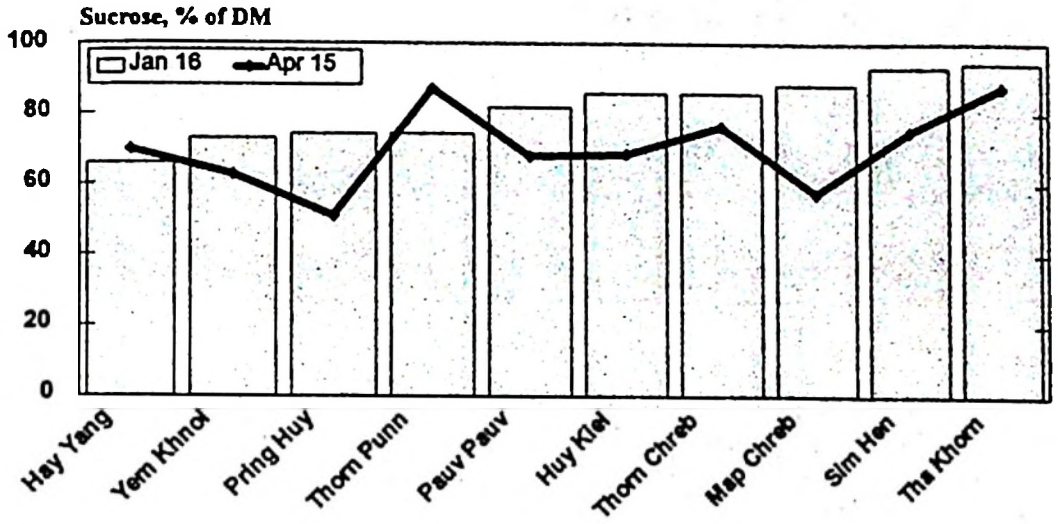
Source: McDonald et al (1981) quoted by Payne (1990).

Table 6.
Average daily amino acid supply.

	[1]Soya beans (g)	[2]Water spianch (g)	Total amino acids (g)
Lysine	9.5	0.7	10.3
Methionine	2.2	0.35	2.55
Threonine	5.9	0.7	6.8
Tryptophan	2.0	0.2	2.2

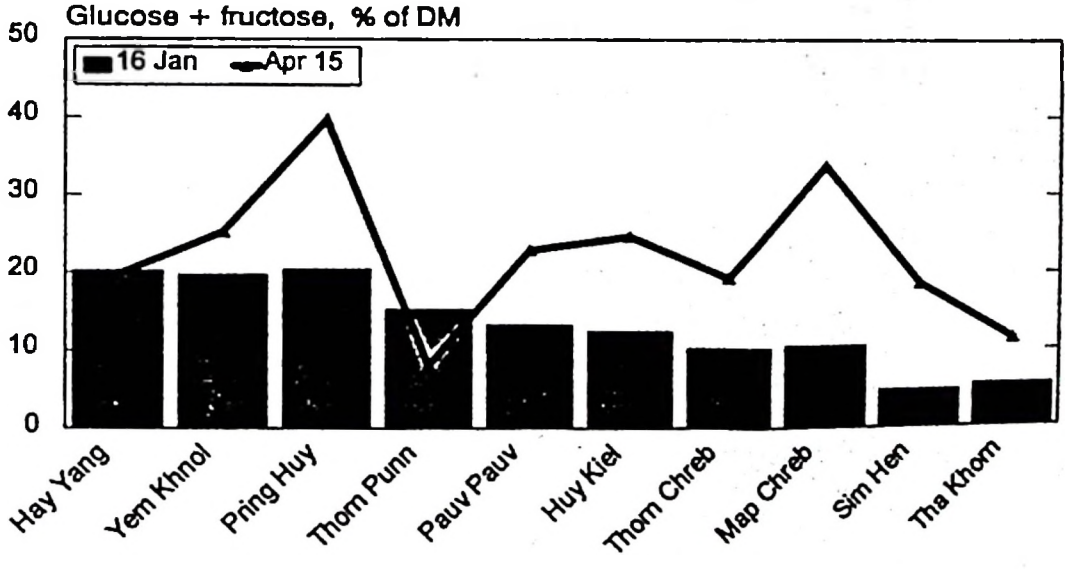
[1]Göhl (1994), [2]Naren et al (1994)

Figure 1. Variation of sucrose content of sugar palm juice in trees from different households at beginning and end of the harvest season



Source: Borin et al (1995)

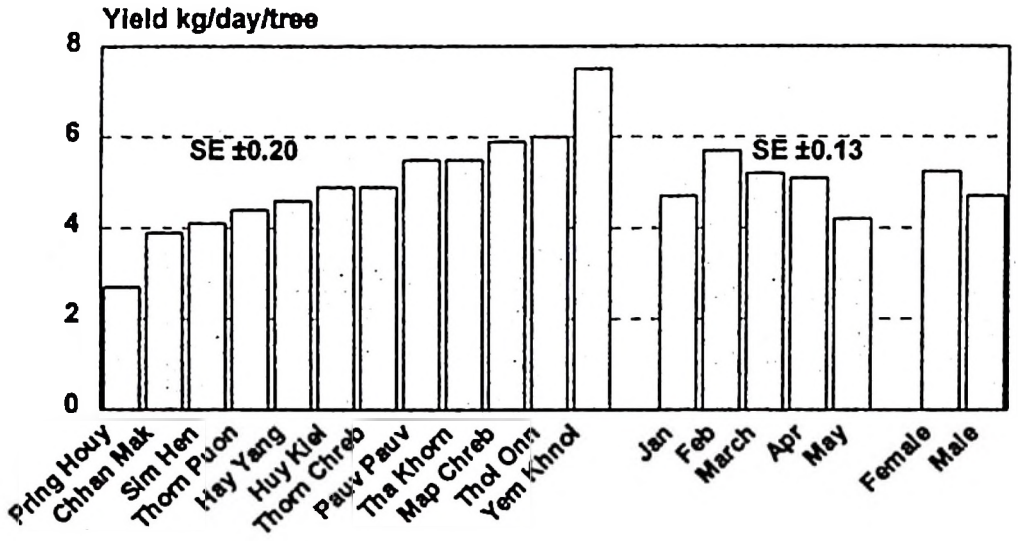
Figure 2. Variation of glucose and fructose in sugar palm juice from trees in different households at the begininng and end of the harvest season



Source: Borin et al, 1995

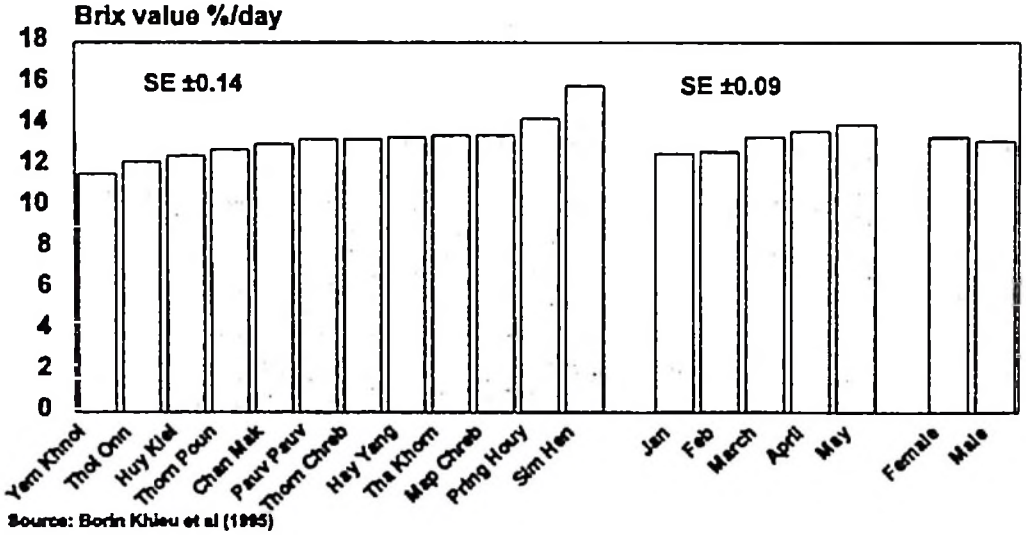
Figure 3. Yield of juice from sugar palm trees

Effect of family, month of harvest and sex of tree



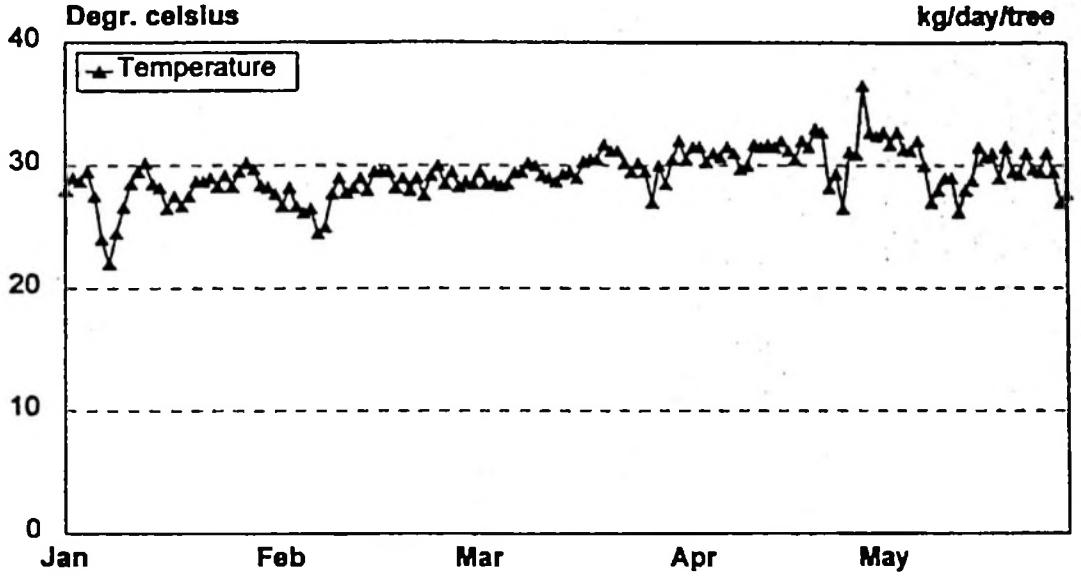
Source: Borin et al (1995)

Figure 4. Brix value of juice from sugar palm trees according to sexes, farms & harvest season



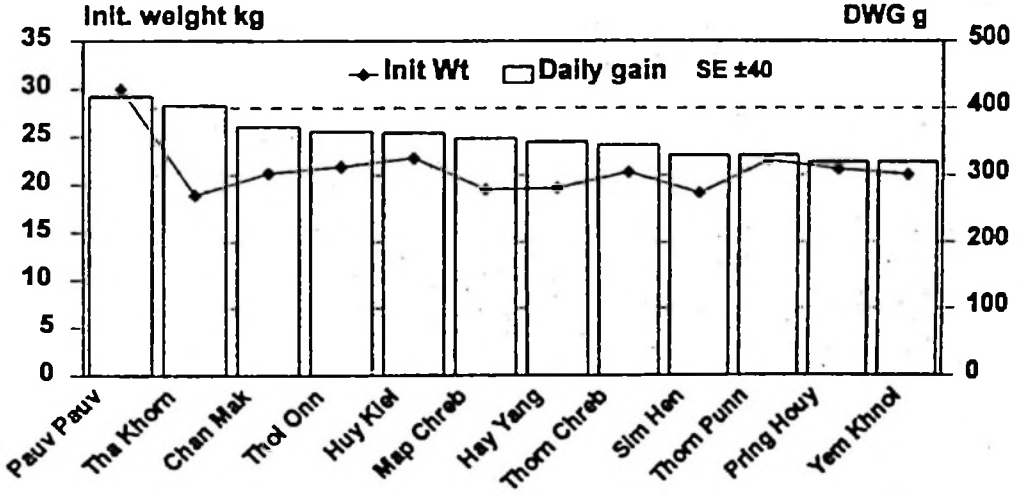
Source: Borin Khieu et al (1995)

Figure 5. Variation of temperature during the experiment.



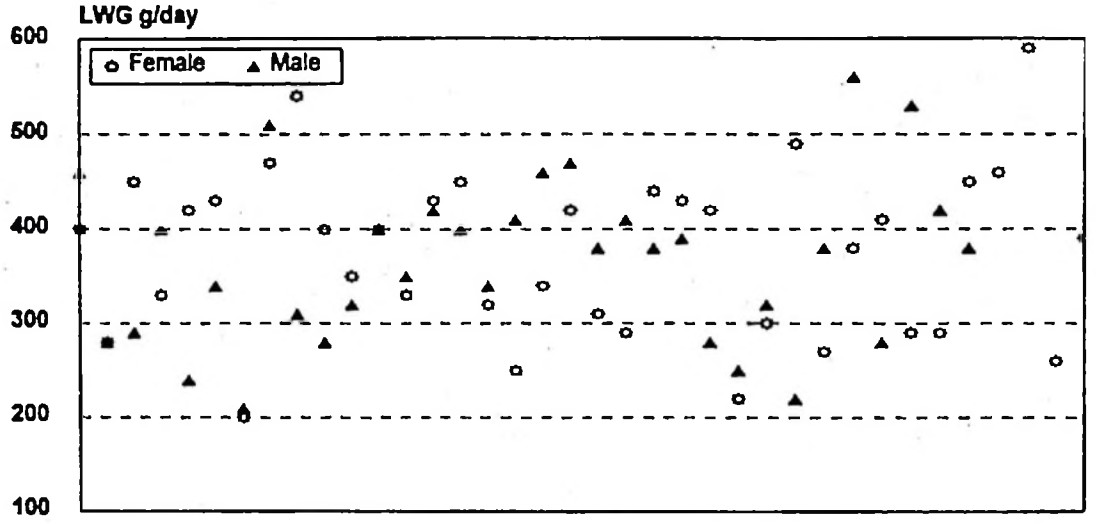
Borin et al, 1995

Figure 6. Average daily weight gain of pigs fed with sugar palm juice



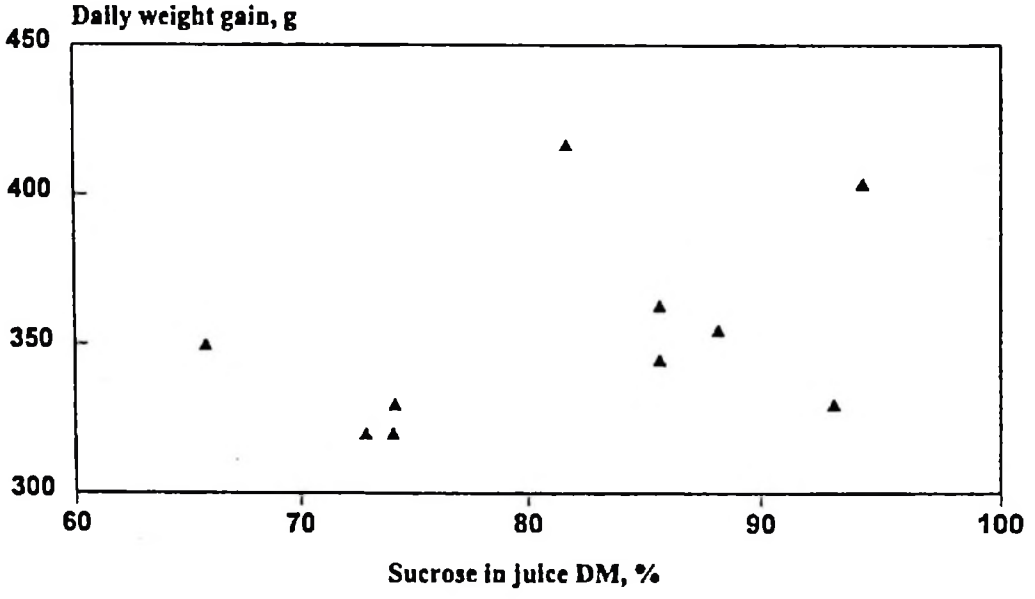
Source: Borin et al, 1995

Figure 7. Mean of live weight gain by individual pigs (males and females)



Source: Borin et al (1995)

Figure 8. Relationship between sucrose content in juice and growth rate of pigs



Source: Borin et al 1995

II

A STUDY ON THE MULTIPURPOSE SUGAR PALM TREE (*Borassus flabellifer*) AND ITS PRODUCTS FOR ANIMAL FEEDING IN CAMBODIA

Borin Khieu[1], Lindberg[2], J. E and Preston[3], T. R.

Abstract

Sugar palm tree play an important role in the small farm systems in Cambodia. It provides different products for human as well as for animal production such as juice, sugar, leaves, timber, fruits and roots as traditional medicines. Therfore, sugar palm syrup production is important product and source of seasonal income for the farmers. But at the same time the production of sugar syrup requires huge amount of energy to boil the juice for sugar. It was shown in this study that when fire wood has to be purchased, some of sugar producers lost money.

In studying 12 farms got an average profit of 150 Riels per tree by feeding pig with juice compared to 11 Riels for sugar syrup production. Also the collection of leaves for thatch was shown to be of interest in comparison with sugar production, as this gave a profit of 6 Riels per day per tree. Furthermore, the environment benefits when trees do not need to be used as energy source for sugar production.

Feeding pigs with palm juice as the main dietary energy source was shown to be an alternative of sustainable production. In order to improve the production, pigs need to be reared in pen which is easy to collect manure for household gas production and decreased the risk for diseases. In addition, it will improve the pig production in the rural communities which provides meat according to the demand in human nutrition and furthermore create work for farmers.

Keywords: **Cambodia; Borassus flabellifer; Palm juice; Palm sugar; Fuel; Economy; Profitability; Environment; Sustainable production.**

---

[1]Department of Animal Health and Production, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh City, Kingdom of Cambodia. Email: borin@forum.org.kh

[2]Department of Animal Nutrition and Management, Swedish University of Agricultural Science, P. O. Box 7024, S-750 07 Uppsala, Sweden.

[3]La finca ecologica, University of Agriculture and Forestry, Ho Chi Minh City, Vietnam. Email: thomas%preston%sarec%ifs.plants@ox.ac.uk

Introduction

The sugar palm has been considered as a valuable multipurpose tree for several centuries for the production of food and construction materials that will produce income for Cambodian rural communities. Romera (1968) reported that the government of Cambodia launched a project for increased production of palm juice and by-products on a producer-cooperative basis, covering 35,000 hectares. However, the political disruption which followed has prevented the realization of this programme. It should be noted that approximately 75% of the total area of 181,035 km² of Cambodia was covered by forest, and so fuel for sugar palm processing was not a problem. Farmers could collect fire wood around their households, or in neibouring forest. Today fire wood has become the major constraint for sugar production. This raised the following questions: How can the problem be solved? What modifications or diversification of palm juice can be applied in the rural communities? If sugar production is to continue what kind of energy sources could be used as a replacement for fire wood?

At present, with 85% of the population being small farmers, the Cambodian economy is mainly dependent on agriculture. Rice cultivation has been the main agricultural activity and one crop per year gives an average yield of 1.5 tonnes per ha (Ministry of Agriculture, 1995). Farmers also have other complementary enterprises such as vegetables, cassava, sweet potatoes, water melon and sugar palm production. However, the contribution made by animals is considerable in the small farm system providing food (meat and eggs), power and cash income. Devendra (1993) reported that in South-East Asia, the contribution of livestock is consistent with the relatively large numbers of different animals species found in the small farm sector. Furthermore, raising animals has other advantages such as providing fertilizer and fuel, in addition to by-products utilization and social value.

The majority of the farmers own 2-3 cattle, which are commonly kept to provide draught power, organic fertilizer and as a form of savings and wealth to share to the married sons or daughters. Chickens are commonly raised for household consumption and gifts, and in addition a few are produced for the market. The rural farmers in Cambodia raise 1-2 pigs to provide seasonal cash income, but pigs are also raised to produce meat to be used for example for wedding feasts. Devendra (1993) reported a very high annual growth rate (16.6%) of the pig production in Cambodia. The main reason for this are the availability and successful transfer of proven technologies in pig production, a large and growing market for the products, good credit facilities and the rapid turnover of capital investment.

Participatory Rural Appraisal (PRA) techniques were applied in all the village studies. The goal of the studies was to better understand the traditional pig production systems in the rural communities, and to study the use of palm tree products for animal production. The aim also was to evaluate the economic profitability of the traditional sugar production practices compared to using sugar palm juice as the energy source for pig feeding.

Materials and methods

The studies were conducted in five villages of Takeo and Kadal provinces in South and North Phnom Penh City. The first PRA was conducted from September to October 1995 in Takeo

province and the second from November 1995 to January 1996 in Kandal province. The studies were not focussed on animal production only, but also on the farming systems as a whole, which was requested by NGO (non-governmental organisations) supported projects in those villages.

The study sites

The first PRA was implemented at Or Pheasang and Kraing Sbauv villages, where the trial to evaluate pig feeding with palm juice was conducted. The villages are located approximately 50 and 25 Km south of Phnom Penh City, respectively. The pH of the soil is approximately 5.5 with an average rainfall of 1,200 mm per year and the humidity ranges from 55 to 75%. In these villages there was already an ongoing (integrated rural development) project supported by a non-governmental organization (Lutheran World Service). Or Pheasang village is populated with approximately 184 households (856 persons). The total population of Kraing Sbauv is 122 households and 502 persons.

The second PRA was conducted in three villages (Sre Tasek, Tropain Putrea and Komnop), Tumnop Thom commune, Punhea Leu district, Kandal Province, approximately 55 km north west of Phnom Penh City. The area is completely deforested since 1979, and has poor sandy soils. There is a total of 109 families with 551 persons, and there are projects supported by a non-governmental organization (GOAL) also in these villages.

Participants

A total of 24 local staff from different projects of the two non-governmental organizations (Lutheran World Service and GOAL) were trained for a week before conducting the village studies (PRA). The team was composed of people with different professions, such as animal nutritionists, veterinarians, teachers, water engineers, foresters, economists, nurses, rural community workers, credit specialists and agronomists.

The villagers, including the 12 farmers who had taken part in the research project (pig trials) and representatives of the local authorities participated in data collection, evaluation of the earlier pig trials (Borin et al. 1996) and planning for future activities.

Data collection methods

The data collection was implemented through Participatory Rural Appraisal (PRA) methods as described by Chambers (1993a and b) and Kirsopp (1994). The secondary data were obtained from local authorities, the two non-governmental organizations and the earlier research review (Borin et al. 1996). PRA methods used included interviews, maps, transect walks, seasonal calendars, matrix, ranking and scoring and direct observation. The teams lived in the villages during the week of the village studies.

Measurements

In order to analyse the profitability of sugar palm production, 1.50 m^3 of fire wood (approximately 450 kg) from the same tree were purchased near the village and distributed

to 7 farmers to boil palm juice. Sixty six kilogram of wood were distributed to each participating farmer in Or Pheasang village. Juice was also weighed and the sugar content measured before boiling. After the boiling procedure, the remaining fire wood was weighed again to determine fuel consumption. The sugar palm syrup obtained after boiling was also weighed.

Economic calculations

The economic calculations were based on the exchange rate during 1995 which was US$ 1=2,350 Riels in early 1995, and in September was US$ 1=2,500 Riels.

Results

Farming systems

Rice cultivation is considered the priority activity in the local farming systems. Local varieties of rice are used which are characterised by long and medium growing periods (5-6 months). The villagers begin preparing their land for rice production after the onset of the rains. In July the seed beds are prepared and sown, transplanting is in August to September, and harvesting between November and January. Farmers use two sources of fertiliser in the rice fields, cattle manure and earth mounds (generally used by those without a source of animal manure). The average yield of rice was reported as being between 1 to 1.5 tonnes per hectare per year. Sweet potato is also a common crop that is grown in the middle of the rainy season and harvested before the rice. The farmers grow water melons in October and harvest them in December, and at the same time some farmers begin sugar palm production, this activity finishing in April-May.

Sugar production

Sugar production has been considered the second most important source of complementary income. At present, some of the sugar palm producers have stopped this activity in places where fire wood is scare. However, the sugar palm still gives a good income to farmers who have access to free fire wood. The price of imported refined sugar was 1,200 Riels and the local sugar 1,100 Riels per kg at the time of the studies. The price of sugar syrup varied from 400 to 600 Riels per kg. The price always increased after May, which is the time when sugar production finishes.

Animal production

The common animals kept by the farmers in these villages are cattle, pigs and poultry, mainly chickens but including a few ducks. Most of the animals are local breeds and are fed solly with locally available feed resources such as rice straw, rice bran, banana stems, water spinach, sweet potatos, water hyacinth etc... (see Table 1). Most of the animals are scavengers.

Cattle

Approximately 60 to 70% of the villagers own cattle (used for draught power). The breeds are commonly local cows (small yellow cows). There are also crossbreeds of Hariana, which are raised in regions where green feed is available around the year, such as along the lake shore or lagoons, while the local cows are kept in areas with the poor soil. During the wet season, cattle graze on the rice bunds and during the dry season their diet is mainly based on rice straw. Sometimes palm juice and scums from sugar palm production are poured on the rice straw and fed to cattle. The main diseases of cattle in these areas are Foot and Mouth disease (FMD), Blackleg and Haemorrhagic Septicaemia, which appear in different times of the year. The Haemorrhagic Septicaemia and FMD normally appear during the rainy season and Blackleg in the dry season. The price of beef is 4,000 to 6,000 Riels per kg, although cattle are not sold by weight but usually through an agreement between the owner and a middleman. A 200 kg cow may cost (1995) approximately 200,000 to 250,000 Riels.

Pigs

One to two pigs are commonly raised for sale or for ceremonial purposes e.g. wedding banquets. They are purchased after the rice harvest and reared for 8-10 months. The main feed resource is rice bran and kitchen waste, and some farmers feed their pigs with the residual solution from the pan after sugar production. Piglets are commonly purchased at a live weight of 4-6 kg, and the common breeds are crossbreds between Yorkshire or Landrace and local breeds, which were found at all the five study sites. The main health problems are parasites, while infectious diseases such as hog cholera, pasteurellosis and erysipelas also cause a considerable losses and the mortality rate is over 50%. The live weight price was 2,600-3,000 Riels per kg in June-July, 1995 and it was increased to 3,300 Riels in January, 1996. The price of pork meat was approximately 6,000 to 8,000 Riels per kg.

Chickens

Each family raises 2-3 chickens but some farmers raise up to 10 breeders, resulting in approximately 20 head for sale in the market per annum. Chickens are fed some rice in the morning and the rest of the day is spent scavenging for food. Chicken cost 3,800 to 4,500 Riels per kg liveweight (January, 1996). The most important diseases are Newcastle disease and Fowl pox which ussually appear after the first onset of rain. Approximately 80 to 90% of the chickens are affected in this period.

Marketing and market accessibility

There were a few private sugar palm syrup collectors in the village, which meant that farmers could sell their daily sugar syrup production in the village. The sugar syrup can also be stored in containers during the production period in order to sell later at a higher price. Sometimes farmers bring sugar syrup to the city to be sold in the market, and sugar can also be sold in the villages for immediate consumption.

Animals are generally sold through middlemen who frequently visit the villages. If possible farmers use their own transport to take animals to the slaughter house, as the price of pigs at the slaughter house is better than the price offered by the middlemen. A few years ago farmers were allowed to kill animals and sell the meat in the nearby villages, but this is not permitted today.

Introduced technology

Since 1993, about 30 cheap plastic biodigesters have been installed in Kandoeung commune and one in Tumnop Thom commune. The digesters were connected to pig pens and latrines and there is one mixer in each digester for cow dung. The gas from the biodigester covers about 80 to 85% of the domestic fuel consumption per day.

Discussion

General aspects

The population of sugar palm trees in Cambodia has increased since 1901 (Dolbert, 1991), when the King of the Kingdom of Cambodia decreed that every Cambodian must plant a few sugar palm trees and the trees have been an important contributor to rural farmer livelihoods since that time. The product that has considered to be the primary source of income is the juice. However, leaves, fruits, fibre and trunk also provide food, animal feed, materials for construction and have the other domestic uses. The trees have the potential to produce inflorescences all the year around or a total of 10-15 inflorescences during the production season. In this situation, the inflorescences can be preserved after the preparation procedures have been successfully completed. Normally, the palm juice is not commonly collected during the rainy season. There are many reasons that farmers do not practise juice collection in the rainy season such as the strong winds which make it dangerous to climb to the tops of the trees. Also it is difficult to protect the collectors from rain, and the tree trunks become slippery. However, some people still collect juice during the rainy season to sell as fresh drink in the cities and towns. The price of sugar syrup varies depending on the location, and in 1995 the price per kg was 500-600 Riels in Bati district in Takeo province and 350-400 Riels in Kampong Chhnang province (Nol Paan 1995, personal communication). The price of fire wood is the major factor which influences the cost of production (Table 2). In 1995 the price of fire wood was 8,000 Riels per m^3 in Kompong Chhnang province and about 20,000 Riels per m^3 in Takeo province. However, transport distance may also influence the cost of sugar syrup, because the important market is located in the city (Phnom Penh). At present there is a fuel problem for boiling juice in the five sites studied. Fire wood has become scarce and sugar production was found to be not profitable when fire wood was purchased. In the traditional sugar production system, fuel consumption has not been included in the cost of production because fire wood could be freely collected (Borin et al 1995).

Leaves are the second most important product from the sugar palm tree, and it can be harvested two to three times a year, except for the trees from which juice is being collected. The leaves are mostly used for thatch, but also matting, baskets, hats, rice storage boxes, fans and fancy boxes are common products. Morton (1988) and Davis and Johnson (1987) reported that a well thatched roof will last for 2-3 years. The price of thatch depends on its quality, and varies from 70-300 riels (1995) per thatch.

Animal production

Preston (1995) reported that the growing discrepancy between the expanding world population and its food producing capacity is primarily caused by competition between livestock and humans for cereal grains. The solution that is proposed is to develop alternative feeding systems for livestock using non-cereal, perennial, high-biomass producing crops that can be grown under rain-fed conditions on sloping lands not suitable for cereals.

Juice and scums from the sugar palm have been used for cattle feeding. The juice or scum is poured over rice straw and fed immediately to cattle. The green and mature fruits are considered a good supplement for cattle in the dry season, and the leaves from small trees are also eaten by cattle during the dry season when there is no green feed available. The waste fruit after human consumption is chopped and fed to cattle, especially to the draught animals. Sometimes the mature fruit is soaked in water to give a yellow pulp which can be fed both to cattle and pigs. The fresh yellow pulp has been reported to be rich in vitamins A and C (Morton 1988). Due to the insufficient and poor quality feed for animals during the dry season, especially for ruminants which are supposed to work hard in the early of rainy season. The situation provides opportunity for microorganisms to easily invade the animals.

The remainder after cleaning the pans used for boiling juice has traditionally been fed to pigs in the rural communities. Farmers mentioned that pigs seem to have better performance during this period compared to periods when they are fed rice bran alone. The price per kg of rice bran varies with its quality from150-250 Riels (1995), and the bran found on many farms and used as pig feed appeared to contain more than 50% of rice hulls, which makes the diet unpalatable. Payne (1990) suggested that rice bran should not be fed to piglets, and no more than 30-50% of the total ration for fatteners due to its high fibre content and laxative effect. The quantity and quality of feed varies according to the money available to the farmers. For example, it is not only feed deficiency which affects the performance of pigs, but there are several factors that should be also taken into consideration, such as management, breeds and diseases (especially parasites). Farmers raise pigs until they reach 70-80 kg, and normally do not have any plans to sell them while they still are growing and look healthy.

At present, the production systems with free ranging pigs seem to cause many problems in the community since the human population is growing, as there is a need to use available land to produce food and this comes in conflicts with free ranging pigs. During the dry season when the temperature is high, pigs do not scavenge in the paddy fields but rather go inside the vegetable gardens cause damage to the gardens. Sometimes they are killed by the pesticides that the farmers have recently sprayed over their vegetable. There is also a high incidence of internal parasites in this system, Payne (1990) reported that the humid tropics provide an almost perfect environment for many parasites. The high mortality in pig production in the rural areas in Cambodia, due to the inadequate veterinarian services, poor and unbalanced diets and the deficient management provided by the owners of the pigs.

Farmers have their own opinions, based on experience, as to the choice of pigs to raise. Some farmers were of the opinion that they could only rear white pigs, while the others preferred black and white pigs. Normally piglets of 4-6 kg live weight are purchased in the rural areas. They are cheap and if they die, the farmers would only loose a small investment, as at the time of the study the price of a small piglet (4-6 kg) was approximately 20,000 to 25,000

Riels and a weaner (15 to 20 kg) about 50,000 Riels (1995). Borin (1994) suggested that it is preferable to purchase pigs with an initial weight of at least 15 kg when feeding sugar cane juice as sole energy source as this weight performs better at small farms conditions and Cunha (1977) suggested that heavier pigs can use higher levels of molasses more effectively than small pigs.

Economic comparisons of different sugar palm products

The average profit from feeding palm juice to pigs was 150 Riels per tree per day (Table 3), compared to 11 Riels per tree per day for sugar syrup production. The profit from selling thatch was 6 Riels per day per tree, including the fruits. The comparison of juice feeding to pigs with sugar production is particularly interesting. Four of the seven families made no profit from making sugar when the cost of fuel was taken into account, and the highest profit from sugar production was still less than the lowest profit from pigs. Four out of the seven farmers (Yem Khnol, Thol Onn, Houy Kiel and Pauv Pauv) were in fact loosing 22, 7, 45 and 36 Riels per tree per day, respectively (see Figure 1). The quantity of fuel consumption depends mainly on the efficiency of the stove that individual farmers have built, and also the skill and experience of each tapper to produce good quality juice. When the inflorescence is managed in the proper way, the concentration of sugar (Brix) will be high, and with less water in the juice the time needed for boiling will be shorter and less fuel will be needed. It was also found that the each sugar producer needs to buy 8 to 10 palm trees for fuel every year in addition to the fire wood that they have bought or collected earlier.

The mean net profit recorded was 22,500 Riels annually per tree by feeding the juice to pigs, compared to 1,600 Riels annually per tree for sugar production. When the purchased price of fire wood was not taken in consideration for sugar production, the profit was 49,000 Riels per palm tree per year. The average cost for fire wood is approximately 39,000 Riels annually per sugar palm tree. Labour costs directly related to the sugar production were not included in the calculation, but the opportunity cost of working on rice cultivation was used (2,500 to 3,000 Riels per day). In regions where fire wood is still available and free, farmers consider that sugar syrup production is one of their main sources of annual income. Moog et al (1994) reported that feeding pigs with sugar cane ad libitum (supplemented with soybean meal) was a profitable alternative and gave higher income per unit of land compared to processing for sugar. This alternative is more environmentally friendly because it avoids the use of fossil fuels and allows the use of manure for more sustainable agricultural production.

Feeding palm juice to pigs is not only profitable for people in the rural areas in Cambodia but also benefits biodiversity and the environment, as trees will not be destroyed for as fire wood to boil the sugar palm juice. Farmers also save time when juice is fed to pigs, allowing them concentrate on other important activities. It takes approximately only 2-3 hours per day to climb 8-10 palm trees and 1-2 hours per day to feed the pigs and clean the pig pen compared to sugar production which takes about 16 hours per day of work for the whole family. In addition, the farmers are able to collect the manure in the pig feeding system as substrate for the biodigester and can use the effluent as organic fertilizer, which is also more beneficial to the environment compared to the use of chemical fertilizers.

Dolbert (1991) in his survey on sugar palm syrup production in Cambodia reported that the

whole family was occupied almost all the time with sugar production and spent about 16 hours per day in collecting fire wood, chopping it and monitoring the bioling process. In some places fire wood has been replaced to some extent by rice hulls using a new design of the stove. In this case 1 kg of sugar requires around 4-5 kg of rice hull, at a cost of approximately 200-250 Riels per day per tree which is equivalent to 33,750 Riels per season per tree. This is cheaper than the equivalent amount of fire wood which costs 49,000 Riels. According to one farmer (Mr Em Pheap) it was much more convenient to boil with rice hulls than with fire wood and also cheaper, but the hulls however were more difficult to acquire.

There are several domestic options for using palm leaves, but the most common is for thatch and mats. Twenty five to thirty six leaves were collected 1-2 times a year from trees that were not being used for juice production. When leaves were used for thatch the profit was 2,250 Riels per tree per year, while the profit was somewhat higher for making mats, although labour costs (opportunity cost) were also included in the calculations. Using the leaves for thatch or mat making, is more preferable from the environmental considerations compared to sugar production.

Sugar palm juice for pigs in the rural areas, has great potential as an energy source which allows farmers to use alternative sources of protein such as water plants and the leaves from multipurpose trees and it shows that the number of farmers who feed their pigs with sugar palm juice has increased considerably in the Or Pheasang village (Annex 1 and 2). Elliott and Kloren (1987) reported that the use of fibre free energy sources such as raw sugar or sugar cane juice permits greater use of cheaper vegetable protein sources which are not usually included to a great extent in conventional diets because of their high fibre content. Therefore, the use of sugar palm juice in pig feeding will allow farmers to use their own local available feed resources and the cost of pig production will be lower. Water plants such as water spinach, water hyacinth and duckweed will be the potential protein resources when pigs are fed with sugar palm juice, as soya beans are expensive and are not considered as a common protein supplement for farm animals in Cambodia. Dry soya beans cost $US 265 per tonne in December 1994 and the price had increased to $US 520 six months later. Soya bean prices are usually lowest in December-February at the early stage of harvest, but the price varies from year to year according to demand at local and/or regional markets.

Low cost plastic biodigester

Biodigestion and gasification are complimentary technologies for generating combustible gas and substrates for the chemical industry. Biodigestion is the technology of choice for farmers for recycling excreta from animals and humans and converting it into biogas (methane). This provides an environmentally friendly system for fuel production and also organic fertilizer suitable for crops or fish ponds (Preston 1994; An et al 1994). The low cost plastic digesters were installed in Or Pheasang village to collect faeces and residues from pig pens and from the human latrine. Also one mixer was installed in the entrance tube of the biodigester. This promises to be an effective way of making the use of latrines more popular by rural families who find the gas production as an incentive to use latrines and keep the house clean (Than Soeurn 1994). In order to encourage farmers, to adopt the technology they were initially asked to pay only 40% of the total cost of installation, because it was a new unknown technology which they were uncertain of. Six pigs are able to produce manure sufficient for

one unit of digester which will provide gas enough to replace 80 to 85 % of fire wood consumption for cooking per day for one family of 5 members. In addition, the effluent from the digester can also be used as fertilizer for duckweed production, which provides good source of protein for pigs (Leng et al. 1995) (see Figure 2).

Conclusion

The studies show clearly that feeding pigs with sugar palm juice gives the farmers more profit than sugar syrup production, when the cost of fire wood is included in the cost of sugar production. However it is till a good source of seasonal income for the farmers who have access to free fire wood. Therefore, feeding pigs with palm juice is an alternative source of income in the rural areas from where fire wood is expensive and furthermore it will prevent the forestation by using as fire wood to boil juice for sugar. It is also suggested that pigs need to be reared in confinement pen that will give less opportinity for diseases and more importantly in this system pigs can not distroy vegetable gardens.

Due to the fluctuation of the price of soya beans, other alternative protein sources should be used in order to ensure profitability. Sugar palm juice has a good potential for pig feeding in the rural areas in Cambodia and should use of cheap protein sources which have a high fibre content.

It is important to install the digester for methane production, so that it can be connected directly to the pig pens. The system provides gas for cooking and keeps the house clean without any pollution from smoke and odours from the pigs' waste. This system has additional advantages in preventing deforestation and can be considered to be environmently friendly and healthy.

Acknowledgements

The financial support from Swedish Agency for Research Cooperation with Developing Countries (SAREC) and the Ecumenical Scholarships Programme in Germany (DIAKONISCHES WERK) is gratefully acknowledged.

Thank are also due to the farmers in Kandoeun commune in Takeo province and in Tumnop Thom commune, Kandal province, who spent their valuable time to provide us with information on their experiences and indigenous practices and also provided accommodation during the Participatory Rural Appraisal exercise. Thanks also due to the PRA team from LWS, FHI and GOAL organizations.

References

An Bui Xuan, Man Ngo Van, Khang Doung Nguyen, Anh Nguyen Duc and Preston T. R. 1994. Installation and performance of Low-Cost Polyethylene Tube Biodigesters on Small Scale Farm in Vietnam. In: Proceeding of National Seminar-workshop "Sustainable Livestock Production on Local Feed Resources" (Editors: T. R. Preston, B. Ogle, Le Viet Ly and Lu Trong Hieu), Ho Chi Minch City, November 22-27, 1993. pp 81-90.

Borin Khieu, 1994. Feeding Livestock on Local Resources in Cambodia. In: Proceedings of National Seminar-workshop "Sustainable Livestock Production on Local Feed Resources" (Editors T. R. Preston, B. Ogle, Le Viet Ly and Lu Trong Hieu), Ho Chi Minch City, November 22-27, 1993. pp 98-104.

Borin Khieu, Preston, T. R. and Ogle, B. 1995. Fattening pigs with the juice of the sugar palm tree (Borassus flabellifer). Livestock Research for Rural Development, 7(2). 25-29.

Borin Khieu, Preston, T. R. and Lindberg, J. E. 1996. Juice Production from the sugar palm tree (Borassus flabellifer) in Cambodia and performance of growing pigs fed sugar palm juice. pp 1-9.

Chamber, R. 1993a. Challenging the professionals: Frontiers for rural development. Intermediate Technology Publications Ltd. 103-105, Southampton Row, London WC1B 4HH, UK. pp 97-105.

Chambers, R. 1993b. Rural Development: Putting the Last First. Longman Scientific & Tichnical. Copublished in the United State with John Willey &Sons, Inc., New York. pp 191-208.

Cunha, T. J. 1977. Swine feeding and Nutrition. pp 154 and 241.

Davis, T. A. and Johnson D. V. 1987. Current Utilization and Further Development of the Palmyra Palm (Borassus flabellifer L., Aracaceae) in Tamil Nadu State, India. 1988, by the New York Botanical Garden, Bronx, NY 10458. Economic Botany, 41(2). pp 23-44.

Devendra, C. 1993. Sustainable animal production from small farm systems in South-East Asia. Charter 3 and 4. pp 23-44.

Dolbert, P. 1991. The Artisan Sugar Palm Syrup Production in Cambodia. Project of GRET (Agricultural Technique and development of Cambodia), translated from cambodian language version. pp 1-9.

Elliott, R. and Kloren, W. R. L. 1987. The use of sugar in diet for monogastrics. Recent Advances in Anim. Nutr. in Australia. pp 290-296.

Kirsopp-Reed Kate, 1994. A review of PRA Methods for Livestock Research and Development. In: RRA Notes, Number 20: Spacial Issue on Livestock (Edited by Kirsopp-Reed Kate and Hinchcliffe Fiona). pp 11-35.

Leng, R. A., Stambolie, J. H. and Bell R. 1995. Duckweed-A Potential High-Protein Feed Resource for Domestic Animals and Fish. Livestock Research for Rural Development. 7(1). (16Kb).

Moog, F. A., Samiano A. M., Valenzuela, F. G., Raymundo, S. G. and Fementira, E. B. 1994. Utilization of Sugarcanes Juice for Swine in the Philipinnes. Proceedings of the 7th AAAP Congress in Bali, Indonesia. 129-135.

Merton, J. F. 1988. Notes on Distribution, Propagation, and Products of Borassus Palm (Arecaceae). 1988, by the New York Botanical Garden, Bronx, NY 10458.

Economic Botany, 42(3). pp 420-441.

Payne, W. J. A. 1990. An Introduction to Animal Husbandry in the Tropics. Fourth edition. Tropical Agriculture Series. Longman Scientific & Technical. Copublished in the United State with John Wiley & Sons, Inc., New York. pp 660-666.

Preston T. R. 1995. Research, extension and training for sustainable farming systems in the Tropics. 7(2). 1-7.

Preston, T. R. 1994. Renewable Energy from Tropical Agriculture: The respective roles of Biodigestion and gasification. CIPAV, Cali, Colombia. In: Proceeding of National Seminar-workshop "Sustainable Livestock Production on Local Feed Resources" (Editors: T. R. Preston, B. Ogle, Le Viet Ly and Lu Trong Hieu), Ho Chi Minh City, November 22-27, 1993. pp 94-97.

Romera, J. P. 1968. Le Borassus et le sucre de palme au Cambodge. L' Agron. Trop. 8, 801-839.

Than Soeurn, 1994. Low cost biodigesters in Cambodia (FAO/TCP/CMB/2254). In: Proceedings of National Seminar-workshop "Sustainable Livestock Production on Lacal Feed Resources" (Editors: T. R. Preston, B. Ogle, Le Viet Ly and Lu Trong Hieu), Ho Chi Minh City, Noverber 22-27, 1993. pp 94-97.

Table 1.

Different feed resources used for animal in the four villages of the study

Feed	Chickens & ducks	Pigs	Cattle
Rice bran	yes	yes	some
Broken rice	yes	yes	
Paddy rice	yes		some
Rice straw			yes
Kitchen waste		yes	
Banana stem		yes	yes
Water spinach		yes	
Water hyacinth		yes	some
water lylium (Prolit)		yes	
Duckweed	yes	yes*	
Palm juice		yes**	some
Scum		yes	
Palm fruits		yes	yes

* Started from 1993 during FAO/TCP project in Cambodia.
** Started in 1995 with small scale demonstration.

Table 2.
Costs and return (Riel) of sugar palm syrup production per palm tree per day.

	Cost	Return
Fire wood	250	
Depreciation cost (ladders and collectors)	20	
Opportunity cost (palm juice)	20	
Opportunity cost (labour of boiling juice)	120	
Other costs	15	
Total	**430**	
Sugar palm syrup, kg		0.8
Market price, kg		550
Sum of return		**440**
Net return		**10**

- The opportunity cost of hired labour for the rice cultivation can be used (3,000 Riels per day). An average of 6 hours spend for boiling and steering syrup of 15 palm trees.
- Price per kg of sugar palm syrup 500-600 Riel.

Table 3.
Daily intake and cost of pig production (Riel)

Ingredients	Amount (day)	(kg)	Cost (day)	Cost Return (day)
Palm juice	2 palm trees	-	40*	
Soya beans	400 g	625	250	
Water spinach	500 g	100	50	
Salt	5 g	150	1	
Lime	5 g	500	2	
Depreciation cost (ladders and collectors)			40	
Health care			26	
Depreciation cost (pen construction)			24	
Opportunity cost (labour)			100	
Cost of piglet			335	
Total			**868**	
LWG, kg/day				0.36
Market price, kg				2,800
Sum of return				**1,008**
Net return				**140**

* Cost of hired 2 palm trees per day
- Opportunity cost of hired labour for the rice cultivation can be used (3,000 Riels per day). Approximately 2 hours are spent to feed and clean 6 pigs per day.
- Market price of live weight pig (2,600-3,000 Riels/kg).

Annex 1.

Farmers practicing palm juice as pigs feeding in Or Phearsang village.

N°	1994 participation	No of pigs	1995 participation	No of pigs
1	Pal Ponn	2	Pal Ponn	2
2	Hang Vy	2	Han Vy	2
3	Map Chreb	2	Map Chreb*	6
4	Prum Yuon	2	Prum Yuon	4
5	Hay Yang	2	Hay Yang*	6
6	Yem Khnol	2	Yem Khnol*	6
7	Sim Hin	2	Sim Hin*	6
8	Chhan Mak	2	Chan Mak*	6
9	Khem Khorn	2	Khem Khorn	1
10	Hang Pauv	2	Pauv Sien	2
11	Pring Houy	2	Pring Houy*	6
12	Ly Khorn	2	Ly Khorn	2
13	Chhen Rin	2	Chhen Rin	2
14	Ho Vin	2	Map San	2
15			Phoeun Rin	8
16			Thol Onn*	6
17			Lin Thorn	2
18			So Maly	2
19			Vay Thea	2
20			Yem Hay	4
21			Thorn Chreb*	6
22			Phol Lack	2
23			Khaim Rem	1
24			Touch Chhien	2
25			Tha Khorn*	6
26			Pauv Pauv*	6
27			Thorn Puon*	6
28			Huy Kiel*	6
29			Om Teck	2
30			Van Phan	2

*Farmer participated in the SAREC M.Sc research (1995).

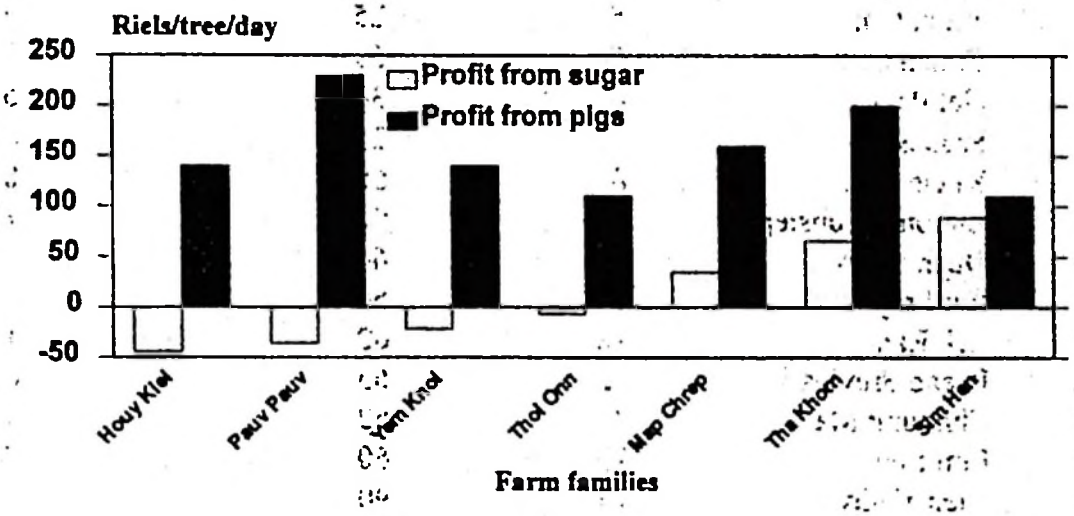
Annex 2.

Farmers practice sugar palm production (Kandoeung commune, Bati District, Takeo)

No	Farmer name	Number of trees	Quantity of juice/day (kg)	Sugar/day (kg)
1	Dul Thy	9	60	10
2	Yuon Om	5	25	3
3	Chhan Sok	7	58	7
4	Nat Phat	6	30	5
5	Sron Sot	4	25	3,5
6	Khein Run	8	60	8
7	Chhom Reunsiep	10	90	15
8	Duch Mom	7	60	7
9	Em Srey	14	60	10
10	Eck Ran	12	62	11
11	Pheap Sreyleap	12	65	8
12	Chhoung Ma	7	52	5
13	Eim Lem	10	60	7
14	Nien Vathy	15	90	15
15	Hay Yang	10	75	13,5
16	Thol On	12	65	*
17	Phoeun Rin	12	45	8
18	Map Chreb	21	140	*
19	Pauv Pauv	43	230	*
20	Sim Hen	15	60	*
21	Tha Khorn	18	100	*
22	Kheun Ry	9	50	10
23	Houy Kiel	20	125	*
24	Khai Rem	35	120	20
25	Map Roeun	10	60	5
26	Phat Leng	10	58	6
27	Vock Heng	11	57	5
28	Enn Sovoeun	10	60	9
29	Houn Hoeun	12	60	8
30	Mann Phy	10	60	5
31	Phol Lack	10	70	13
32	Han Vy	8	60	6
33	Phok Mue	18	90	15
34	Bun Kai	8	60	5
35	Nhan Panha	10	75	14
36	Yim Von	9	70	10
37	On Chhea	10	70	13
38	So Maly	8	65	10
39	Phan Mom	10	70	14
	Average	12 trees/family	72	9.5

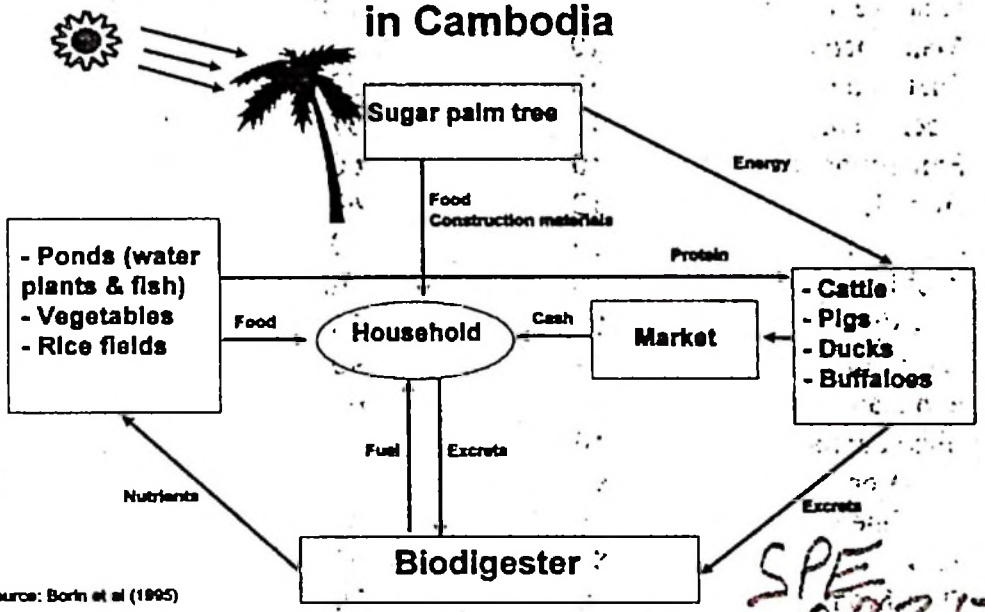
* Farmers participated in the SAREC M.Sc research on pig feeding with palm juice (1995).

Figure 1. Comparative profit of different farmers from sugar palm trees used for sugar production or for pig rearing



Source: Borin Khieu et al (1995)

Figure 2. Integrating the sugar palm (Borassus flabellifer) in farming systems in Cambodia



Source: Borin et al (1995)

The following MSc theses in the programme *Integrated livestock based farming systems for sustainable use of renewable natural resources* have been published up to 1996
The theses can be obtained from the department as long as the supplies last.

Becerra, M. 1994. Evaluation of feeding systems for growing ducks based on aquatic plants and sugar cane juice.

Bitende, S.N. 1994. The potential of *Acacia tortilis* fruits and *Sesbania sesban* leaves as livestock feeds in smallholder farming system.

Bui Huy Nhu Phuc. 1994. Effect of protein supply in sugar cane juice based diets for growing pigs.

Le Duc Ngoan. 1994. The use of African palm (*Elaeis guineensis*) oil as an energy source for pigs.

Mai Van Sanh. 1994. Effects of restricted suckling versus artificial rearing on performance and fertility of *Bos taurus* and *Bos indicus* cows and calves.

Mejia, C. 1994. Effects of restricted suckling versus artificial rearing on milk production, calf performance and reproductive efficiency of dual purpose Mpwapwa cattle in a semi-arid climate.

Mlay, D.G. 1994. Cereal crop residues for livestock feeding based on urea-molasses blocks and high offer level in central Tanzania.

Msangi, B.S.J. 1994. Effect of Magadi soda treatment, high feeding level of maize stover and multinutritional blocks on the performance of crossbred dairy cows in the coastal region of Tanzania.

Nguyen van Thu. 1994. A study of the use of female cattle and buffalo crushing sugar cane in Colombia.

Ospina, L. 1994. Effect of protein supply in cassava root meal based diets on the performance of growing finishing pigs.

Shirima, E.J.M. 1994. Quality and quantity of maize and sorghum vegetative parts harvested at different stages of plant growth as fodder for livestock.

Solarte, A. 1994. Experiences from two ethnic groups of farmers participating in livestock research in different ecolocical zones of the Cauca valley of Colombia.

Toung Naren. 1994. Optimum protein supply and level of inclusion of water spinach (Ipomoea aquatica) in sugar cane juice based diets for growing ducks.

Beteta Herrera, T. 1996. Experiences of recyling manure in Colombia.

Bui Xuan An. 1996. The impact of low-cost poly-ethylene tube biodigesters on small scale farms in Vietnam.

1996

Bui Xuan Men. 1996. Improvement of the local duck production system in the Mekong Delta,

Dereje Fekadu Fantaye. 1996. A study of the potential of Enset (*Ensete ventricosum*) in ruminant nutrition in Ethiopia.

Goromela, E.H. 1996. The influence of indigenous browse and other local feeds on the milk production and nutrition of dual purpose goats in Central Tanzania.

Khieu Borin. 1996. Study on the use of the sugar palm tree (*Borassus flabellifer*) for different purposes in Cambodia.

Nguyen Thi Loc. 1996. Evaluation of the protein supplementation of traditional diets and cassava root silage for local crossbred pigs under village conditions in central Vietnam.

Nguyen Thi Mui. 1996. Effect of management practise on biomass juice yield and composition of sugarcane and on soil fertility.

Nguyen Nhut Xuan Dung. 1996. Identification and eveluation of indigenous plants for livestock and humans in the Mekong Delta region in Vietnam.

Rodriguez Jimenez, L. Appropriate use of local resources as a strategy to develop sustainable farming systems in Central Vietnam.

Tadelle Dessie. 1996. Studies on village poultry systems in the central highlands of Ethiopia.