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RESEARCH ARTICLE

POST HARVEST HANDLING OF PINEAPPLES: A KEY ROLE TO MINIMIZE THE POST HARVEST LOSS

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ABSTRACT

Pineapple is an important fruit crops of India and cheaply available in the market. It is one of the widely grown and consumed fruit in all parts of the world due to presence of distinct flavour and taste. It is rich in carbohydrate, potassium, calcium, phytonutrients, vitamin C and bromelain. In terms of pineapple production India's has 6th in the world and leading pineapple growing states are West Bengal, Assam, Tripura, Karnataka, Bihar, Manipur, Meghalaya and Nagaland. It has been observed that at post production level a significant proportion (15-25 %) of the produce get spoiled due to improper post harvest handling practices, which causes huge economic loss to the growers. The availability and accessibility of food can be increased through improved production technology, distribution cool chain, preservation and by reducing the losses. Thus, reduction of post harvest food losses is a most critical component of ensuring future global food security. Post harvest loss of pineapple can be minimize by adopting various suitable post harvest handling practices that are presently in practice all over the world to extend its shelf life. Post harvest handling practices viz., post harvest management, processing and value addition and waste utilization for pineapple are discussed in brief.

INTRODUCTION

The pineapple is a non-climacteric, parthenocarpic, multiple fruit often called as syncarp or sorosis, and composed of some 100–200 berry-like fruitlets, sometimes called eyes, attached to a central core. It is an herbaceous perennial plant, 0.75–1.5m tall with a spread of 0.9–1.2 m with a very short and stout stem and a rosette of waxy, straplike, long-pointed green or red-striped leaves, usually needle tipped and generally bearing sharp, up-curved spines on the margins (Fig.1). Pineapple (*Ananas comosus* L. Merr.) belongs to family Bromeliaceae, belived to be originated from South America, Southern Brazil, Northern Argentina and Praguay (Paul and Lobo, 2012). Before the arrival of Christopher Columbus in 1493 the fruit had been domesticated by native South American. The pineapples are commercially grown over a wide range of latitude from 30° N in the northern hemisphere to 33° 58´S in the South (Malezieux *et al*, 2003). In ideal condition pineapple plants flower 10-12 months after planting and fruits become ready 16-18 months after planting and in case of crown as planting materials require nearly 23 months to produce a new fruit under normal conditions, while slips and suckers need 20 and 17 months. The fruits can be harvested from May to June and November to January and fruits mature in the winter are more acidic than summer. The fruits with crown can be kept for 10-15 days after harvesting (Medina and García, 2005). Pineapple is the 3rd most important tropical fruit in the global market after banana and citrus. Nearly 70 % of the production is consumed fresh domestically where as 30% is exported. The five leading pineapple producing countries are Costa Rica, Brazil, Philippines, Thailand and Indonesia (FAO STAT 2013). India's ranks 6th in the production of pineapple and contributes 1,571,000 tons per annum and major pineapple growing states are West Bengal, Assam, Tripura, Karnataka, Bihar, Manipur, Meghalaya and Nagaland (FAO 13, NHB Data Base 2014). The pineapple cultivars mostly grown in India are Kew, Giant kew, Queen and Mauritious (NHB Data Base 2014). The fruit of different cultivar varies in size, shape, colour and presence of spine in the leaves (http://prsvkm.tripod.com, http://nhb.gov.in) (Table 1). Pineapple is produced for both fresh consumption and processing (Hassan and Othman, 2011) and fruits are often called as nature's wonderful medicines, rich in vitamins, minerals, anti-oxidants and phyto-nutrients without which human body cannot maintain proper health and develop resistance to disease. It also contains pectin, cellulose which

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stimulates intestinal activities and energy giving substances like oils, fats and proteins. The pineapple fruits provide nutrients vital for health and maintenance of our body. However, their availability is seasonal and they are perishable. Hence, there is need for postharvest management and processing of pineapple into different value added product such as juice, RTS, squash, jam and canned pineapple slices to reduce the post harvest loss (http://prsvkm.kau.in/). Pineapples contain 85 to 86.3% moisture, and 13-19% total solids, of which sucrose, glucose and fructose are the main components. Carbohydrates constitute up to 85% of total solids whereas fiber makes up for 2-3%. It is also rich in potassium, calcium, iron and vitamin C. The pulp has very low ash content, nitrogenous compounds and lipids (0.1%). The nutrient value of raw, juice and canned pineapple is given in table 2 (http://www.nal.usda.gov/fnic/foodcomp/). Pineapple has beneficial health effect on dyspepsia due to chronic digestive disturbance, Bronchitis, high Blood pressure, arthritis and intestinal worms and nausea including morning sickness and motion sickness (Hossain *et al*, 2015). In a survey conducted by Deka *et al*, (2004) reported that the post harvest losses of pineapple in Assam state is about 9.25%, out of which 4.22 % at growers level and 5.03% at middleman's level. Keeping in view of significant post harvest losses, in this article we will discuss the various post harvest management tool to combat post production losses.

Table 1 Characteristics of the major pineapple cultivars grown in India.

Characteristics	Cultivars	
	Queen	**Kew**
Cultivated area	Tamil Nadu, Karnataka, Odisha, Bihar, Jharkhand and NE states of India	Tamil Nadu, Karnataka, Odisha, Bihar, Jharkhand and NE states of India
leaves	Very spiny, silvery	Spineless
Fruit weight	1.0-1.5 kg	1.5-3 kg
Fruit shape	Conical	Ovoid
Peel colour	Yellow, small prominent eyes	Yellow, eyes are broad
Colour of flesh	Golden yellow	Light yellow
Taste	14-19 °B, Acidity 0.6-0.8% and low fiber	12-16 °B, Acidity 0.6-1.2 % and fiberless
Purpose	Table and processing	More suitable for canning
Disease problems	More resistance than 'Kew'	Mealy bug wilt, fusariosis, fruitlet core rot and butt rot
Physiological problems	Chilling injuries, internal browning	Internal browning

(Source: Paull and Lobo, 2012; http://prsvkm.tripod.com)

Causes of post-harvest losses of pineapple: In pineapple fruit physical injuries, sun burn, rodent's infestation, contamination with pathogenic fungi and bacteria are major causes of losses. Due to lack of awareness, knowledge and skills related to pre and postharvest management of produce among the handlers and marketers supplemented by high temperature and unavailability of efficient cool chain infrastructure aggravate the postharvest loss. The poor handling during transportation and use of inappropriate marketing structures also contributes to loss.

Loss reduction through postharvest management: Postharvest management is a set of post-production practices that includes cleaning, washing, selection, grading, disinfection, drying, packing and storage. These eliminate undesirable elements and improve product appearance, as well as ensuring that the product complies with established quality standards for fresh and processed products. Postharvest practices include the management and control of variables such as temperature and relative humidity, the selection and use of packaging, and the application of such supplementary treatments as fungicides. The aim of postharvest management is to minimize the post harvest loss in such a way that it could be beneficial to the whole community, whether through increased export earnings or extending the availability of fresh produce through the year (Hassan *et al*, 2015).

Maturity index: The harvest maturity of pineapple fruit is based on peel colour and shape of individual fruitlets or eyes. The peel colour of fruit may vary due to altitude, season, rainfall, microclimate and field practices. The eyes turn from green to yellow orange from the bottom and maturity can be judged on the number of rows of eyes that have changed colour and fruit is ready to harvest when 30-50% eyes turned yellow from the base. For distant market harvesting should be done when the fruit is 10-20% yellow stage or even 100% green but mature stage just before striking colour changes begins (Adikaram and Abayasekara, 2012). The external colour and aroma of pineapple are an important parameter to judge the quality of fruit by the consumer and minimum TSS of 12-14°B and acidity 0.9-1.3% ensure the minimum degree of consumer acceptance (Soler, 1992). Maturity index can also be estimated by relating it to the time after flowering or mid-flowering, but the number of days may vary from place to place. The period from flower induction to ripening varied from 140–221 days (Thompson, 2003).

Table 2 Nutritional profile of fresh pineapple and its processed products.

Nutrient	Raw/fresh	Juice	Canned
Water (g)	86	86.37	85.73
Energy (kcal)	50	53	52
Protein (g)	0.54	0.36	0.36
Total lipid (g)	0.12	0.12	0.12
Carbohydrate (g)	13.12	12.87	13.45
Total dietary fiber (g)	1.4	0.2	0.8
Total sugars (g)	9.85	9.98	12.65
Minerals			
Calcium (mg)	13	13	14
Iron (mg)	0.29	0.31	0.39
Magnesium (mg)	12	12	16
Phosphorus (mg)	8	8	7
Potassium (mg)	109	130	105
Sodium (mg)	1	2	1
Zinc (mg)	0.12	0.11	0.12
Vitamins			
Vitamin C (mg)	47.8	10	7.5
Thiamin (mg)	0.079	0.058	0.091
Riboflavin (mg)	0.032	0.021	0.025
Niacin (mg)	0.5	0.199	0.292
Vitamin B-6 (mg)	0.112	0.1	0.074
Folate (µg)	18	18	5
Vitamin A (µg)	3	0	2
Vitamin A, IU	58	5	38
Vitamin E (mg)	0.02	0.02	0.01
Vitamin K (µg)	0.7	0.3	0.3

(Source: USDA Nutrient Database, 2015)

Harvesting: The harvesting operation is carried out manually by cutting stalk with help of sharp knife, pruning knife leaving the stalk 2 cm long. Before havesting, grower may use ethepon

to accelerate the shell degreening and to encourage uniform colour development but reduces the shelf life and this treatment may be done 2-7 days before harvesting the fruit. Spraying @ 5% K_2SO_4 and ethepon 100 mg/l, 4 weeks before harvest increases soluble solids, potassium content, flavour and reduces the harvest period by 1 week (Nanayakkara *et al*, 2005). In Nagaland, fruits are harvested by picker walking between the rows and select the fruit in the field based on size, colour or both and stored in carrying bamboo basket on their back. Harvesting should be done early in the morning to have best keeping quality (http://www.fruitipedia.com/pineapple.htm).

Sorting and Grading: To stimulate the consumers appeal and increase profits of the producer these two steps are most important to increase the shelf life of the produce. Fruit should be free of surface debris and stains. Fruit should have no wounds, sunspot/sunscald, multiple fasciated fruits, scratches, punctures or bruises. It should have no scars or residues from insects or spray chemicals and free of soft rots or surface moulds. The size of the crown and ratio of crown to fruit length should be guided by market requirement**.** In local market grading is done through visual observation based on size and colour of the fruit.

Washing of the fruits*:* After trimming, cutting the stem, sorting and grading, fruits are subjected to clean soft water washing. If fruits are quite dirty, then washing should be done in water containing disinfectant like sodium hypochlorite @ 100-200 ppm to generate chlorine in the water solution. After chlorine disinfection rinsing with clean water is absolutely essential. It is desired that no hard water with heavy minerals/metals or contaminated with chemicals used for washing of the fruit at any stage (www.kau.edu/prsvkm).

Hot water treatments: Black rot of pineapple (*Chalara paradoxa*) is a common postharvest problem in many countries and consumer's resistance to the use of fungicides has precipitated the need for alternative means of controlling the insect pests and diseases. Hot water treatment is essential to kill the mealybug, scale insects, thrips, mites and prevent from storage rots. Pineapples inoculated with 10^4 spores/ml, *C. paradoxa*, followed by a hot water dip treatment at 54 °C for 3 min were free of disease when stored at 10 °C for 21 days followed by 48 h at an ambient temperature (28 ± 2 °C) where as dip-treated fruit stored at 28 ± 2 °C for 6 days also remained healthy (Wijeratnam, *et al*, 2005)..

Fungicidal treatment: Usually 1000 ppm thiobendazole or Bavistin (www.kau.edu/prsvkm) is applied for disinfecting the fruits from pathogens associated at pre-harvest stage with fruits. The fruit should be dipped for 3-5 minutes depending upon the size of the fruit.

Air Drying: Before taking the wax treatment it is essential that fruit should be subjected to air-drying to eliminate the excess of water adhering to the shell of the fruits (www.kau.edu/prsvkm).

Waxing: Pineapples are commercially treated with a fungicide in a dip or spray application to control postharvest fruit rot, caused by the fungus (Robert *et al*, 2003). A food grade wax, usually containing polyethylene/ paraffin or carnauba/paraffin-based, may also be applied to the fruit with the fungicide. The major advantage of waxing is the reduction of the internal browning symptoms of chilling injury and it also reduces postharvest water loss and improves fruit appearance (Paull and Lobo, 2012).

Packaging: Pineapples are packed along with crowns for prolonged shelf life and to avoid infection at the crown attachment point. Two methods are used i.e. Horizontal packing and vertical packing keeping the crown on the topside. The fruit packed in bamboo or wooden boxes is more prone to physical injuries due to sharp edge of bamboo and nails present in wooden boxes. To minimize the physiological weight loss, fruit should be packed in corrugated fiber boxes (Singh, 2009). Pineapples will only fit into boxes in small numbers of around four or six packed vertically or horizontally with a crown of leaves cut to fit snugly into the box (Thompson, 2003).

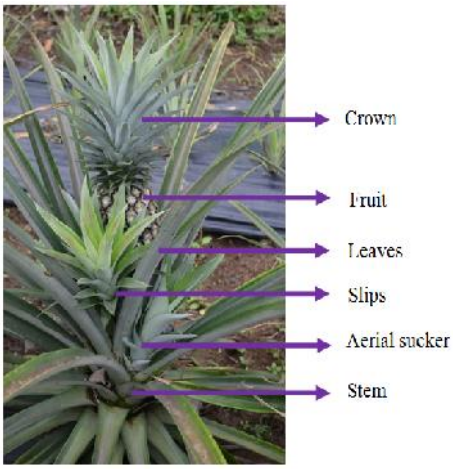

Fig.1 Morphological structure of pineapple plant

Pre-cooling: It is the key component in the preservation of quality for perishable fresh produce in post-harvest systems. Pre-cooling is one of the most important of all the operations used in the maintenance of desirable, fresh and salable produce. It rapidly lowers the temperature of freshly harvested produce and is done immediately following harvest to minimize spoilage. If pineapples are to be exported to the distant market within 2 – 3 days of harvesting, then pre-cooling is advisable. Pineapples are very sensitive to temperature and depending upon mode of transport fruit should be cooled as soon as possible at least within 10 hours of harvest. Pre-cooling temperature for $1/8^{th}$ mature fruit is advised at 13-15°C for 6 to 8 hours (www.kau.edu/prsvkm). It varies and depends on the size of fruits and harvesting time. Among all the pre-cooling method, forced air cooling system is more efficient but this requires a specially designed unit and compatible packaging (http://www.iica.int).

Storage: The most suitable storage temperature for Queen cultivar is 12-14 °C provided that it is harvested at 50–80% yellow and less than 10 °Brix total soluble solid (TSS). Queen pineapples stored at 2 or 4°C developed a white, watery pulp while fruit stored at higher temperatures developed internal browning. Storage at 3 and 8°C for longer than two weeks may cause consumers unacceptability due to bad appearance of crown and shell where as at room temperature of 20°C and 60% R.H. they could be kept for only about 3 days (Thompson, 2003). Refrigerated storage recommendations are as follows:

- 10°C and 90% R.H. for 2–4 weeks for green fruit
- 4.5–7°C and 90% R.H. for 2–4 weeks for ripe fruit
- Under controlled atmosphere storage pineapple can be stored at 7–13°C and 85–90% R.H. with 2–5% O_2 and 5–10% CO_2 for 2–4 weeks.
- Storage of pineapples under hypobaric condition can extend the storage life for up to 30–40 days.

Loss reduction through processing and value added product

Fruits are highly perishable in nature which needs processing to make it durable and processing is any deliberate change in a fruit that occurs before it's available for us to eat. Processing and value addition promotes the shelf life of the product and it could be a use full tool to combat the post harvest loss. The different value added product of pineapple fruits are given below:

Pineapple juice: It is a natural juice extracted from pineapple fruit and unaltered in its composition during preparation and preservation which can be marketed by bottling in to sterilized glass or PET bottles or can (Fig.2). Addition of preservative in glass or PET bottle at a specified level such as Potassium metabisulphite <350ppm or Benzoic acid < 600 ppm per liter can extend the shelf life of the juice about 5-6 months. Pineapple juice blended with carrot juice: orange juice in ratio of 60:10:30 respectively shows the most effective juice blend for minimum change in TSS 10 °Brix to 12 °Brix and acidity 0.97% to 1.83%. (Jan and Masih, 2012)

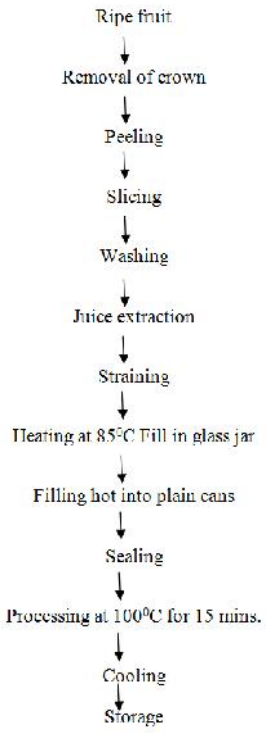

Fig. 2 Flow chart for production of pineapple juice (Source: Singh I S, 2009).

Pineapple squash: The pineapple squash should be prepared from fully matured or ripened fruit, free from sun burn, insect, rodent's infestation and diseases. It is prepared by the addition by the addition of sugar, citric acids and preservatives to freshly extracted fruit juice (Singh, 2009). It is usually diluted 2-3 times with water before consumption. The process flow chart for pineapple squash is shown in fig.3.

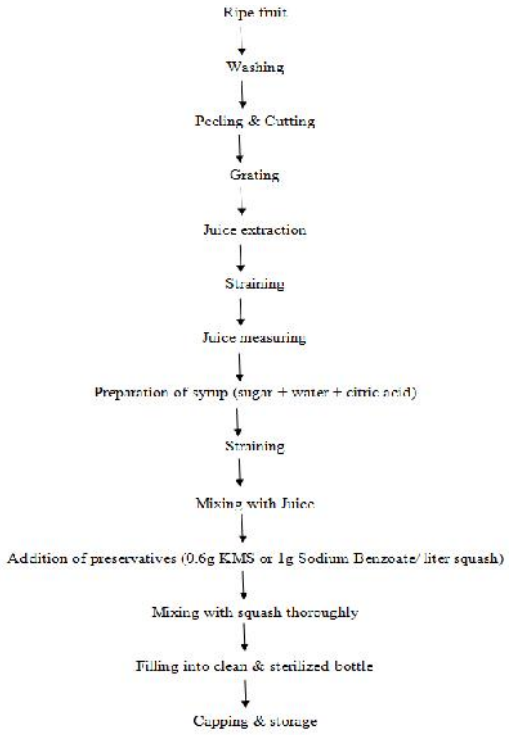

Fig. 3 Flow chart for production of pineapple squash (Source: Singh I S, 2009).

Pineapple RTS beverage: The ready to serve (RTS) beverages are very popular among consumers of all age groups because of its easiness to carry and consume. The RTS should contain at least 10 % fruit juice and 10 °B TSS. It is prepared from the extracted pineapple juice, adjusting its soluble solids and acidity as per FSSAI specifications for RTS beverage by mixing the juice with required quantity of sugar syrup prepared from sugar, citric acid and water (fig.4). To increase the consumer appeal, permitted colour and flavor can be added. The beverage is filled into bottles leaving a head space of 2.5 to 3.0 cm, crown corked and processed in water for 15-20 min. at 85°C and air cooled. It is reported that blended RTS beverages can be manufactured from papaya-pineapple (Sindumathi, and Premalatha, 2013**)** and pineapple-watermelon (Oyeleke *et al*, 2013).

Pineapple Jam: Pineapple jam is prepared by boiling mature pineapple fruit pulp with sufficient quantity of sugar and other ingredients to a reasonably thick consistency, firm enough to hold fruit tissues in position. The selection of fruit is very important and pineapple must be perfectly ripe and unripe or immature fruit contains acids and could affect jam quality. The jam should contain minimum 45% fruit, 65 °B TSS and acidity 0.52 %. Preservatives can be added @ 40 ppm SO_2 or 200 ppm

benzoic acid per kg of final product to extend the shelf life (Fig.5).

Canned pineapple slice: Kew is the suitable variety for canning of pineapple slices. It produced by washing of fruit, peeling and removal of eyes and core. Slicing of the pineapple should be done in the form of ring and pour in syrup and fill into the can with pineapple slice and drain weight must be not less than 50% of the net weight, leaving 1.6 cm or 1 inch headspace. Followed by exhausting and thermal processing (exhausting) of can for few minute to destroy the *Clostridium botulinum* at definite temperature. The shelf life of canned pineapple slice is more than one year. Fig.6 shows a typical pineapple canning process flow chart (Singh, 2009).

Wine: Fruits are highly perishable in nature and have to be either consumed immediately or preserved in different value added products. In developing countries like India, due to the lack of proper post harvest management and utilization of pineapple fruit results in considerable amount of postharvest losses. Such fruit can be exploited for production of wine by setting up of pineapple based wineries in pineapple growing region that could result in the economic upliftment of the people, income generation through employment opportunities and handsome return to orchardist by providing sufficient remuneration (Reddy and Reddy, 2012). The production of pineapple wine would certainly be advantageous in that region where the large amount of fruit gets spoiled through improper post harvest handling. Various research institutions in India like CFTRI, ICAR, DFRL, NIFTEM and other private companies are trying hard to reduce these losses by processing the fruits into drinks and fresh cut fruits for the local market. However, little work is done on processing the fruits into other product such as wine which are currently not available on the Indian market. Wine is an alcoholic beverage, made from a variety of fruit juices by the fermentative action of selected yeast, is adapted to an ageing process handed over from generation to generation (Fig.7). Pineapple wine is prepared from the juice of pineapples and fermentation of the pineapple juice takes place in temperature-controlled vats and is stopped at near-dryness as a result a soft, dry, fruit wine with a strong pineapple flavour is obtained (Idise, and Emmanuel, 2012; http://winemaking.jackkeller.net). Roodagi *et al*, 2012 reported that wine prepared from 30 °Brix ameliorated pineapple juice shows best result during chemical analysis and consumer acceptability.

Loss reduction through waste utilization: India is a heavily populated country and this is the only reason for enormous wastes being produced regularly out of household & industrial activities like peeling and cutting of raw fruit and vegetable waste prior to processing, eating, cooking (Das *et al*, 2013). When fruits and vegetables are consumed for household purposes, waste might mean any rotten or over/under-ripe fruit or vegetable. Waste utilization in fruits and vegetable processing industries is one of the important and challengeable jobs around the world. The full utilization of horticultural produce is a requirement and a demand that needs to be met by countries wishing to implement low-waste technology in their agribusiness. The waste obtained from fruit processing industry is extremely diverse due to the use of wide variety of fruits and vegetables, the broad range of processes and the multiplicity of the product (Rudra *et al*, 2015). In this regard, several efforts have been made in order to utilize pineapple wastes obtained from different sources. The post-harvest processing of pineapple fruits yields skins, crowns, and waste from fresh trimmings and the pomace after extracting the juice. Several studies have been carried out and researchers trying to explore the possibility of using these wastes and attention have been given on the utilization of pineapple waste primarily for extraction of bromelain enzyme and secondarily as low-cost raw material for the production of vinegar, anti-oxidants, fiber and animal feed production.

Pineapple vinegar: Processing of pineapple into vinegar is a way to utilize the over ripe, blemished or surplus fruits, discarded cores and peels. Although not as popular as coconut vinegar, pineapple vinegar is already being exported in small quantities. Pineapple vinegar can be produced by alcohol and acetic acid fermentation (Sossou *et al*, 2009). Pineapple vinegar production flow chart is given in fig.8.

Ferulic acid: Ferulic acid is the most abundant hydroxycinnamic acid found in plant cell walls. This phenolic antioxidant is widely used in the food and cosmetic industry. Pineapple peel has been used for the alkali extraction of ferulic acid (Rudra *et al*, 2015).

Bromelain: It is a proteolytic enzyme which is known as bromelain derived from the stem and juice of pineapples (Gautam *et al*, 2010). It has been extensively used in food industry for meat tenderization, baking processes, prevention of browning of apple juice (Azura *et al*, 2012), chill proofing beer; to increase the solubility of gelatin for drinking and in the leather-tanning process. In modern therapy, bromelain is used as a digestive aids and for its anti-inflammatory action after surgery and to reduce swellings in cases of physical injuries; also in the treatment of chronic diseases like cancer. Bromelain is also used as active ingredient to provide gentle peeling effects in cosmetic industries (Khan and Abourashed, 2010). The fruit which is normally used as food where as the stems are waste by-product and thus, it is a very cheap source for the production of bromelain (Tochi *et al*, 2008). Apart from the stem and fruit, it had also been reported that other parts of the pineapple plant contain bromelain. The bromelain can also be extracted from the peel, core, stem and crown of wastes from two pineapple cultivars (Ketnawa *et al*, 2012). The highest protein contents and proteolytic activity were obtained from the extracts of the crowns while lowest values were recorded from the stem of both cultivars.

Pineapple fiber: Pineapple leaves yield a strong, white in colour, smooth, and glossy as silk, medium length fibre with high tensile strength. It has a softer surface than other natural fibres and it absorbs and maintains a good colour. Some varieties are cultivated especially for the production of fiber and their young fruits are removed to give the plant maximum vitality. The 'Perolera' is a suitable cultivar for extraction of fiber due to its leaves that are long, wide and rigid. The outer, long leaves are preferred. Usually extraction of fiber is done by either manually or mechanically. In the manual process, they are first decorticated by beating and rasping and stripping, and

then left to ret in water to which chemicals like 0.5% urea or diammonium phosphate (DAP) may be added to accelerate the activity of the microorganisms (Asim *et al*, 2015) which digest the unwanted tissue and separate the fibers. The rested material is washed clean, dried in the sun and combed. In mechanical processing, the same machine can be used that extracts the banana fiber from their pseudostem.

Feed for animal: Feed production has become a new industry. The utilization of agro-industrial wastes as animal feed seems to mitigate the difficulties of forage shortage during critical seasons. Several studies have focused on exploiting pineapple wastes as feed for ruminants. The outer peel or skin and core from the pineapple canning industries, called bran, and the leaves are being utilized as feed for ruminants. Cattle preferred fermented pineapple waste with higher acidity to fresh waste and pineapple waste from the field or from the cannery are being used as dairy feed. Dried and ensiled pineapple waste can be used as supplemental roughage and could replace 50% roughage in the total mixed ration for dairy cattle.

CONCLUSION

Pineapple is the third most abundant tropical fruit in the world after banana and citrus. It is highly nutritious food product which has close attention because of its health benefits as well as economic potential for farmers, entrepreneurs and consumers. Pineapple often face storage problem like any other food item because of living entity, physiologically active even after harvest, continuously respiring and therefore degrading the reserve food material and losing moisture due to transpiration, quantitative and qualitative declines and increased susceptibility to spoilage organism. An efficient post harvest system can prolong the shelf life by adopting suitable handling practices at optimum stage of maturity followed by proper harvesting practices, careful handling of harvested produce, avoiding direct exposure to sun beside overloading during transport, sorting and grading, application of post harvest treatment, packing either in bulk bin or stackable containers and transporting by refrigerated truck or rail to the consumer. Reduction of post harvest food losses is a key issue to ensure the future global food security. Hence, post production losses of pineapple can be minimized through various suitable post harvest management, value addition and waste utilization techniques that are currently in practice at global level to increase the shelf life of the produce.

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