# CHAPTER I

## INTRODUCTION



During the processing of raw agricultural produce into consumable products, a number of residues are available in the form of by products and wastes. Their accumulation results not only in disposal problem but also leads to serious environmental pollution hazards. Under the energy crisis and pollution problems, one solution lies in the developement of utilization of wastes. Therefore, the main objectives of waste utilization are two folds, firstly minimizing environmental pollution, secondly utilizing waste as a source of useful economic products.

The canning of pine-apple is characterized by an extensive use of water during processing. It generates large quantities of effluent of high BOD and COD content. These constitute a serious environmental problem. Pine apple processing consumes about 50% of the fruit. The remaining 50% constitutes the waste. The core, freshy waste and scrapings from the skin are recovered and process for juice. The liquid waste was treated before being allowed to flow into the river. The solid wastes were dumped into the ground. In Thailand there are about 10 pineapple canneries. Each cannery generates approximately 300 ton/day of solid waste and 2,000 $m^3$/day of liquid waste.

It has been suggested that the pine apple processing effluent with high BOD and COD content could undergo a Reverse Osmosis and Ultrafiltration treatment, thereby producing large quantities of good water, which could be recycled in the cannery. The concentrated effluent, with still higher BOD and COD content, could then be used for alcohol, vinegar or other kinds of fermentation.

The liquid recovered from the solid wastes could also undergo a UF/RO treatment. The liquid from solid waste contains higher BOD and COD content than the effluent so becomes a better source of fermentation. The residue after squeezing out liquid may be pressed and dried for sale as cattle feed or use as substrate for biogas production.

## 1.1 Reverse Osmosis and Ultrafiltration

Ultrafiltration and Reverse osmosis are techniques which are based on the ability of polymeric membranes to separate various species on the basis of molecular size, shape, and/or chemical composition. Ultrafiltration is used in this thesis when the membranes allow the passage of smaller molecules (up to molecular weight 500). The word Reverse osmosis is used when the membranes allow only limited passage of small molecules such as inorganic salt. Both processes take place at 0 to 50$^{o}$C and allow treatment of heat-sensitive process. By appropriate manipulation of membrane fabrication procedures it is possible to tailor both reverse osmosis and ultrafiltration membrane permeability characteristics for a given application. In the former case one obtains a trade-off between rejection and permeate flux in the later case it is possible to vary the so-called molecular weight cutoff of the membrane. That is to say one can obtain membranes in a variety of sieve sizes on a molecular scale. Molecular-weight cutoffs are only nominal values and the shift from zero to complete rejection may occur over a fairly wide range of molecular weights. The cutoff levels are also depend to some extent on whether one is dealing with a compact globular macromolecule or a well solvated macromolecule with an elongated configuration.

Ultrafiltration and Reverse osmosis permit separation of dissolved materials from one another or from the solvent without a phase change, thus without expending energy represented by the latent heat of vaporization or crystallization. The processes utilize selective membranes which behave discriminately between components of a solution and thus is more permeable to one component or a group of components than to other components. The techniques are utilized to fractionate relatively dilute liquid waste from pineapple cannery in order that the concentrated waste can be further effects by other means such as fermentation and the clean water can be recycled as process water.

Many types of membranes modules are commercially available. The module should be selected for any particular applications since they are different in design and perfermance. Tubular modules are selected in this work. The advantages in comparison with the other type of modules such as flat plate, spiral wound and hollow fibre, are their ability to handle "dirty" applications, readily cleanable and large volumetric pumping rates.

## 1.2 Purpose of this work

The primary objective of this work is to study the effects of operating conditions for Reverse Osmosis and Ultrafiltration systems which are used to increase the concentration of solutes in the liquid-waste of a pineapple cannary. It is expected that Ultrafiltration and Reverse Osmosis will :

1.2.1 produce high enough quality permeate so that it can be recycled into the cannery with minimal further treatment.

1.2.2 produced high enough BOD and COD content retentate so that it can be used as a substrate in fermentation process effectively.

## 1.3 Working programmes

The programmes of this work are :

1.3.1 Laboratory studies on the operation of Ultrafiltration and Reverse Osmosis system.

1.3.2 Determination of flow rate and the dependence of flux rates on the operating conditions.

1.3.3 Determination of the rejection properties of the membrane and the dependence of the retention efficiency on the operating conditions.

1.3.4 Determination of the physical and chemical properties of the concentrate and permeate.

## 1.4 Characteristics of pineapple cannery waste

The pineapple cannery industry is a large user of water. The flow diagram of canning process for Siam Food Products, a cannery in Chonburi province, is shown in Figure 1.1. An average of 2-3000 $m^3$ per day of liquid waste was rejected with an equivalent of 4-30 tons of sugar per day. A large part of this water can be processed by Ultra-filtration and Reverse Osmosis and reuse again, the concentrated waste can be further used as a substrate in fermentation process.

The waste effluents from the cannery plant, contains about 0.2 to 1.0% sugar (see Table 1.1). The sugar concentration in the liquid waste is not constant but varies with the seasons due to variation of the fruits (Table 1.2) and the production capacity of the plant.

The solid waste is mostly pineapple shell derives from Peeling and Coring section (GINACA) (see Figure 1.1). This solid waste may be pressed and dried for sale as cattle feed, for it still contains many valuable materials and vitamins as indicated in Table 1.3. The juice resulting from squeezing solid waste contains higher dissolved solutes (sugar and other materials) than the direct liquid waste, therefore is of interest for further Utilization.

The analysis in Table 1.4, shows that the liquid squeezed from the solid waste contains more than 3% sugar, and some protein which may be possible to fractionate by a system of UF and RO membranes.

Table 1.1

Analysis of pineapple cannery liquid waste

| | |
|---|---|
| Acidity (ppm as $CaCO_3$) | 880 |
| COD (ppm) | 62,000 |
| pH | 3.4 |
| Total solid (ppm) | 5,413 |
| Total dissolve solid (ppm) | 3,223.6 |
| Total sugar % (gm/ml) | 0.285 |
| Reducing sugar % (gm/ml) | 0.228 |
| Turbidity (JTU) | 105 |
| Total Nitrogen (ppm) | 19.4 |
| $Cl^-$ | 180 |

SOURCE : Annual Report 1980, "Asean working group on the management and Ultilization of Food Waste materials."

Table 1.2

Effect of variation in seasons on pineapple constituents

| Year & month | °Brix | pH | % acidity (citric acid) |
|---|---|---|---|
| July | 14.4 | 3.76 | 0.60 |
| August | 13.7 | 3.97 | 0.49 |
| September | 12.7 | 3.84 | 0.54 |
| October | 13.2 | 3.90 | 0.44 |
| November | 12.1 | 3.80 | 0.51 |
| December | 13.2 | 3.70 | 0.60 |
| January | 12.2 | 3.57 | 0.43 |

SOURCE : Annual Report 1980 "Asean working group on the management and Ultilization of Food Waste materials"

Table 1.3

Chemical compositions and Vitamins of pineapple fruit

(per 100 gm)

| | |
|---|---|
| Moisture (%) | 84.9 |
| Fat (%) | 0.3 |
| Calory (per 100 gm) | 54.0 |
| Protein (%) | 0.4 |
| Ca (mg) | 22.0 |
| P (mg) | 8.0 |
| Fe (mg) | 0.4 |
| Vitamin A (IU) | 15.0 |
| " $B_1$ (mg) | 0.09 |
| " $B_2$ (mg) | 0.04 |
| " C (mg) | 17.0 |
| Niacine (mg) | 0.2 |
| Fibre (gm/100 gm) | 0.5 |

Source : Annual Report 1980," Asean working group on the management and Ultilization of Food Waste materials"

Table 1.4

Analysis of Juice squeeze from pineapple shell

| | |
|---|---|
| Moisture | 88.17% |
| NaCl | 0.03 |
| Reducing sugar | 2.90 |
| Total solid | 4.04 |
| Soluble solid | 3.90 |
| Protein | 0.41 |
| Ash | 0.43 |

Source : Annual Report 1980, "Asean working group on the management and Ultilization of Food Waste materials."

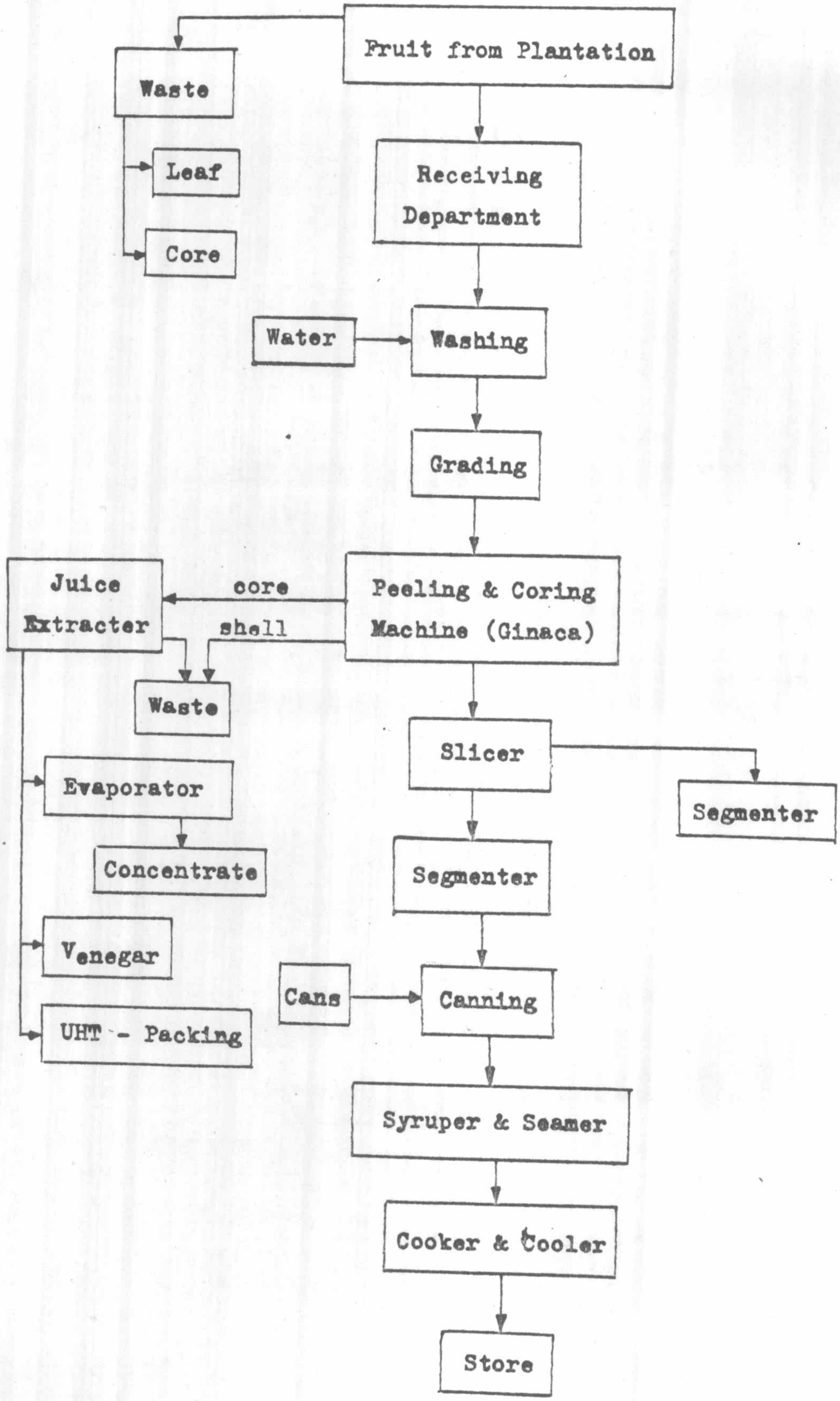


Figure 1.1 Flow chart of pineapple cannery

Figure 1.2 Process lines of pineapple cannery plant

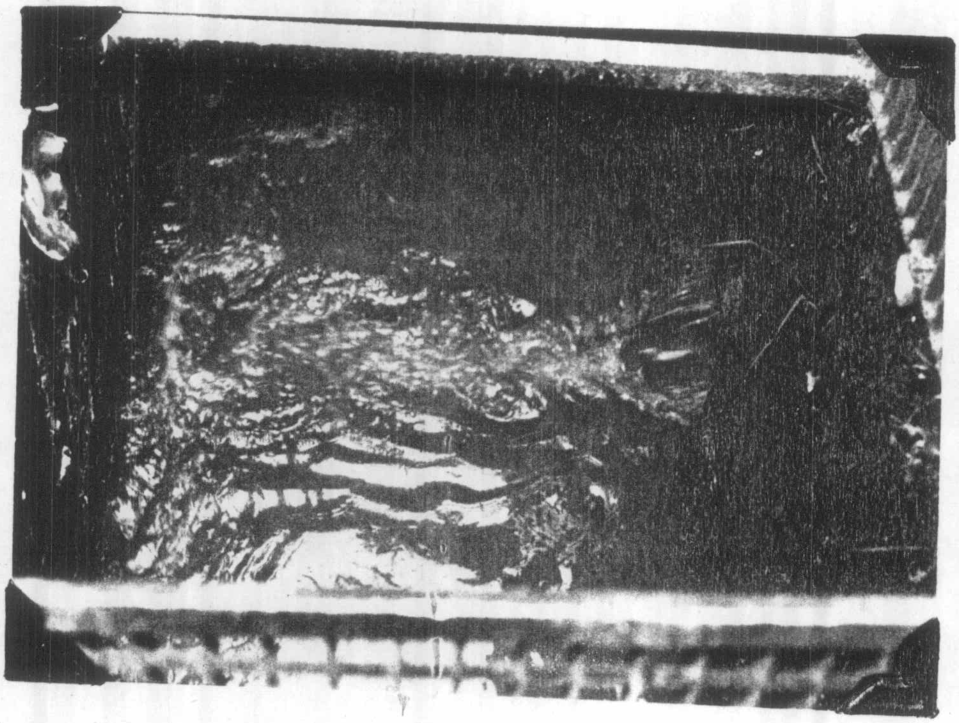

Figure 1.3 Pineapple cannery liquid waste from the plant about 2-3,000 $m^3$/day

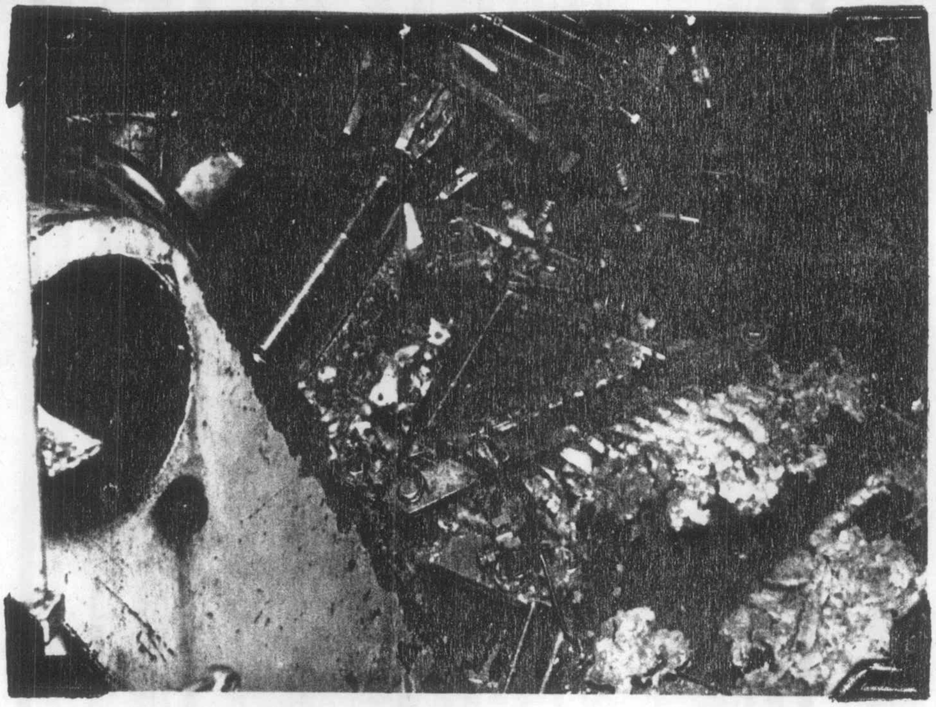

Figure 1.4 Peeling and coring machine (GINACA)

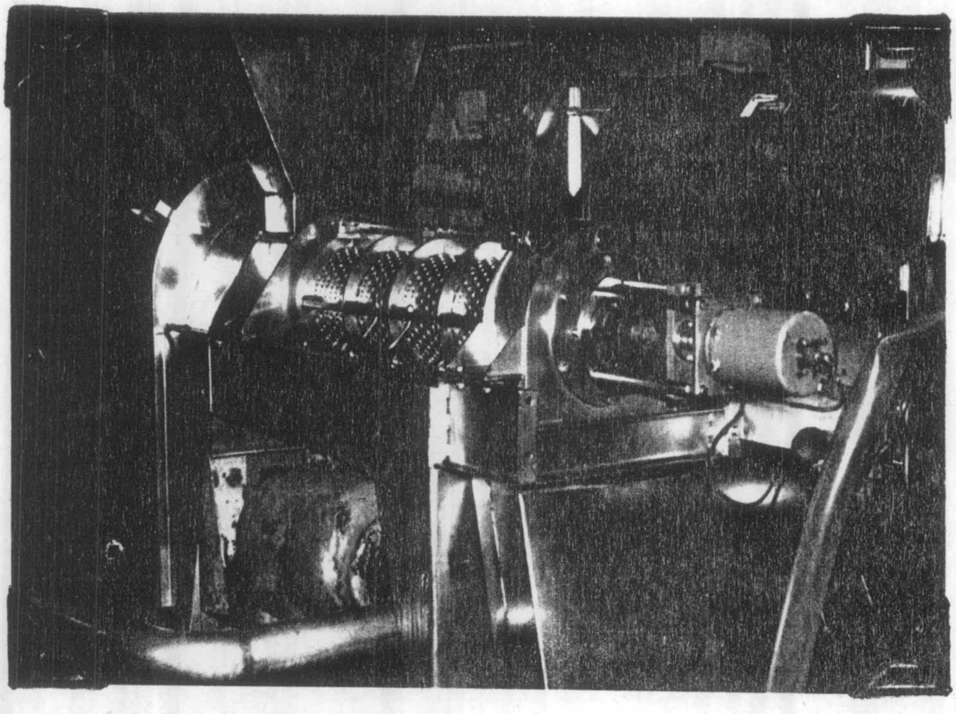

Figure 1.5 Squeezer

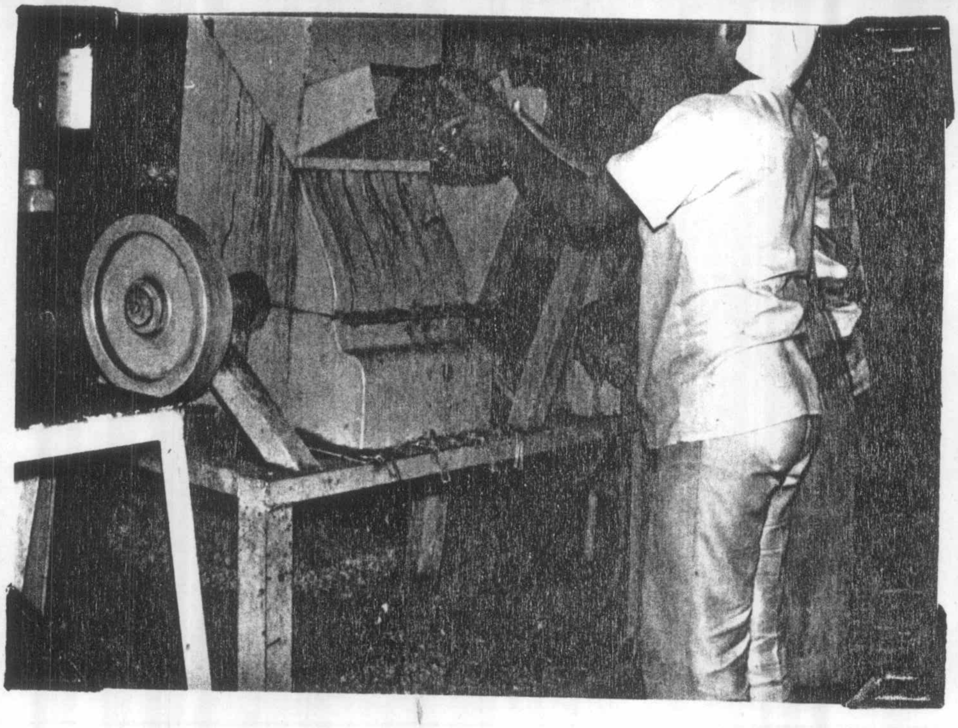

Figure 1.6 Crusher

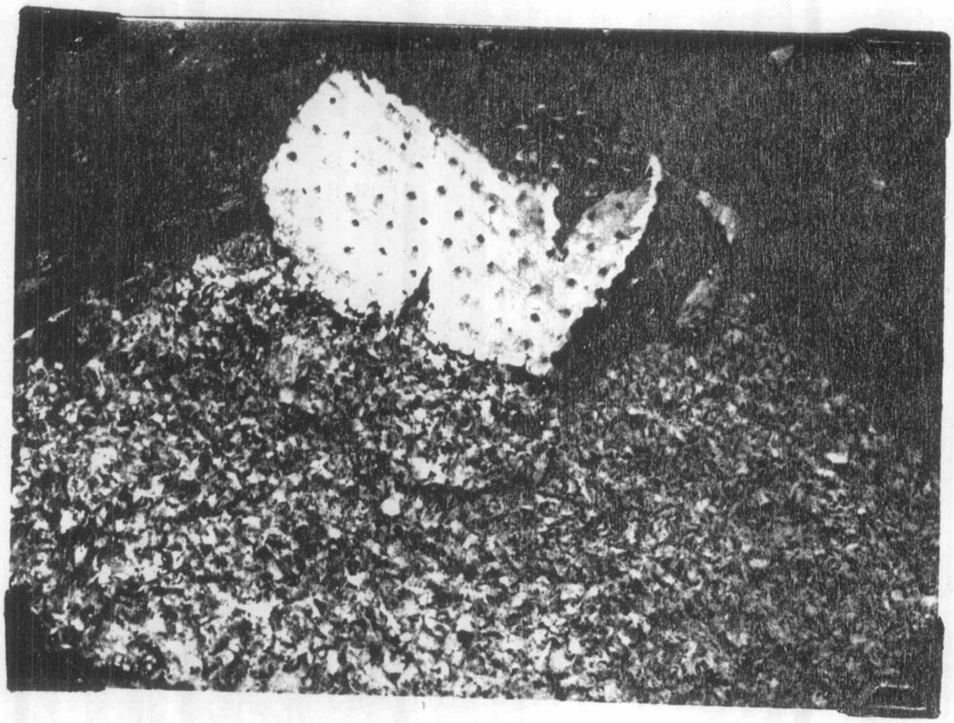

Figure 1.7 Pineapple shells before and after crushing