# PINEAPPLE

## Post-harvest Operations

INPhO - Post-harvest Compendium

Food and Agriculture Organization
of the United Nations

# PINEAPPLE: Post-harvest Operations

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**Last reviewed:** 13/11/2005

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## 1. Introduction

Pineapple is the second harvest of importance after bananas, contributing to over 20 % of the world production of tropical fruits (Coveca, 2002). Nearly 70% of the pineapple is consumed as fresh fruit in producing countries. Its origin has been traced to Brazil and Paraguay in the Amazonic basin where the fruit was domesticated. It has been defined as the most probable area of origin the zone comprised from upper Panama and Brazil, Paraguay and Argentina, including the northern Amazonian forest and the semi-arid regions of Brazil, Venezuela and Guyanas (Collins,1949).

Worldwide production started by 1500 when pineapple was propagated in Europe and the tropical regions of the world. The most spread variety is Cayena lisa (Smooth Cayenne) which was first introduced in Europe from French Guyana. It was until late XIX century when canned pineapple was produced commercially in Hawaii.

Thailand, Philippines, Brazil and China are the main pineapple producers in the world supplying nearly 50 % of the total output (FAO, 2004). Other important producers include India, Nigeria, Kenya, Indonesia, México and Costa Rica and these countries provide most of the remaining fruit available (50%)

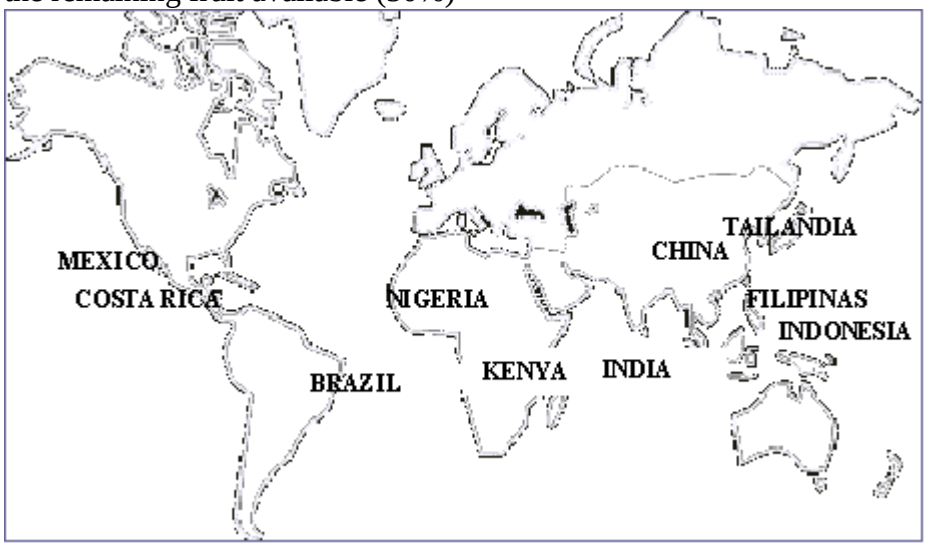


**Fig. 1. Main pineapple producing countries**

Weight percent composition of a typical Cayena lisa pineapple is: Pulp ( 33 % ), core ( 6 % ), peel ( 41% ) and crown ( 20 %), Fig. 2. Typical pineapple and Fig. 3 Weight percent composition

**Fig. 2. Typical fruit of the Cayena lisa variety**

**Fig. 3. Weight percent composition Cayena lisa pineapple.**

***a) Origin***

Pineapples are not found in true wild state. It does not appear to have been derived from other edible fruit species of the Ananas genera and the Bromelieaceae family, such as A. bracteatus, A. fritzmuelleri, A. erectifolia and A. ananasioides, which produce very small and almost seedless fruit (Collins, 1949, 1960).

Pineapple production regions are usually confined to altitudes below 800 m above sea level, although Kenya reports production fields located between 1400 and 1800 m, and Malaysia orchards as high as 2400 m (Purseglove, 1968). When pineapple is grown at altitudes greater than 1000 m smaller fruit are produced; the pulp has less attractive color and flavor and elevated tartness (Purseglove, 1968).

It has been suggested (Neild and Boshell, 1976; Py et al., 1987) that optimal growth temperature lies between 20 to 30°C, and more specifically at 23 - 24°C. When ambient temperature drops to 10-16 C, fruit growth is constrained. Plants may stand sub-freezing temperatures for very short periods. Conversely, exposure to temperatures well over 30 °C heat damage may occur due to increased respiration rate and metabolism and impaired nutrient absorption (Bartholomew and Kadziman, 1977).

***b) Taxonomia***

MORPHOLOGY AND TAXONOMY According to Py et al. (1969) the taxonomical location of the pineapple is:

| | |
|---|---|
| Category | Group |
| Kingdom | Vegetal |
| Phyllum | Pteridofitae |
| Class | Angiosperm |
| Subclass | Monocotyledoneal |
| Order | Farinosae |
| Family | Bromeliaceae |
| Genus | Ananas |
| Species | comosus |

***c) Botanical description***

Pineapple is a member of the Bromiliaceae family, Anana genus and sativa species (Py, 1969). The stem is a stick with a wider upper section and narrower and usually curved lower section. The top of the fruit is covered with phylotaxia leaves; below this level there is a zone of dry leaves and a curved section underground from which many roots protrude. The main stem extends to the flower butt then in the central axis of the flower buds forming a single mass that ends at the apex of a crown of leaves (Fig. 4). In some pineapple varieties and other wild Ananas the flower butt is well developed. In contrast the butt of commercial clones is short and covered by leaves. The main stem produces side sprouts that receive different names. The sprouts emerge first at the base of the stem, their leaves are long and narrow, but shorter near the bottom, and are considered as the best material for propagation. A second type of shorter sprouts is formed from stem spuds and is also used for vegetative reproduction. A third type emerges from the butt underneath the fruit; this type has shorter and compact leaves resembling a small pineapple fruit. All of these sprouts have a curved base since they emerge from horizontal spuds and then grow vertically. The basal side sprouts function in wild species and in plants derived from vegetative propagation, since once the flowers and end fruit have dried out and disappeared, side stems develop, fruit are formed and new side stems are generated; thus, pineapple may be considered as a perennial plant (Collins, 1949 ).

***d) Reproduction***

Reproduction of pineapple is made in vegetative form using the crown or the suckers or Stem shoots of healthy and productive plant. These materials must be properly selected by size to assure crop uniformity (Py, 1969).

**Fig. 4 Pineapple plant (SARH, 1994)**

The major characteristics of the producing plant are:
Average height and width of 1 to 2 m in the adult plant. The leaves (Fig. 5) have a concave form which allows the plant to collect water. Color of the leaves varies depending on the cultivar, but usually green, red and purple are predominant.
The pineapple fruit is the result of the flowering. Prior to the maturation of the first fruit the plant already developed new propagation material (Stem shoots, suckers, slips). The flowering process involves the sprouting of nearly 50 to more than 200 individual flowers, depending on the cultivar. The fruit may have no crown or develope multiple crowns. The flowers are hermaphrodites and at the end of the flowers a crown containing ca. 150 leaves is found. It is possible to induce flowering by external means. The time from culturing to harvest depends on the cultivar and the climate of the growing region. Production sites near the Equator may require 12 months, whereas in sub-tropical areas, this period may extend for up to 36 months (SARH, 1994).

*Fig. 5. Pineapple leaves (SARH, 1994)*

*Fig. 6. Typical pineapple flower*

***e) Flowering***

Pineapple flowers fuse together and with the central stem (Fig. 6). This happens in such a way that it becomes almost impossible to distinguish where one flower from the next. A common flowering may contain 100 to 200 flowers, arranged in a spiral fashion. Since only very few flowers open every day, the flowering period may extend for one month or longer (Collins, 1949).

Reproduction of pineapple plant is mostly asexual. However, sexual reproduction is carried out under control cultivation. The plant produces stem shoots, suckers or slips from axial sprouts; these are capable of generating new growth axels and hence, new fruits. Therefore, the plant has the potential to generate a sequence of several production cycles (Coveca, 2002).

Vegetative propagation is classified according to the position at which the culturing material is reproduced with respect to the plant. This way the following parts can be defined:

Suckers: they grow in the underground part of the plant

Stem shoots: they appear at the butt usually grouped near the base of the fruit.

Slips: they appear at the butt and grouped near the base of the fruit.

.Additionally, the crown is used as culturing material. On the other hand, a periodical renewal of cultures is required in order to keep fruit quality in commercial plantations. Most of large production fields allow plants to produce only two or three harvests. Lack of renovation produces decreased fruit size and lack of uniformity. Renewal of culturing material is made by different means: stem shoots from the previous harvest, planting of the fruit crown, and suckers produced along the peduncle (Coveca, 2002).

***f) Fruit***

The fruit of pineapple consists of the fusion of tissues from individual fruits and the axis of the flowering. From each flower a single fruit is developed with the external appearance of a hard and prominent polygonal shield. The lower half of the shield is covered by the bracteal apex, which is bent upwards; the upper half is covered by the three sepals. External color and texture of bracts and sepals is quite similar. The middle portion of each fruit protrudes and the external cavity of the flower is found right underneath, which is represented by a chamber with hard walls, from which base the remaining of stamen and pistil are observed as dark and tough threads. Ovary cells are left inside. In their upper part the seeds are located, while the lower part is occupied by large cavities with shiny walls which were part of the nectaries. In some cultivars these cavities are smaller and appear only as three slots that irradiate from a central point; in other varieties the cavities appear as large empty chambers. In some cultivars these cavities are markedly reduced and are seen as three slots that emerge symmetrically from the center; in other cultivars they may appear as large hollow chambers. Sugar rich

internal tissues correspond to part of the ovary walls, particularly to the bracts and sepals. These cavities are joined directly to the fruit axis, from which six groups of vascular bundles emerge; these bundles connect to parts of the flower, while an independent group supplies the bracts. The central axis increases its size and contains sugars, but it is tougher and more fibrous than individual fruits (Collins, 1960).

The fruit has a cylindrical shape with flat berries of 2.5 cm of diameter, pulp from pale to gold yellow, a soluble solids content near 13 % and 0.6 % of citric acid, which confers the fruit with a particular flavor that is widely appreciated for consumption either fresh or canned. The average weight of the fruit is ca. 2.5 kg, although there are important variations caused by the plantation density and handling. (Fig. 7)

The following are the main components of the pineapple plant: Shoot apex: It is located on top of the fruit and it is actually the apical meristem of the plant. Since the fruit is harvested and handled with the crown, this material is only available during the harvest season at the processing plants. Small crowns are discarded during selection. Slips : These develop from an axial bud from the fruit peduncle. Normally, two suckers are produced by plant, although in fruits harvested from May to June may increase to five, due to floral differenciation by the parent plant that may occur naturally or induced during November to January. Suckers:These are the offsprings that originate from the axial buds of the stems; it is the most abundant type and usually four sprouts are produced by each plant. All three types of materials described differ in their shape and in their cycle length. The crown requires nearly 23 months to produce a new fruit under normal conditions, while slips and suckers need 20 and 17 months, respectively (SARH, 1994).

**Fig. 7. Pineapple Varieties**

***g) Cultivars***

The origin different pineapple cultivars may be attributed to somatic mutations. Since there is not self-pollination and cross-pollination occurs only occasionally, natural hybrids are rare. Additionally, seeds do not germinate readily. Up to date, there are neither reports in the technical literature on pineapple variability, nor a systematic classification of the cultivars. Commercial production for export markets is based on a limited number of cultivars and in some small fields in the American continent still produce less known cultivars (Collins, 1960).

**MAJOR COMMERCIAL PINEAPPLE CULTIVARS Source: Coveca (2002)**

| Cayena lisa | Spanish from Singapur | Green Selacia | Queen | Red Spanish | "Perola" | "Perolera" |
|---|---|---|---|---|---|---|
| - Its production cycle is one of the longest among the cultivars<br>- Low production of suckers to stem shoots<br>- Prone to plagues and diseases<br>- High sugar content,13 to 19 °Bx<br>- Good tolerance to fruit collapse<br>- Pale yellow pulp color<br>- Clear yellow color juice with high sugar content | - Mostly used for canning<br>- Produced in south east Asia<br>- Average weight, 1 kg<br>- Golden yellow pulp color<br>- Low acid and sugar content, 10 to 12 °Bx<br>- High quality for juice production<br>- Good producer of suckers and stem shoots<br>- Very sensitive to nematodes and fruit collapse | - Mutation obtained from Spanish from Singapur<br>- The main difference from t he original cultivar are the green flower leaves and yellow suckers<br>- Retains the main qualities of the Spanish from Singapur | - Intended for the fresh market.<br>- Average weight 0.5 to 1 kg.<br>- Pulp color is gold yellow<br>- High sugar content,14 to 18 °Bx<br>- High tolerance to stress, plagues and pathogens, Better than Cayena lisa<br>- Highly susceptible to cold and internal darkening.<br>-- Usually harvested prior to maturation | - Cultivated widely in the Caribbean<br>- Average weight of 1.2 to 2 kg.<br>Medium sugar content, 12 °Bx, with low acidity<br>- High ability to produce suckers and stem shoots<br>- High tolerance to elevated temperatures and droughts.<br>- Develops internal darkening and breakdown<br>- Sensitive to nematodes and high Manganese content in the field. | - Average weight of 0.9 to 1 kg<br>- High sugar content, 13 to 16 °Bx<br>- High content of ascorbic acid<br>- Resistant to droughts, sand fleas and nematodes<br>- Highly sensitive to Fusariosis<br>- Cultivated in Brazil | - Average weight of 1.5 to 3 kg.<br>- Low sugar content, 12 °Bx<br>- Good suckers producer, from 4 to 11<br>- Resistant to fusiarosis<br>- Prone to mechanical fruit damage<br>- Sensitive to the Melanoloma fly |

However, several new varieties have been introduced to improve the quality of the fruit that reaches the international markets such as MD2 (Golden ripe, Extra sweet and Maya gold). These varieties are hybrids that were developed Hawaii from Cayena lisa with an average weight ranging from 1.3 to 2.5 kg, it has an intense orange to yellow-orange color and a high sugar content of 15 to17° Bx. Fruit are sweet, compact and fibrous. Main differences found with respect to the Cayena lisa variety are: better resistance to internal darkening, lesser ascorbic acid content more prone to rotting and sensitive to Phytophthora. The La Josefina variety was released in 1996 for the fresh fruit market. It is a hybrid developed from other two clones. Its production cycle is annual with a generation of 2 a 3 suckers per plant. Average fruit weight is 1.1 to 1.3 kg and contains an elevated sugar concentration (17 to 22°Bx). Differences with respect to the Cayena lisa variety are: longer shelf life, greater sugar content and resistance to black heart disorder and shorter production cycles. Finally, variety RL41, is a hybrid obtained from cultivars Cayena lisa and "Manzana" with an average weight of 1.4 to 2 kg and a high sugar content, 15 to 18° Bx. Compared to Cayena lisa, this variety

has a greater ascorbic acid content and shorter production cycles, as well as lesser resistance to rotting but more resistant to flower induction (FAO, 2002).

***h) Cultural practices***

One of the main aspects of the pineapple production is ground preparation, for which suitable machinery is required. Preparative work must be efficient to assure good drainage and penetration of the roots. Ground must be plowed at least 30 cm (see Fig. 8). Recent experiments have been conducted to show producers the benefits of deep plowing. Good soil preparation increases the fruit population per area and better yields are obtained. As it was described above, commercial pineapple propagation is made in vegetative form, using either the crown or either suckers or stem shoots. Each plant produces one crown and from 1 to 6 offsprings. Competence by weeds is critical and need to be eliminated. Plantation cleanup had been made manually, but in recent years herbicides have been employed successfully and producers are now convinced of the benefits of this type of control. The plant is usually fertilized four times during the vegetative cycle of 18 months with formulas based on Nitrogen, Phosphorus and Potassium. An important aspect of this culture is flowering control by hormones (calcium carbide or Ethrel), by which it is possible to achieve anticipated. This has become a rather common practice because by flowering control, fruit may be available in the market for ten months of the year. The plant is sensitive to excessive soil (Fig. 8 ) moisture and requires light and permeable soils with clay-sandy texture. When fully developed the plant can reach 60 to 120 cm, depending on the variety (SARH, 1994).

**Fig. 8 Soil type for pineapple (SARH, 1994)**

***i) Soil preparation.***

Maximal production potential for this fruit is reached when it is planted on light to medium texture soils that have no flooding problems, mildly acidic (pH 4.5-5.5). A good seeding bed is obtained by proper cutting, burning and/or blending of harvest by-products, plowing, soil revolving, leveling and drainage.

Mowing. This operation is needed to destroy the residues from the previous crop. In order to properly burn or blend these residues grinding must be as fine as possible. Burning is recommended only when plagues and pathologies were detected on the previous cycle. Passing heavy RASTRA several times on the ground helps in reducing the particle size of the residues.

Blending of crop residues. Residual material from the previous crop may be used to elevate nutrient content and organic matter of the soil. Incorporation of this material needs to be done by deep fallow at least 5 months prior to the planting. Improper blending increases the risk of attack by plagues as termites, loury louse and mites.

Plowing. The purpose of this operation is to break and loosen the surface ground, to incorporate residual materials from the previous crop, destroy some ground plagues by

exposure to sunlight, improve air flow and water penetration. This process must be as deep as the soil and machinery permits. This is made at least two months before planting. Based on local conditions the mesh plough is preferred over the disk plough.
Tracking. This operation is made to break and disperse the lumps remaining from the plowing. At least two passes in crossed direction and at least 20 cm deep are required to get the soil ready. A reasonable time period may be allowed between tracks to allow weeds to emerge and be destroyed by the second rastra.
Leveling and drainage. This is made with a heavy plank or metal beam pulled by the tractor at the time of effecting the last pass, in order to level off the uneven parts of the field that may produce flooding. If this is not achieved, it is recommended to prepared small ditches that serve as drainage with enough depth and slope to eliminate excess water, but taking care not to overdrain the field so that it becomes dry or eroded (SARH, 2004).
Erosion control. It has been estimated that 50 tones of soil are lost per hectare peach cycle under the traditional system .To reduce erosion, one or several of the following practices may be used: Beds with controlled slope. The contour has an inclination of 0.3 to 0.5%; the width varies according to the density and distance between rows, which ranges from 145 to 110 cm (Fig. 9), making sure that the edges are softened to avoid slides.

**Fig. 9. Soils with melon-type beds (SARH, 1994)**

Draining and irrigation ditch systems. Theirsetup is strictly necessary when melon-type beds are employed (Fig. 9), although they can be used with the traditional system too. Their objective is to collect the excess rain water before the rate of fall may cause erosion. According to the local rain fall and the terrain slope the distance between them could range from 20 to 100 m. Live wall Terraces. They are unpredictable when the slope is greater than 5 %. Their performance is based on soil movements and employs land preparation labor. The base of the terrace can be formed by “cocuite: barriers (Gliricidia sepium) (Fig. 10), established by seeding or planting in its place one or two rows of pineapple keeping a distance of 10 cm between plants. The terraces are laid out and their width is reduced as the slope is increased (SARH, 1994).

**Fig. 10. Live wall Terraces (SARH, 1994)**

Acidity control. In order to neutralize the acid residues from the fertilizers used during the crop cycle and after replenishing Calcium and Magnesium ions that were lost by erosion, leaching and harvest of fruit and stem shoots, from halft to two tons of agricultural grade lime should be applied per hectare, depending on the acidity of the soil. Lime applied must be dolomitic and contain at least 10% of magnesium carbonate and the rest of calcium carbonate. It must be fine ground so that 80% should pass through mesh 60. It is important to spread evenly on the ground either manually or mechanically. It is recommended to perform soil analyses every 3-4 years, in order to monitor the trend of acidity and nutrients to take corrective actions if necessary.

***j) Genetic propagation***

Pineapple propagation is asexual and natural vegetative buds are used. In order to maintain genetic purity it is necessary to dispose of propagation material from sick plants and those showing genetic malformations such as multiple crowns, spiny leaves and malformation fruit (Fig. 11). Male plants that reach a fairly exuberant vegetative development, can hardly yield fruits, and if so, the product is too small. Genetic, safety and weight uniformity of propagation materials is a key factor that increase productivity of pineapple plantations. Purification and production of propagation material offers the advantage of improvement in genetic quality, safety and uniformity, with a concomitant decrease of production costs due to reduced attacks by floury louse-red rot and less proportion of low quality fruits (SARH, 2004).

In recent years biotechnology research has focused on genetic improvement to control flowering, increase certainty and control of flowering induction in order to reduce the cost of carbide application. To suppress flowering a gene capable of shutting down the senses through regulation of the periods for ethylene production has been cloned. In addition to the biotechnological alternatives other products and techniques have become available for flowering control, including application of Ethephon, Ethret-480, calcium carbide and propionic acid. These products act on the foliage for suckers production and increased yields. Plastic cushioning has been used to improve CO2 absorption in some cultivars (COVECA, 2002).

**Fig. 11. Malformation in pineapple leaves(SARH, 1994)**

***k) Pineapple Propagation***

Pineapple propagation or reproduction is done asexually, using shoots emerging from different parts of the plant, these growths are known as bulbs, crowns and auxiliary buds (Fig. 12). Seeds are disinfected by immersion on a fungicide and insecticide solution to prevent plagues and pathogens attack. Treatment consists on dipping the seeds on the solution for one minute and let them dry for 24 h or more, then sow and thus avoid workers poisoning. Chemicals that have been employed with good results are: insecticides, Basudin or Diazinon at a concentration of 280 ml in 200 litres of water; Fungicides, Ridomil Mz 72 at 1 kg in 200 litres of water. These products are mixed in the same container used for disinfection. The type of propagation material may be the crown, from the top of the fruit and from which one seed is used; the bulb, located at the peduncle of the fruit, from which 1 to 3 seeds may be obtained; and the buds, from the leaf axis, and from which 3-5 seeds can be extracted per plant. Additionally, another reproduction system by slip, meristems or by hormone stimulation may be used (Oirsa, 1999) (Fig. 13).

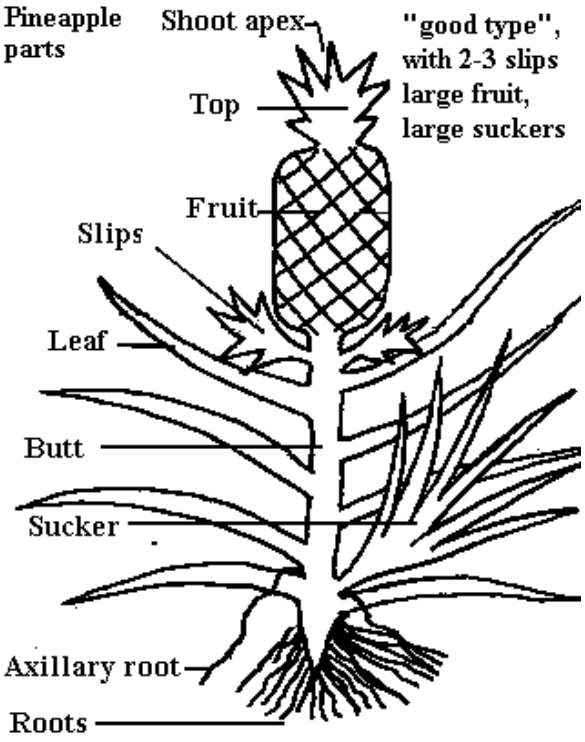


**Fig.. 12.- pineapple parts (Elfick, 2004)**

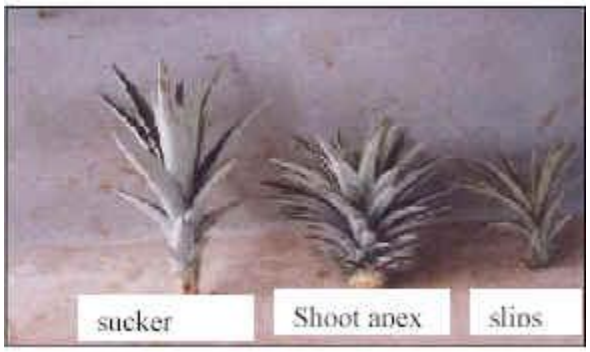


**Fig. 13.- Seeds for pineapple propagation (Oirsa, 1999).**

l) Planting

This type of activity for export fruit is done using a single string placed in the center of the bed; the string is marked with the desired distance and then a small hole is made where the seed is placed. The marks on the string are used as guides and then, a second line is placed 40 cm from the first string. Planting is done at the middle of the marks in three lace-bobbin style. By using beds with marked holes, from 3,000 to 4,000 seeds could be planted by worker each day.

Plant density. In order to reach crop yields of 100 tons a minimum of 60,000 plants per hectare need to be planted, using the arrangement of 30 cm between plants, 40 cm between lines and 70 cm from the aisle or between the double lines. If density needs to be increased the distance between plants can be varied and the rest may remain unchanged.

To estimate the density the following formula:

100/distance between plants+ aisle width = a

100/distance between plants = b

D = a * b* 2

m) Induction of flowering

This is a very important operation in pineapple production since it allows programming harvest volume and time. The plant must reach a weight of 3 a 3.2 kg in 7 to 8 months of growth. Ethrel®, with its active ingredient Ethephon, is used to induce flowering. This ethylene producer must be applied at dusk or night time when temperature reaches 25 to 27°C, and stomata are open. Ethephon is used at 1 to 1.5 ml/l of water, 100 lb urea in 2,500 litres of water, and 4 litres of Boron, which in such proportion increases the level of fertilization during induction. The mixture contains enough calcium carbonate to take the pH over 6 or near the optimal, 8.5. Five months later, the fruit is fully mature. The mixture is sprayed using one ounce per plant.

n) Crown strangulation

This is an operation performed 14 weeks after induction; the center of the fruit is withdrawn so a wider, heavier and better shaped fruit develops. This operation is not done on pineapple plantations intended for export because of the high costs involved this is not done; instead nitrogen levels are controlled or chemicals are used (Fruitone).

o) Undergrowths

In pineapple production fields undergrowths and weeds of several types emerge: they could be narrow or wide leaves; the latter being the most aggressive. Weed control begins with ground preparation by breaking soil lumps. The white straw (S. spontaneum) found in the fields must be eliminated to avoid recontamination and spread of the pathogen on the field.

Herbicides are used for weed control (Diuron and Atrazine) at a dosage of 2.5 to 3.5 kg/Ha and with the proper humidity better performance is achieved. In case of problems with graminiae, specific compounds are used (Fusilade, Igran 500), combined with manual chime.

***p) Harvest***

It is done 5 to 51 or 52 months after induction based on the external maturity of the fruit for domestic market. The harvest operation is done using special devices to draw the fruit from the field by breaking the fruit that shows proper maturity stage and placing them at the edge of the field where they are manually sorted by size (Fig. 14). The fruit is carried in trucks placing the crowns downwards for cushioning. From 50 to 80 dozens may be transported, depending on the size. Fruit are marketed by the dozen; those intended for industrial processing are placed in crates at the edge of the parcel and the crowns are chopped off, after which they are transported in bulk in larger trucks to the processing plant. Fruit for export markets use different systems, depending on the buyer. Some buyers require green fruit (color 0) which means soft green color near the peduncle, with 12°Bx, porosity of 1.5 and translucency 0 to 0.5. Other buyers demand ripened or off-green fruit with a minimum of 12°Bx, porosity of 1.5 and translucency of 1 to 1.5. When Ethephon is applied at 1 ounce in 20 litres of water, sprayed on the fruit one week prior to the harvest. Then, when color turns golden yellow fruit are harvested with care to avoid mechanical damage. Fruit are carried to a truck with 2 inches of polyfon in the bottom and 1 inch on the sides. From 3 to 5 layers of pineapples are placed crowns facing to avoid damage. Another way to harvest is using a mechanical harvester which may cut the process time to one fourth and produces minimal damage to the fruit by handling (Oirsa, 1999).

**Fig. 14 Mechanical harvest operation (Oirsa, 1999).**

## 1.1 Social and economic impact of pineapple crop

Pineapple dominates the world trade of tropical fruits, although other fruits have gained market share. Statistics from 2000 indicate that pineapple trade took 51 % from a total of 2.1 million tons of the whole fruit market with mangoes taking the second place, with 21.7 %. Pineapple is the best positioned fruit since its trade is oriented to developed countries as Japan, the USA and the European Community (Coveca, 2002). Consequently, during the past decade world production of pineapple as increased at a rate of 1.9% per year, despite the occurrence of unfavorable weather and economic situations (FAO, 2002).

***Production and Export***

Despite the fast expansion of the trade of fresh pineapple, currently only 8% of the crop is exported. Costa Rica and Ivory Coast are the main suppliers of fresh pineapple despite they rank eighth and tenth places as overall producers (see Table 1). Belgium, France, Germany and Netherlands participate in the world trade by re-exporting. With the exception of the Philippines, the six main pineapple producers in the world contribute minimal amounts to the market of fresh pineapple trade.

**Table 2.- Export of fresh pineapple as percentage share of total production per country.**

| | |
|---|---|
| Netherlands | 88.9 |
| Ivory Coast | 82.2 |
| Belgium | 78.9 |
| Costa Rica | 67.9 |
| Honduras | 61.3 |
| France | 52.2 |
| Ghana | 36.4 |
| Malaysia | 14.7 |
| Nicaragua | 12.9 |
| United States | 12.5 |
| Germany | 11.2 |
| Philippines | 8.9 |
| Ecuador | 5.1 |
| México | 4.7 |
| Brazil | 1.2 |
| Thailand | 0.2 |
| China | 0.2 |
| India | 0.1 |
| Colombia | 0.02 |
| Nigeria | 0.00 |

Source: Statistical data base, FAO (2000)

## 1.2 World trade

***a) World trade of fresh pineapple***

Twelve countries absorb 90 % of the world demand of fresh pineapple. The US leads the demand and France, Japan, Belgium, Italy, Germany, Canada, Spain, England, Korea, Netherlands and Singapore share the rest of the supply.

Total production of pineapple (Table 2) was 14 million tons in 2003 (FAO, 2004). Thailand became the leader in production in 1975, while China took the fourth place from India in 1999. Table 2 depicts the list of main pineapple producing countries.

The supply of single strength pineapple juice is concentrated mainly in Philippines and Thailand with ca. 65% of the juice available, while Indonesia supplies 70% of the concentrate juice. However, canned pineapple is the most important product in pineapple world trade. Its consumption raises every end of year due to Christmas salads and a greater demand by fast food outlets. Nevertheless, single strength and concentrated juice have greater price by ton.

Thailand, Philippines and Indonesia cover nearly 80%of the canned pineapple supply in the world market. While the US and Germany acquire most of the available product since 1990, the demand of such countries fluctuates continuously (Coveca, 2002).
Conversely, vacuum packed and cold stored pre-cut pineapple products are gaining market share in Japan and Hawaii because of their ease of preparation and convenience for consumption. In these countries, from 10 to 20% of the pineapple consumed is in the pre-cut form (Anon, 1999)(MA-JC, 2000)

**Table 2.- Main pineapple producing countries - Pineapple production (MT) Year 2003**

| | | | |
|---|---|---|---|
| Thailand | 1,700,000 | Papua New Guinea | 18,000 |
| Philippines | 1,650,000 | Cambodia | 16,000 |
| Brazil | 1,400,190 | Puerto Rico | 15,000 |
| China | 1,316,280 | Central African Republic | 13,800 |
| India | 1,100,000 | Mozambique | 13,000 |
| Nigeria | 889,000 | Japan | 13,000 |
| Costa Rica | 725,224 | Reunion | 10,000 |
| México | 720,900 | Liberia | 7,000 |
| Kenya | 600,000 | Guadeloupe | 6,975 |
| Indonesia | 467,395 | El Salvador | 5,800 |
| Venezuela | 383,922 | Sudan | 5,200 |
| Colombia | 353,000 | Samoa | 4,600 |
| Viet Nam | 338,000 | Mauritius | 4,560 |
| United States of America | 285,760 | Guyana | 4,500 |
| Malaysia | 255,000 | Trinidad and Tobago | 3,800 |
| Cote d´Ivoire | 225,000 | Fiji Islands | 3,662 |
| Congo | 192,080 | Haiti | 3,500 |
| South Africa | 167,724 | French Polynesia | 3,500 |
| Bangladesh | 153,000 | Congo | 3,294 |
| Peru | 150,000 | Argentina | 3,200 |
| Australia | 140,000 | Pineapples Production (Mt) | 2003 |
| Dominican Republic | 110,000 | Portugal | 2,000 |
| Guinea | 105,000 | French Guiana | 1,810 |
| Guatemala | 102,299 | Belize | 1,662 |
| Ecuador | 89,504 | Uganda | 1,650 |
| Benin | 87,000 | Korea | 1,057 |
| Tanzania | 77,500 | Brunei Darussalam | 1,000 |
| Cameroon | 76,365 | Gabon | 700 |
| Honduras | 61,814 | Togo | 550 |

| | | | |
|---|---|---|---|
| Ghana | 60,000 | Suriname | 375 |
| Bolivia | 58,098 | Timor-Leste | 200 |
| Madagascar | 51,000 | Guinea-Bissau | 200 |
| Sri lanka | 50,500 | Antigua And Barbuda | 185 |
| Nicaragua | 48,000 | Seychelles | 160 |
| Paraguay | 42,500 | Zimbabwe | 120 |
| Cuba | 40,543 | Cook Islands | 25 |
| Angola | 40,000 | American Samoa | 20 |
| Laos | 36,000 | Wallis and Futuna Islands | 5 |
| Swaziland | 32,000 | | |
| Panama | 24,000 | | |
| Martinique | 20,800 | | |
| Jamaica | 20,571 | | |

Source: Faostat Database FAO (2004)

## 1.3 Primary Product

***a) Fruit characteristics***

Based on a number of research works made in Hawaii (Gortner, 1967) a specific terminology for development, maturation, definition of the edible stage and senescence for pineapple was proposed. This proposal was based on physical and biochemical changes that take place during propagation and development of the fruit. There is a time span of 110 between the end of flowering and the point at which the fruit is at its edible stage. Changes in chemical composition occur when half of the peel turns yellow. Chlorophyll, carotenes, xanthophiles and anthocyanines are the main pigments found in pineapple. Their presence changes the external color of the fruit from green, green-yellow, or yellow, to a mixture of yellow and purple with or without green. External color of pineapple is an important trait in consumer preference. During maturation chlorophyll fades out and total and pulp carotenes increase, while peel carotenes decrease. Both peel and pulp carotenes raise at senescence (Dull, 1971). These changes define four stages in fruit development (Fig. 15).

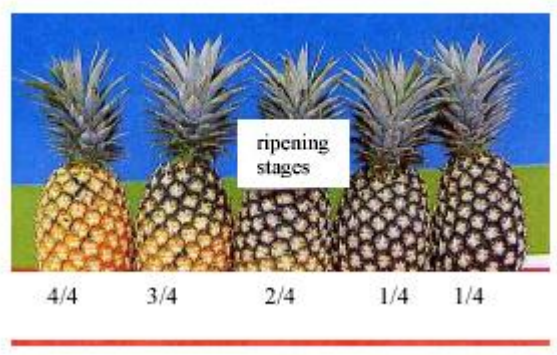


**Fig. 15.- Stages in pineapple maturation (SARH,1994)**

Changes in maturation stage are evident when peel color turns from green to yellow at the base of the fruit. Pineapple is a non-climacteric fruit and can be harvested as soon as it is

ready for consumption. A minimal content of soluble solids of 12% and a maximal acidity of 1% insure a minimal level of consumer acceptance along with size and texture uniformity, absence of rotting, sunburns cracks, bruises internal breakdown endogenous brown spot, gomosis or damage by insects. Crown leaves should be green, medium length and erected. Soluble solids must fall between 11 and 18%, titratable acidity as citric acid from 0.5 to 1.6%, Ascorbic acid should fall between 20 and 65 mg/100g of fresh weight, depending on the cultivar and stage of maturity. Pineapple fruit can be classified in three categories: category A, defined by fruits weighing more than 1.5 kg; category B, fruits weighing between 1 and 1.5 kg; and category C, fruits weighing less than 1 kg (Infoagro, 2002).

Today, pineapple consumers not only consider the physical appearance of the fruit to make a purchasing decision and such process has become more complex. In addition to physical appearance other qualities are considered, including color, sweetness, aroma, fruit uniformity, size and country of origin or brand name. The proper time for harvest depends on its end use. Fruits for export should be cut when the fruit is completely developed but green. Pineapples for domestic market are cut mature but not fully ripened. Harvest is made manually; the fruit is torn to tear it from the peduncle. For transport fruit are placed on leaves or a sawdust bed alternated with crowns, to decrease mechanical damage. It is not advised to pile up too many layers of fruit .

Harvested fruit are placed in trucks or wagons crown side down and up to 3 layers high. It is important to avoid fruit overheating either in the field as well as during transport and handling. Fruit are taken to the packing plant and then washed and coated with a mixture of a fungicide and a liquid wax (Agronegocios, 2004).

For international markets pineapple is classified as:

US Select (10 fruits of 1.4 to 1.8 kg), No. 1 (8 fruits of 1.81 to 2.0 kg) and No. 2 (6 fruits of 2.01 to 2.5 Kg).

Packing for export markets is a one-piece box made of telescopic fiber capable of holding 9 kg (20 lb) or 18 kg (40 lb). In order to get better fruit strength during transport and prevent damages, pineapples with 1/4 ripening (yellow color at the base of the fruit covering 25% of the surface) are selected.

Transport temperature and relative humidity should 7 to 13°C (45 - 55°F) and 85 to 90%, respectively. Chilling injury may occur below 7°C (45°F). Pineapples for export must meet the following requirements: uniform size and shape, proper firmness, free of rotting, sunburns, cracks, bruises, internal breakdown endogenous brown spot, gomosis and damages caused by insects. Crown leaves should be green, medium length and erected. Soluble solids must fall between 11 and 18%, titratable acidity as citric acid from 0.5 to 1.6%, Ascorbic acid should fall between 20 and 65 mg/100g of fresh weight, depending on the cultivar and stage of maturity.

Waxing can be applied to modify internal O2 and CO2 contents of the fruit in such a way to reduce the occurrence and severity of endogenous brown spot. (Infoagro,2004).

Sea transportation is the main form of handling pineapple for international trade of fruits and vegetables. It is the most economical and specialized means for handling large amounts of fresh produce. Depending on the volume, it can be done in refrigerated ships (reefers) or in containers equipped with cooling systems. Reefers are usually large capacity vessels (over 4,000 tons) and are equipped with efficient air circulation systems with control of air velocity and exchange. Loading is made through side scuttles or by continuous conveyors installed from the pier to the cargo warehouses. The Reefers are specialized forms of transport for fruits and vegetables, they have built good thermal insulation and ducts designed for cold air circulation, as supplied by the refrigeration system (Con-Air System) or with independent cooling system connected to the electrical network (Reefer System). The main advantage for the use of the containers is the versatility of treating the refrigerated fruit as part of any

shipment in container carriers which in turn are usually equipped with electric supply and outlets; thus, containers have the autonomy to self-contain the cargo with no need of additional facilities to keep the storage temperature constant. There are also refrigerated containers with controlled atmospheres, which can adjust levels of O2, CO2, relative humidity and temperature. Refrigerated containers are built with standard dimensions: 8 x 8 feet wide, and either 10, 20, 30 or 40 feet long. The most common containers are those with 40 feet long, and then those with pies 20 feet long. Transport by truck given its flexibility (shipping door to door) is a preferred way of handling but complementary to the other systems in smaller volumes and relatively shorter distances. International cargo by ground is used to move products between neighboring countries and as a supplement to sea transport to mobilize containers to/from shipping ports (CCI,2004).

***b) Food for human consumption***

Pineapple composition has been investigated mainly in the edible portion. Reported ranges of the main components from data collected from several commercial operations and include additional variables as environmental factors and degree of maturity of the fruit. Pineapples contain 81.2 to 86.2% moisture, and 13-19% total solids, of which sucrose, glucose and fructose are the main components. Carbohydrates represent up to 85% of total solids whereas fiber makes up for 2-3%. Of the organic acids, citric acid is the most abundant. The pulp has very low ash content, nitrogenous compounds and lipids (0.1%). From 25-30% of nitrogenous compounds are true protein. Out of this proportion, ca. 80% has proteolytic activity due to a protease known as Bromelin (Dull, 1971).
Fresh pineapple contains minerals as Calcium, Chlorine, Potassium, Phosphorus and Sodium. Table 3 depicts the overall composition of fresh pineapple

**TABLA 3. Pineapple % composition**

| Component | %, wet basis |
|---|---|
| °Brix | 10.8-17.5 |
| Titratable acidity (as citric acid) | 0.6-1.62 |
| Ash | 0.3-0.42 |
| Moisture | 81.2-86.2 |
| Fiber | 0.3-0.61 |
| Lipids | 0.2 |
| Esters (ppm) | 1-250 |
| Pigments (ppm carotenes) | 0.2-2.5 |
| Total Nitrogen | 0.045-0.115 |
| Protein | 0.181 |
| Soluble Nitrogen | 0.079 |
| Ammonia | 0.010 |
| Total amino acids | 0.331 |

(Dull, 1971)

Pineapple fruit is a rich source of vitamin C and is usually consumed fully ripened as juice,dessert or at breakfast (Fig.s 16,17, 18,19 and 20)


**Fig. 16&17. Different forms of pineapple consumption 1**


**Fig. 18&19. Different forms of pineapple consumption 3**

**Fig. 20. Different forms of pineapple consumption 5**

***c) Food for livestock***

Utilization of byproducts from pineapple culture, canning and juice extraction has been encouraged for feed production. Leaves can be used in three forms: fresh, dried and in silage (Geo coppens, 2001).

Hearts and peels from the canning operation can be dried and mixed with molasses to produce a meal. Yield per hectare for crowns and hearts can be as high as 10 tons in fresh, which turns into 1 ton of dried product. Solids from the centrifuge from juice production may be used as feed for pork (FAO, 2004)

***d) Other Uses:***

Pineapples may offer additional advantages for a whole utilization, in particular as a fiber source. Among the qualities of the fiber is the texture, its length (60 cm), high water and dye holding capacity, high whiteness, brightness, resistance to salt and tension strength. Consequently, some producing countries exploit pineapple fiber for the paper and clothing industries. This fiber resembles silk in texture and color. It is used in some Asian countries for manufacture of high value garments. In the paper industry pineapple fiber has been found to produce fine and flexible sheets of paper.

Bromelin has been produced traditionally from stems in Hawaii. Currently it is been extracted in other countries as Taiwan, Thailand, Brazil and Puerto Rico. Typical use of bromelin has been as meat tenderizer and as component of pharmaceuticals.

Bromelin is a protease that can be obtained from the juice of pineapple stems by methanolic precipitation. This enzyme has been used by at least ten years. Applications of Bromelin in the food industry are in meat tenderization, chillproofing of beer, in protein solubilization, fish waste treatment, leather coloring and as latex paints stabilizer. It is also employed in production of hydrolyzed proteins and to increase the solubility of gelatin and an aid to treat digestive disorders. Residual stem materials from Bromelin extraction may be used as feed additive and culture media for plants as tea and orchids. Calcium citrate, a valuable chemical derived from citric acid is also a by-product from Bromelin processing. Therefore, commercial production of Bromelin has an important value added. The process for Bromelin preparation has been described: pineapple stems are washed, crushed and cold-pressed through a screw press. The juice extracted is mixed with methanol to coagulate impurities at the mixing tank. After impurities are separated, the extract is again mixed with methanol and allowed to settle. The Bromelin suspension is decanted and dried. Methanol is recovered in an adsorption tower. Waste and residual methanol from the filter press and the mixer are distilled and recycled. Capital investment, energy consumption, engineering and technological abilities and land required for the plant are relatively small compared to other chemical facilities. The manufacturing process is simple and easy to operate; pollution control as well as maintenance of equipment and facilities are reasonable too. Tropical and sub-tropical countries with abundant pineapple production make this project feasible and production may be intended for export markets (TTPC, 2004)

***Medicinal uses***

In order to encourage pineapple consumption, some producing countries run promotional campaigns to make the consumers aware of medicinal and therapeutic qualities of the fruit. Among the different medicinal and healing properties of pineapples it has been said that the fruit is antiparasitic, abortive, detoxifier, vermifuge and stomach disorder relief. Pineapple also improves digestion, regulates stomach acidity, aids in detoxification processes, the neutralization of free radicals and blood clots, as aid in the treatment of rheumatoid arthritis, reduction of sciatica symptoms, collagen production, weight control and in the treatment of albuminuria. Evidence of these claims was generated from studies made in the US and Europe (Coveca, 2002).

One of the best known properties of pineapple is as a diuretic. This helps to eliminate toxins through the urine, helping patients with ailments of kidneys, bladder and prostate. Due to the fiber content of the pulp, pineapple prevents constipation and regularizes the intestinal flora.

Furthermore, there is evidence of appetite reducer, heart protection and aid for fever, sore throat and mouth aches and inflammation. Lightly boiled ground pineapple can be used to clean infected wounds because it eliminates dead tissues, not affecting live tissue, acts as disinfectant and accelerates cicatrization (mundogar, 2004).
In summary, pineapple is a rich source of Vitamin C as well as other vitamins and fiber. Pineapple's Bromelin stimulates digestion and the proper performance of the small intestine and kidneys; it helps in detoxification, normalizes colonic flora, helps in hemorrhoid alleviation, and prevents and corrects constipation. It has been used to heal colds, mouth, throat and bronchial infections. Cooked peel cleans blood and alleviates swellings. Juice helps to cure cystitis, and fevers(gastronomia, 2004).

***e) Selection and Care***

Pineapple fruits must be well ripened, have proper humidity, good formation, well developed eyes, free of decomposition, scalds caused by the sun, free of injuries caused by contusions, burns, illnesses, insects or mechanical injuries. The base should be well cut. The leaves should be of the same color, singular, more or less right, well stuck to the fruit, they should not be more than five per each crown. The longitude of the leaves should not be less than ten centimeters or more than double the size of the fruit. The Pineapple is initially assessed by the external appearance: it should be fresh, clear and shiny. When it is completely ripe, the leaves of the crown must be of a light green color, the crown must be very green and well developed (Proyecsacorp, 2004).

## 1.4 Alternative products from pineapple

A commercial product is available in the form of simple pineapple pulp. Frozen juice is obtained from pressing fresh clean ripe pineapples without concentration, dilution or fermentation and strained trough a 0.5 mm mesh; then centrifuged, homogenized, the air removed, pasteurized and aseptic packaged prior to freezing. The product does not contain added sugar or preservatives and has a minimum of 12 °Bx, 20 to 40 % solids, 0.9% acidity and pH values from 3.6 to 3.8. The packing unit is a steel drum and the product is held inside a double caliber 2 polyethylene bag, each unit contains 200 kg and drums are transported at -18°C or lower. The refuse bins remain sealed and mixed transport with toxic or corrosive chemicals shall be avoided. The drums shall be opened only for sampling at the receiving station. Each batch of 10 drums should have a 300 g sample attached for quality control analyses (colfruits, 2004).

## 1.5 Requirements for export and quality assurance

***a) Export grading***

International demand for fruits shows concomitant growth due to the important place fruits occupy in the diet of either American or European consumers who associate healthy eating habits to fresh fruit and vegetable consumption.
The Codex standard for pineapple 182-1993 (Rev. 1-1999) is the guide for pineapple exports.(Codexalimentarius, 2004).

***Quality Criteria***

Piineapple should be exported with the required size and stage of ripeness (as defined in the market specifications) (Fig. 21) uniform in size and ripeness within each carton (Medlicott, 1990).

**Fig. 21 Washer and disinfectant containers for pineapple fruits ( SARH, 1994)**

***Export Criteria***

Organic pineapple.

The European Union (EU) represents the largest market in the world for organic pineapple with more than 2,000 tons in 2002. The second largest market is the USA with nearly 1,000 ton/year. Although the trade of organic pineapple in the EU goes back to the late 90's, this market is still limited and growing due to some technical limitations that restrict the supply. The main drawback in production of organic pineapple is the ban to ethylene application to induce flowering. Currently the EU market is supplied by countries from African as Cameroon and Ghana, from Asia as Sri Lanka y and Latin America as Dominican Republic and Honduras. In 2002, pineapple imports of the four largest markets in the UE (Germany, France, Netherlands and the United Kingdom) were in excess 1,500 tons. Germany is the single country that consumes most of the organic pineapple with 726 tons, and the Netherlands follows in second place with 625 tons in 2003. The future of the market for organic pineapple in the EU depends on the stand taken by the accreditation authorities on the issue of ethylene application. Perspectives on the US market are also favorable. Although Honduras was in the position of becoming the main supplier to the American market for organic pineapple, the production fields were almost completely destroyed by the hurricane Mitch in 1998. Another drawback for market expansion was the ban for ethylene utilization that took effect on January 2001. Due to these two factors US imports of organic pineapple in 2001 were limited to 4 containers a week. When the ban was cancelled in 2002, the supply raised again. The main suppliers for the US market are Latin American countries and Hawaii. Importing countries of fresh organic pineapple forecast a 20% annual growth. In late 2002 the category of Fair Trade for tropical fruits was introduced, thus originating the concept of sustainable pineapple, which has been experiencing a very fast growth rate. The volume of Fair Trade pineapple was estimated in 1,000 tons in 2003. Currently, the entire production is destined to the Swiss and England. Producing countries of the Fair Trade pineapple are Costa Rica and Ghana (Centeno, 2003).

***Market requirements***

The requirements for pineapples to be exported to the US are rather simple. Handling must include washing, disinfection, sorting, waxing and manual or mechanical packing, cooling and storage.

***Storage and Transportation***

Transport of pineapples for export shall be done in refrigerated trucks or containers. Transit time should be calculated so that fruit are at the optimal ripening conditions right before reaching the consumers. An important consideration is that the transport system used are designed to maintain the fruit temperature but not to decrease it, hence it is necessary to introduce the fruit already cooled to the proper temperature. Product stacking will depend on the type and size of container and must be carefully planned to minimize physical damage (Colfruits, 2004).

### 1.6 Consumer preferences

***a) Varieties***

It has been proposed that there are more than 100 varieties, but only 6 to 8 of them are cultivated commercially. These include varieties from the Cayena group, such as Cayena lisa and Champaka. These two varieties represent the two major and most demanded varieties worldwide. Their leaves have few spikes that helps for easier handling; the fruit is cylindrical with flat berries of 2.5 cm of diameter, the pulp color ranges from pale yellow to gold yellow, with ca. 13 % soluble solids and 0.6% citric acid. This composition confers a distinct and well-appreciated flavor of pineapples. The fruit is cultivated in Hawaii, Australia, South Africa and most tropical exporting countries. Cayena lisa has been the variety most frequently produced in the main and technified production fields; however, this variety is now been replaced by Champaka, because the latter variety has demonstrated advantages on overall quality, yield, and resistance to post-harvest handling (SARH, 1994). The Singapore variety, of cylindrical and reddish fruits is produced in Malaysia. The Queen variety refers to a group of cultivars with spiny leaves and yellow fruits; the Red Spanish variety is similar to the Queen variety; the Big Head (Cabezona) variety is the main variety from Puerto Rico and has wider bottom; the Montelirio is a variety from Central America, similar to Cayena in shape and color, but less sweet; the Pernambuco and other newer varieties are native from and produced in Brazil (Collins, 1960).

## 2 Harvesting and Post-production operations

Traditional and improved picking operations (Fig 22)

**Fig. 22 Basket picking operation (SARH,1994)**

### 2.1 Harvesting

Location of the crops, internal ways and access to the main roads leading to the packing site must be considered so that pineapples can be transported in the minimum time under controlled conditions. Transporting pineapples from the production field to the packing

location is made by tows, trucks or specially-designed vehicles. Availability of a double roof, thermal insulation and sliding curtains help keep the storage temperature of the fruit during loading and unloading. The equipment must be kept clean and disinfected and fitted with good suspension, low-pressure tires and even and smooth floor surface, such that the packing units can be easily handled. Bulk transportation the use of vegetative material is placed on the vehicle platform to avoid extreme temperatures and to act as cushion against mechanical collisions during transport (Colfruits, 2004).

### 2.1.1 Yield

In order to reach crop yields of 100 tons a minimum of 60,000 plants per hectare need to be planted, using the arrangement of 30 cm between plants, 40 cm between lines and 70 cm from the aisle or between the double lines. If density needs to be increased the distance between plants can be varied and the rest may remain unchanged.
To estimate the density the following formula:
100/distance between plants+ aisle width = a
100/distance between plants = b
D = (a ) (b) (2)

### 2.1.2 Transportation

Export logistics for pineapple
The harvested fruit is deposited in drawers and transported to the packing plant, where it is submerged in disinfectant in trays. Another alternative process consists on submerging the fruit completely in similar solution (with Triadimefon), this process is used especially to export to United States and Europe. The boxes used in the packing are revised to detect the presence of insects. The fruit is placed in boxes of 10 - 20 kg and, finally, put in pallets. The pallets, properly maintained in refrigeration chambers are loaded in the refrigerated containers. Each container has a capacity of 1500 boxes of 20 kg and/or 3000 approximately boxes of 10 kg. The refrigerated container is maintained at 7.5 - 8° C previous to export. Each container has a thermograph for the control and registration of the temperature while traveling as well as with the respective filters for the control of the ethylene. Is important to offer and use an appropiate packing for the pineapple, for the cultivation and preparation of the fruit, because just with a safe and functional protection it can keep the quality of the product until arrival to the final market. The packing also helps to promote the fruit's sales because of the presentation, as well as the description of content and origin. The appropriate packing use for the product fulfills the following functions: To avoid the loss of aroma, to protect the product against the admission of flavors and disgusting scents, to offer a good period of conservation, to avoid the accumulation or loss of humidity, to protect the product against damages, to offer a space to print the relative necessary information about the product. A careful crop handling and postharvest contributes to the maintenance of the quality of the products. The gathered pineapples should be packed in clean plastic boxes (Fig. 23) and be stowed. An important characteristic in this stage is that the boxes should have holes with lengthened form in all sides for the ventilation, because it allows a quick exit of the heat of the fruit. The packing measures for the pineapple are not standardized, but are guided with the international packing norm for agricultural products according to the size. The product should be kept at temperature packing from 7 - 10° C, with a relative humidity of 90%. The pineapples should be fixed inside the box, in order to avoid wounds in the shell and/or the crown (Isabellefruits,2004).

**Fig..23 Packing of pineapple fruits**

***2.1.3 Grading :***

After pre-grading, washing, waxing, and fungicide treatment, the pineapples are left to dry and then are graded for packing. Graders remove any fruit that shows signs of fresh mechanical damage or any of the conditions that qualify the fruit for rejection in the pre-grading stage. Remaining pineapples are classified for packing based on size, stage of ripeness, and, if applicable, shape. Fruits of different shape may not be mixed in the same carton.

***2.1.4 Packing.***

The preferred method of packing is to place the fruit vertically on the base, and then to place dividers between the fruits to prevent rubbing and movement. With some cartons, this is not possible and fruit are laid horizontally in alternating directions; where two layers of fruit are packed, a layer of card is required between the layers : 6 count - 1.75 kg fruit (3.8 lb) ,12 count - 1.25 kg fruit (2.7 lb) ,12 count - 1.00 kg fruit (2.2 lb) and 20 count - 0.75 kg fruit (1.6 lb)

Fruits are normally packed to a net weight of 10 to 15 kg (22 to 33 lb) depending on the carton and the market. High value small pineapples may be shipped in some instances at 6 kg (13 lb), whereas the large fruit in some cases may be packed up to 20 kg (45 lb). Packaging: A full-telescopic two-piece fiberboard carton with internal dividers between the fruit; bursting strength 275 lb/in2. Top and bottom ventilation, in addition to side vents are required, particularly where sea-shipments in break bulk are used. Where staples are used in carton construction, care should be taken to ensure complete staples closure to prevent fruit damage. Storage and Transportation:

Where sea-shipment is to be used, the fruit should be harvested on the day prior to shipment. Green fruit should be stored at 10ºC, 85 to 95% relative humidity, and under these conditions, should have a storage life of two to three weeks (Fig. 24). This will be dependent on the sugar content and the agronomic conditions during production, in addition to the handling and storage procedures. Where exports are made by air with fruit harvested at more advanced stages of maturity, pre-export storage can be used and the suitable storage temperature decreases to 7.5ºC, 85 to 95% relative humidity. Potential Post-harvest Losses: Losses in pineapples during air-transport are minimal if careful handling is employed. On sea-shipments and long term storage however, the fruit are more susceptible to post-harvest losses as a result of increased handling, control of temperature and disease incidence Mechanical damage: Bruising or puncturing caused by poor handling, dropping or abrasion, will result in localized areas of softening and development of secondary microbial infection (Foodmarketexchange, 2004).

**Fig. 24 Pineapple refrigeration**

For canned pineapple can sizes used are: 608X700 (108 oz), with a net weight of 3030 oz, 6 cans per box and a total weight of 20 kg per box; size 401X411 (30 oz), with a net weight per can of 820 oz, 24 cans per box and a total weight 24 kg per box; size 307X409 (20 oz), with a net weight of 560 oz, 24 cans per box and a total weight of 16 kg per box; size 307X309 (15 oz), with a net weight of 425 oz, 24 cans per box and a total weight of 13 kg per box; and size 307X201 (8 oz), with a net weight of 227 oz, 24 cans per box and a weight of 7 kg per box. The packing is in corrugated cardboard carton to prevent dents during transportation. The packing in tray of 12 cans for retail can size is available with and without shrink wrapping. Products can also be palletized on wooden pallet or slip sheet for the convenience of handling. For industrial use, product of 108 oz. can be palletized without cartons. Pineapple juice is extracted from selected fruits where pulp is controlled to the requirement. NFC (not from concentrate) pineapple juice is single strength at 12 ± 1 °Bx. It is aseptically processed, while some juice will be processed through evaporators to the desired °Bx. All juice and concentrate will be stored in cold storage to preserve the quality. Frozen concentrate is stored at the temperature of -20°C. Aseptic product can be stored at the ambient temperature but it is recommended to stored at 5 °C in order to preserve the quality and to prolong the storage life and packed in steel drum or wooden bin. The canned pineapples are packed in accordance with the US FDA, and are available in different sizes to serve both retail and institutional purposes. The cuts include slice, chunk, tidbit and crushed packed in either natural juice or syrup. Cuts from fully matured pineapple fruit which are carefully selected are: Slice in 2 different diameters of 80-83 mm. and 90-97 mm., chunk that is a segment of pineapple good for barbeque, salad or full-bite snack, tidbit/pieces in various sizes from small pieces for pizza topping to large piece as natural snack and crushed/chopped pineapple that can be used as desert topping and pie filling (tpc-canning.com 2004)
Pineapples are also separated according to degree of ripeness. Average weight of the fruit is ca. 2.5 kg, pulp color must be in the range of pale to gold yellow, with 13 % of soluble solids and 0.6 % acidity as citric acid. These attributes are an important part of the overall qualities of a widely accepted pineapple flavor for either fresh or canned product.

***Inspection***

Mechanical damage: Many factors contribute to pineapples skin damage, including the harvesting tool used, dropping of fruit into crates, overfilling of crates, and jostling of fruit during field transportation. Similar problems can result from poor handling during washing, grading, and packing.

Pineapples handlers can minimize fruit damage by taking protective measures throughout all handling stages. Staff should be trained in proper harvesting techniques. In addition, transporters should drive slowly and carefully when taking fruit from the field to the packing house.
At the packing house, crates should include foam in their base and contain only one layer of fruit. In automated operations, all machinery should be padded where possible. Palletized systems are preferable for moving produce in both field crates and final packages.

## 2.2 Packinghouse operations

The fruit is harvested and delivered to the packinghouse. Field Managers are in contact with growers to schedule deliveries of fruit to meet market demands. Growers who want their fruit picked up in the groves will schedule transportation with the Field Manager. Many Growers elect to deliver the fruit to the packinghouse themselves.
The fruit is gradually pre-cooled before packing. This allows the fruit to cool down over a 12 hour period from the ambient temperature at delivery time.
Packers have a built in system that allows full bins to be weighed before packing. Empty bins are then weighed so that the grower is given credit for every pound of fruit delivered to the packinghouse.
The fruit is placed on the packing line and graded (Fig 25). The fruit is then placed into tight fill cartons by a sizer machine. The fruit is labeled during the process. The sizer insures not only that the correct number of fruit is packed into the cartons by size, but also that the weight of the carton is correct.

## 2.3 Packing

All cartons of fruit are checked once more by quality control personnel before the carton is sealed and placed in a cooler until shipment time. The cartons of fruit are stacked on pallets and these pallets are placed in a shipping cooler, where temperature is maintained between 8-10 °C (Calavo Products, 2002).

**Fig. 25 Pineapple selection and inspection line**

## 2.4 Cooling system

Pineapples are placed in an insulated room equipped with refrigeration units and forced air-cooling where fans pull cool air through pineapple packages. After storage the pineapple pallets are placed in refrigerated containers with fresh air supply or controlled atmosphere.

## 2.5 Storage of fruits and vegetables

Chilling damage arises in the varieties "Queen" and "Smooth Cayenne" when they are stored for 14 days at temperatures of < 7°C. Signs of chilling damage are: loss of skin gloss, formation of brown to black stripes under the skin and around the woody central cylinder (endogenous brown spot), watery flesh, insipid taste, susceptibility to rotting and loose crown leaves. At temperatures > 10°C, the crown leaves have an increased tendency to bolt. Bolted crown leaves impart a tired appearance to the fruit and diminishes its value. In addition, the tendency to fruit rot (black rot) also increases, often occurring as butt rot above the stem but also arising in the crown. Susceptibility to chilling damage reduces as ripeness increases.
The cargo and holds/containers must be cooled before loading starts, to ensure that the cold chain is unbroken and the quality of the fruit is not reduced.
Pineapples require particular temperature, humidity/moisture and ventilation conditions. Recommended ventilation conditions: air exchange rate 40 - 60 times per hour with constant supply of fresh air, so as constantly to remove the ripening gases arising and to keep the CO2 content of the hold air low. Spoilage may occur as a result both of inadequate ventilation (danger of rotting) and of excessive ventilation (drying-out, weight loss. Pineapples display 2nd order biotic activity. They are living organs in which respiration processes predominate, because their supply of new nutrients has been cut off by separation from the parent plant. Care of the cargo during the voyage must be aimed at controlling respiration processes (release of CO2, water vapor, ethylene and heat) in such a way that the cargo is at the desired stage of ripeness
( tis-gdv,2004)

***Compatibility groups for storage of fruits***

The best storage environment for an individual fruit or vegetable depends on its unique requirements for temperature, relative humidity, and ethylene exposure. Most compatibility charts for mixing products during postharvest handling divide fruits and vegetables into eight groups. In practice it is very difficult to separate products into this many groups-very few wholesale or retail handling facilities, if any, have eight temperature-controlled rooms. Researchers of UC Davis (Thompson, Kader and Sylva, 1999), have developed a three-group chart that is easier to use and still provides good product shelf life (Table 4).

**Table 4 Compatible Fresh Fruits During 7 Day Storage**

http://rics.ucdavis.edu/postharvest2/Pubs/postchrt2.shtml

| | |
|---|---|
| avocado | olive |
| babaco | orange |
| tuna | pepino |
| carambola | pummelo |
| feijoa | Sugar apple |
| granadilla | tamarind |
| Grape fruit | watermelon |
| guava | cranberry |
| lemon | pineapple |
| mandarin | Ugli fruit |

*Source: (UC Davis, 2004)

Group 3- Fruits
code thermometer
45-50 °F, 7-10 °C & 85-95% RH

## 2.6 Transportation system

Marketing and physical distribution of fresh produce inherently means moving the produce. The commodities are handled, either manually or mechanically, many times from harvest and through the distribution process before the consumer buys and prepares them to eat.
For domestic transportation the use of road vehicles offers substantial advantages of convenience, availability, flexibility permitting door-to-door delivery, and reasonable cost of transport. The use of road transportation for fresh produce is increasing and likely to increase in countries all over the world. Produce may be transported by pick-up, enclosed truck, open truck or refrigerated vehicle (Harris, 1988).
For perishable products, however, the increased speed of handling and reduced transport costs that came with containerization were not enough. Ocean transport of cooled and frozen cargo received a substantial boost with development of mobile refrigerated cargo ships that lack this flexibility. Controlled atmosphere (CA) technologies allow operators to lower the respiration rate of produce by monitoring oxygen, carbon dioxide and nitrogen levels within a reefer. In this way, CA can slow ripening, retard discoloration, and maintain freshness of pineapple. Although it is likely that container ships will dominate the perishable trade between North America, East Asia and Europe, conventional refrigerated vessels can serve many smaller ports, especially in the developing world, that are unable to handle large container vessels. Thus, in north-south trade and in certain niche markets, conventional refrigerated ships may have a brighter future, but even here, competition from container vessels is bound to increase as cost decline (Agricultural Outlook, 1999)

## 2.7 Processing

There is a series of physical properties of pineapples that play important roles during processing. Leverington (1970) described research works on the relationship between translucency and other quality characteristics. It was found that in addition to be considered as a maturity index, translucency is a quality attribute of the fruit. Translucent or semi-translucent slices are generally considered as desirable and associated with better flavor. Fully translucent pulp have an overripe flavor, while those not translucent are too sour. As pulp becomes more translucent air cavities decrease in size and therefore in porosity. Internal color affects the appearance and acceptance of the fruit; yellow-gold color has been regarded as best.
Traditionally pineapple is consumed fresh or canned (Fig. 26). Diversification of pineapple products is a good strategy to increase consumption in the main markets of the world. Thus, pineapple is now consumed in the form of single strength or concentrated juice, dehydrated and/or sugared, canned in slices or bits. The variety traditionally employed to develop these products has been Cayena lisa. Among the newer developments are dried chips, cocktail-type drinks, dried powdered, isotonic mixtures and wine; there are also new canned forms as whole fruit, bars, flakes and cubes. For fresh consumption, new varieties have been introduced: MD2, Josapine, LR41 and Gandul (Coveca, 2002).

**Fig. 26 Canned pineapple**

Essentially a prime table fruit, pineapple pulp (Table 5) is perfectly suited for conversion to frozen juices (Fig. 27 ), nectars, drinks, jams, fruit cheese, concentrates (Fig. 28) or to be had by itself or with cream as a superb dessert. It can also be used in puddings, bakery fillings, and fruit meals for children, flavors for food industry, and also to make the most delicious ice cream and yoghurt. While the raw fruits are utilized for products like chutney, pickle, sauce. pineapple beverage, etc. ripe ones are used in making pulp, juice, nectar (Table 6), squash, leather, slices, etc. Major export products include dried and preserved vegetables, jams, fruit jellies, canned fruits and vegetables, dehydrated vegetables, frozen fruits, vegetables and pulps (Table 7) and freeze dried products.
Ripe pineapple may be frozen whole or peeled, sliced and packed in sugar (1 part sugar to 10 parts pineapple by weight) and quick-frozen in moisture-proof containers. The diced flesh of ripe pineapple, bathed in sweetened or unsweetened limejuice, to prevent discoloration, can be quick-frozen. Half-ripe or green pineapples are peeled and sliced as filling for pie, used for jelly, or made into sauce.

**Table 5 Industrial processing possibilities**

| | |
|---|---|
| pineapple pulp | Glazings |
| Fruit cocktails | Dried pineapple slices |
| Juice | Pineapple wine |
| Nectar | Flavored yoghurt |
| Fruit sauces | Ice cream |

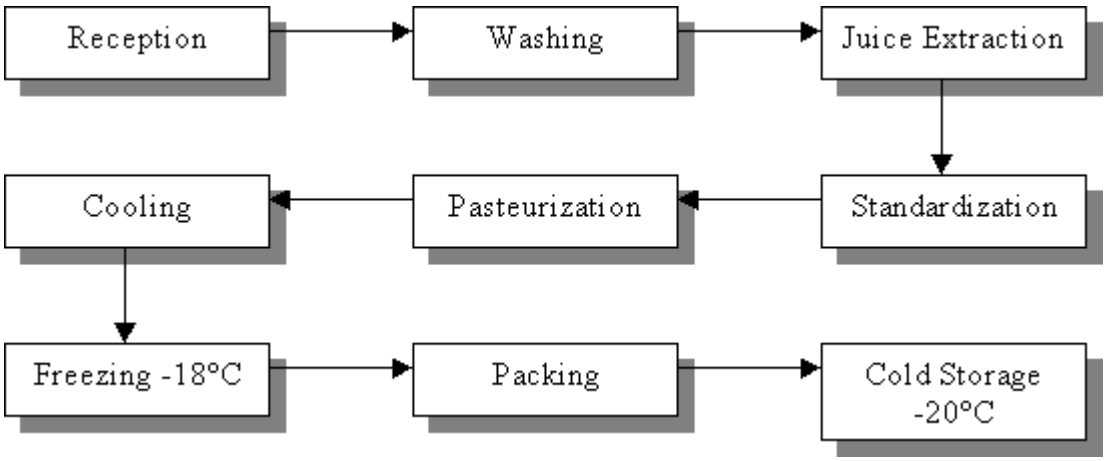


**Fig.. 27 Processing of frozen Pineapple juice**

***a) Fresh consumption and processing***

Processed pineapples shall meet standards of quality to assure market acceptance. Processing plants reject fruit with bruises, with defective heart, or multiple crowns. Porosity should be minimal and the °Bx to acidity ratio should be near 20. Acidity should be kept close to 0.75%.

In average the yield in processing ranges from 45% to 55%. End products include packed pineapple, which includes pulp from the cuts made to the base, crown and peel. This product may be done in small slices, chunks or bits. The pieces are placed in cans containing syrup. It is important to maintain a good control of the °Bx of the syrup in order to reach an equilibrium between the fruit and the syrup. The thermal treatment and final pH value of the product are key factors to assure product quality. Either cans or glass jars can be employed for packing purposes. Pineapple pieces can be mixed with other fruits to prepare fruit cocktails, which entails another commercial alternative (Coveca, 2002).

In the process for preparation of pineapple products, fruit are unloaded from trailer trucks to conveyor bands where crowns are taken off and fruit are placed in a washing vat, then through an elevator the pineapples go to a roller sorter, and then separated in two different sizes and two slides take the fruit to different packing lines. The Guinaka brand peeler(Fig 28) removes the peel and forms a cylinder with the peeled fruit, by a circular blade that spins at high speed. The cylinder is sent by another slide where they are placed manually in another machine that removed the core. The coreless cylinder is then moved to the dicer and the product is then ready to be packed in buckets holding 10 to 15 kg. The product is frozen in a chamber set at -20°C, for further transfer to distribution points or processing. Pineapple cylinders are sliced and canned with syrup, then passed through an exhauster with steam at 3 bar and 120 °C to eliminate air and create vacuum (Fig 29). Cans are sealed and sent to the autoclave. After the thermal treatment the cans are placed in a cooling vat for 10 minutes; this produces a thermal shock that inactivates bacteria. Finally, cans are labeled and boxed and ready for distribution.

**Fig. 28 Guinaka peeler**

**Fig. 29 Exhauster**

Other different products of pineapple processing are:

***Dried pineapple:*** In this product, most of the free water of the fruit is eliminated. Usually, chunks or slices are prepared for better presentation and make handling easier. Final moisture is near 5%, and this allows the dried fruit to have a long shelf life as long as proper packing is provided and storage is done in a fresh place. (Fig. 30)

***Juice:*** Pineapple juice is obtained from crushing fruit pieces and proper pysical separation of the solids (Fig. 31). Juice must be pasteurized and packed to extend its shelf life and a preservative or refrigerated storage may be used as additional barriers to microbial spoilage. No juice should reach the market if it becomes fermented or mixed with water. Packing may be plastic bottles or bags, coated cans, multilaminate (plastic, paper, metal foil) or any newer materials. The pH values of the product must be controlled so it remains agreeable for human

consumption. It is a common practice to blend batches of juices to attain proper acidity and sensory qualities. Juices from other fruits can be blended with pineapple's and interesting mixtures make novel products.

***Nectar:*** It is the product of blending juice with a certain amount of solids from the pulp containing the same amount of °Bx as the original fruit. Normally, nectars are prepared by diluting fruit pulp to 30 °Bx. Methods of preservation and packing are similar to those described for juice.

***Pulp:*** It is the product of the basic processing of peeled pineapple pulp by crushing. Pulp may be preserved by thermal treatment, by preservatives addition and proper handling in either small packages, or in bulk packages for further industrial processing and formulations as ice cream mixes, jellies, jams, sodas, etc.

***Concentrated frozen pulp:*** It is the product from thermal treatment of the pulp to remove at least 50% of the initial water content. Concentration and freezing are applied to preserve the pulp for extended periods of time. The concentrated pulp is stable without the addition of chemicals as long as it is kept frozen. Upon reconstitution (by replenishing the previously eliminated water) the pulp should have the same qualities as the original pulp.

***Aseptic pulp***: It is the pulp that was heat-sterilized and packed aseptically; no chemicals are added and has a long shelf life. There is very specific equipment to perform this process and it is considered to be at the cutting edge of technology.

***Concentrated Frozen Juice:*** This product is prepared by direct application of heat to pineapple juice to reduce its water content. Preservation methods are similar as described for concentrated pulp in which no chemical additives are used.

***Jelly:*** Jellies fall in the group of fruit preserves, which are defined as semisolid products prepared by mixing 45 parts of fruit and 55 parts of sugar. This mixture is cooked until the final solids contents reach 65 to 68%. It is hot-filled for better stability. Usually, jellies are prepared from fruit juice and a gel-type product is obtained; it may or may not contain fruit pieces. Final textural firmness is dependent of the type of gel-forming agent as pectin which is added under controlled acidity and solids content to assure the proper texture of the product. To assure proper shelf life at ambient temperature, preservatives may be added. These chemicals are mainly used to control mold growth; but once the jar is open, it shall be stored under refrigeration.

***Marmalades:*** This is also considered as a fruit preserve using the same proportions of fruit and sugar, and cooked until the same solids content as jellies. Consistency is semi-fluid and not a gel as jellies. Preservation criteria and shelf life considerations are similar as for jellies.

***Fillings:*** Pineapple pieces mixed with bakery cream may be used as cake fillings for institutional service and large-scale production of bakery goods. Stability of the product depends on the cleanliness and hygiene of the manufacturing process. Product may be packed in plastic bags, plastic containers or metal bins. If no additives are used, the fillings must be kept refrigerated. Due to its elevated nutrient and water content, shelf life is not very long.

***Vinegar:*** Vinegar is prepared by an acetic fermentation of alcohol solutions derived from sugar or starchy materials (fermentable sugar content of 8-20%). This is done by strains isolated from the raw materials. Peel and other pineapple by-products from processing can be used as raw materials to prepare natural vinegar and thus make a proper use of residuals. Vinegar must be pasteurized once it is prepared and bottled. It is stable at ambient temperature (Coveca, 2002).

**Fig. 30 Dried pineapple chunks**

**Fig. 31 Traditional extraction of pineapple juice**

***Sauce***

Concentrate 1 kg strained pulp containing 20 g sugar to 1/3 of its original volume in the presence of suspended spice bag containing 50 g chopped onion, 5 g garlic and 50 g ginger, 10 g powdered spices and 5 g red chillies. Press out spice bag occasionally and squeeze it out finally to obtain maximum spice extract. Add 15 g salt and remaining 40 g sugar and cook to thick consistency. Add 450 ml vinegar and cook again to end point. Add and mix preservative after dissolving in minimum quantity of water. Heat to boiling and hot pack.

***Jam***

Boil 1 kg pulp of ripe firm peeled fruit with 100 ml water 3 g citric acid and 10 g of pectin. Add 750 g sugar and cook to thick consistency. End point is confirmed by sheet test. Boiling mass is allowed to fall after cooking from a laddle which will flow in the form of a sheet. Pack hot in clean dry glass jars.

***Jelly***

Mix 1 kg grated pulp of fully mature peeled but somewhat raw fruits with ripe pineapple pulp (1 kg), 2.5 litre water 10 g citric acid and 2 g of pectin. Boil for 30 min, cool and allow to settle for 2 hours. Separate the supernatant (upper layer) and filter. Test for pectin quality. Formation of single clot with small quantity of ethyl alcohol added to test samples indicates high pectin content. Concentrate further if necessary to obtain single clot. Cook gently the extract with equal quantity of sugar to obtain the end point indicated by the formation of sheet. Pack hot. Cover with a layer of melted wax and close the lid.

***Preserve and candy***

Cut rectangular slices (4x1 cm) or suitable sized cubes from the fully mature ripe washed peeled fruits after removing seeds. Keep in 1.5 % limewater for 3-4 hours. Drain and wash 3-4 times in plain water. Dissolve 400 g sugar in 600 ml hot water and filter. Boil pieces in sugar syrup and keep overnight. Next day drain the syrup, raise its Brix to 50. Add slices, boil and keep again. Repeat this process every day, untill Brix reaches 70-75°. Keep for a week. Drain the syrup, fill the pieces in dry jars and cover slices with freshly prepared sugar syrup of 70°Bx.

For the preparation of candy, raise the Brix of syrup to 75°, and keep it for a week. Drain and dry the pieces under shade. Dip pieces in boiling water to remove adhering sugars. Drain, dry and pack.

***Toffee***

Concentrate 1 kg sieved pulp to 1/3 volume and cook with added sugar (600 g), glucose (100 g) and hydrogenated fat (100 g) till a speck of the product put into water forms compact solid mass. Make thick paste of 100 g skim milk powder in minimum quantity of water and mix with the boiling mass. Spread 1-2 cm thick layer of the cooked mass over /SS trays smeared with fat. Add flavoring material at this stage, if necessary. Allow to cool. Cut and wrap in butter paper (Indiaagronet.com, 2000).

# 3 Pest control and decay

## 3.1 Pest species

DISEASES AND PLAGUES

Rotting caused by the cottony wood-louse is the most widely spread and harmful disease in pineapple culture mainly for the cultivar “Smooth Cayenne”. A quick expansion occurs from the initial infestation point. As soon as symptoms appear the insects invade healthy plants. Roots stop growing, then collapse and rot, causing plant fading. The plague starts at the tips of the leaves (Fig. 32), which develop a yellow-red color. Control of cottony wood-louse is essential but it can only be achieved if the related ants are eliminated, for which periodical insecticide (Parathion) spraying. The “Smooth Cayenne” cultivar is very susceptible to fading, although some resistant clones have appeared. Cultivars “Red Spanish” and “Singapore Spanish” are used for genetic improvement due to their resistance. The actual cause of the disease appears to be a virus, but nobody has proven it yet. The yellow spot has been associated with a transmitted virus. The inoculum is an adventitious of the family of weed Emilia sonchifolia. The only way of control is by suppression of the weed. Nematodes may be found in excess of 100.000/cm3 of soil and are one of pineapples worst enemies. Nematodes infect roots producing tonsils (Meloidogyne) and lesions (Pratylenchus), or can penetrate directly the roots (Rotylenchus). Other genera have also been found to be involved. Nematodes usually prefer light soils, although they may also be found in common and clay-type soils. In the first 3-4 months after ground clean up and planting, the count of nematodes is low, but then populations raise steeply, and growth of Ananas plants are severily hindered, with the appearance of chlorotic leaves. Then, the number of nematodes drops abruptly in a similar way as in drought conditions. This oscillating trend is more marked in short cycles as those of export. All vegetative material capable of hosting nematodes shall be destroyed before planting. (Infoagro.com. 2002).

## 3.2 Pest Control

Two weeks prior to planting, soil may be fumigated with D-D (300 L/Ha), but this compound is too toxic for the plant. EDB (ethylene dibromide) when applied at 100 kg/Ha, decrease

phytotoxicity problems. Fumigation may increase crop yield from 3 % to 32 %, depending on the abundance of nematodes at the moment. It is advisable to fumigate only when strictly necessary, since is an expensive and dangerous procedure. Another promising nematocide is Oxamilo, which can be ground and unlike the other active compounds it is transported donwards from leaves to roots. Nevertheless before a product is applied one has to make sure that its use has been approved and be aware of potential problems caused by its residues. It is recommended to allow the soil to rest for six months so that nematodes may be eliminated. This is a very expensive method and can hardly be considered. Sinfilides are miriapodes that may turn disastrous in pineapple plantations. They are ca. 4 mm long and feed on roots. As a reaction to the invasion, roots turn into a broom shape, their radicular system is downsized and becomes prone to fungal attack and the plant stops its growth. The above mentioned fumigants are active against this plague, but the use of Lindane (2 kg active compound/Ha) acts as reinforcer. Fenamifos and Etoprofos can be used too. Other plagues affecting pineapple culture are mites (Fig. 33), fruit flies, the moth Castnia licus (same as in bananas) and the butterfly Thecla basilides. The latter can only be controlled after hormonal treatment. The heart rot is caused by Phytophthora cinnamomi and by P. parasitica in warm regions. Their zoospores are chemically transferred to the trichomes and penetrate the cells of young leaves. In order to control the disease the vegetative material can be immersed in Difolatan, although other authors prefer Metalaxil and Aliette. It is also recommended ground Captafol at a rate of 2 % on 3.500 L/Ha, applied immediately after planting, one months later and one week after the treatment for flowering induction. Thielaviopsis paradoxa causes rotting of plant material for planting and of fruits post-harvest. Prevention is done by immersion of the stem in benzoic acid, Shirlan or Imazalil. Fruit gomosis is produced “Red Spanish” cultivar, while cultivar “Smooth Cayenne” is resistant. It seems to be caused by caterpillar feeding and can be controlled by ground insecticide application (Infoagro.com. 2002).

***Brown spot***

**Fig. 32 Pests and diseases in pineapple plant and fruit (SARH, 1994)**

**Fig. 33 pineapple plague (SARH, 1994**

# 4 Economic and Social Considerations

## 4.1 Gender aspects: Role of the men and women in post harvest operations

A study of the role of women in postharvest handling and marketing of pineapple and others fruits. In Guatemala women leaders of the Cooperation for rural development of the west are well aware that in order to achieve integral development of a community, community organization is imperative. These women supported the organization of rural women of Xolsacmaljá and Chuculjuyup, who wanted to generate their own income and contribute to the household economy. These pheasant women started organizing due to the abundant harvest, since each one alone could only market very small amounts of fruits. Although they joined efforts to sell their crops in larger scale profits were barely enough to provide adequate support for their families. Then these women decided to start a project for fruit transformation that INCAP offered. In 1992, after feasibility studies and financing programs, the woman's project for dried goods was created, involving the construction of a small drying plant for apples. When the plant started, it only processed second quality apples. This operation was not difficult and did not require specialized technologies for dried fruit preservation. However, in addition to local fruits, they currently process tropical fruits (pineapple, papaya, mango, banana meal). They have also expanded their industrial capabilities to marmalades, syrups and other products including snacks, teas, bakery ingredients among others, which have been accepted in international markets due to their all-natural labeling. Cooperative members have received training for resource management, entrepreneur abilities and leadership, among others. They have successfully participated in local and national fairs.

At the village of Taido Anomabu in Ghana, the project Hunger Ghana produced a wide selection of projects. In a particular project, villagers were trained in all aspects of pineapple production, and contact was established with business partners from Accra, who bought the entire crop of 1997. From marginal producers, the project turned the small operation into a lucrative business. Villagers built a multi-purpose building that became an important center for the community serving as school, training center and meeting hall.

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Acknowledgments:
We thank to the Instituto Tecnologico De Veracruz (UNIDA), COVECA (State government of Veracruz), Loboni Fruit Company, Loma Bonita, Oaxaca. Mexico and the Centro De Investigacion Regional Golfo Centro (INIFAP) Campo Experimental Cotaxtla, Veracruz, Mexico for their invaluable cooperation and materials kindly provided for this work.