ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 17, Issue, 09, pp.34496-34518, September, 2025
DOI: https://doi.org/10.24941/ijcr.49469.09.2025

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

ORIGIN, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY, BREEDING AND CULTIVATION OF PINEAPPLE

***Swamy, K.R.M.**

Retd. Principal Scientist & Head, Division of Vegetable Crops, ICAR-Indian institute of Horticultural Research, Bangalore-560089

ARTICLE INFO

Article History:
Received 20th June, 2025
Received in revised form
24st July, 2025
Accepted 29th August, 2025
Published online 27th September, 2025

Keywords:

Pineappel, Origin, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding

***Corresponding author:**
K.R.M. Swamy

ABSTRACT

Pineapple belongs to the Family Bromeliaceae, Genus Ananas and Species *Ananas comosus* (L.) Merr. Selection of crops to combine with pineapple cultivation can occur in the form of crop rotation or inter row cropping. This practice has been adopted recently in some parts of the world because it permits use of resources more efficiently during the long production cycle of pineapple and in addition reduces the dependency on one crop and spreads income along the cultivation cycle. The pineapple crop also offers protection against heavy rain and winds to the intercropped species. In turn growth of the pineapple crop is healthier due to frequent weeding, fertilizer and pesticide application to the inter row crops. Pineapple cultivation is carried out routinely as a monocrop; as a result the crop is susceptible to many fungal diseases. Recent reports recommend crop rotation in pineapple farms as a means of controlling fungal diseases. The original plant is called the 'plant crop' while the fruit developed from the lateral, axillary branch attached to the axis of the plant crop is called the 'first ratoon'. A healthy root system is necessary to produce successful ratoon crops. Ratoon crops are fertilized, irrigated, forced, ripened and harvested in a way similar to the plant crop. The amount of fertilizer used however is reduced. Ananas comosus belongs to the Bromeliaceae family, which is widely distributed in the Neotropics, Mexico, Brazil, and the Amazons, from Guayanas to northern Argentina, as well as in Africa and Asia. This fruit is consumed fresh and canned, but also in the form of juice, yogurt, ice cream, and jam. Vinegar and refreshing beverages such as garapiña and tepache are produced from its juice. Tepache and garapiña are alcoholic beverages. Garapiña is made from pineapple pulp and peel while tepache is usually made from pineapple peel only, but it can also be made from other fruits such as apple, orange, guava, and tamarind. Both beverages have been consumed since pre-Hispanic times and the etymology of the name is unclear. Some authors report that the name derives from the indigenous Nahuatl language: *'tépiatl'* or *'tepiatzin'* means water or beverage from maize, a variety named *'tépitl'*. Tepache and garapiña have a low alcohol concentration and are consumed principally in Mexico City; however, variants can be found and consumed in the Mexican states of Hidalgo, Puebla, Morelos, San Luis Potosí, Oaxaca, Jalisco, and Nayaritm. The pineapple is a tropical plant with an edible fruit; it is the most economically significant plant in the family Bromeliaceae. The pineapple is indigenous to South America, where it has been cultivated for many centuries. The introduction of the pineapple plant to Europe in the 17th century made it a significant cultural icon of luxury. Since the 1820s, pineapple has been commercially grown in greenhouses and many tropical plantations. Pineapples grow as a small shrub; the individual flowers of the unpollinated plant fuse to form a multiple fruit. The plant normally propagates from the offset produced at the top of the fruit or from a side shoot, and typically matures within a year. Some *Ananas* species are grown as ornamentals for color, novel fruit size, and other aesthetic qualities. Some *Ananas* species are grown as ornamentals for color, novel fruit size, and other aesthetic qualities Some *Ananas* species are grown as ornamentals for color, novel fruit size, and other aesthetic qualities. In the US, in 1986, the Pineapple Research Institute was dissolved and its assets divided between Del Monte and Maui Land and Pineapple. Del Monte took cultivar '73–114', dubbed 'MD-2', to its plantations in Costa Rica, found it to be well-suited to growing there, and launched it publicly in 1996 as 'Gold Extra Sweet', while Del Monte also began marketing '73–50', dubbed 'CO-2', as 'Del Monte Gold'. The Maui Pineapple Company began growing variety 73-50 in 1988 and named it Maui Gold.

Citation: Swamy, K.R.M. 2025. "Origin, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding and Cultivation of Pineapple". *International Journal of Current Research, 17, (09), 34496-34518.*

INTRODUCTION

Pineapple belongs to the Family Bromeliaceae, Genus Ananas and Species *Ananas comosus* (L.) Merr. (Ali *et al*., 2020b ; Wikipedia, 2025). Pineapple is the third most important tropical fruit in the international trade after bananas and citrus; the world pineapple production in 2007 was estimated at 21 008 795 tonnes. About 70% of the total production is consumed domestically, whereas 30% is exported. The most important producing country is Thailand producing 2 815 275 tonnes followed by Brazil (2 676 417), Indonesia (2 237 858), Philippines (2 016 462), Costa Rica (1 968 000), China (1 386 811), India (1 308 000), Nigeria (900 000), Mexico (671 131), Vietnam (470 000), Kenya (429 065), Colombia (342 014), Venezuela (363 075) and Malaysia (360 000) (FAO, 2009). Successful production is influenced by several factors especially low production cost, and availability of manpower and land resources. Costa Rica is the most important exporting country with an export quantity of 1 353 027 tonnes followed by the Philippines (270 054), Ecuador (99 581), Cote D'Ivoire (96 558), USA (89 269) and Panama (61 210). Other exporting countries include Honduras, Guatemala, Brazil, Mexico, Ghana and Malaysia (FAO, 2009). The USA is the largest pineapple importer totalling 696 820 tonnes in 2007, followed by Belgium (292 499), the Netherlands (200 026), Germany (167 416), Japan (165 794), Italy (142 168), United Kingdom (116 730), Spain (113 182) and Canada (102 064). The European Union is the largest export market for pineapple (FAO, 2009) (Hassan *et al*., 2011a). For a very long time, the world production and marketing of pineapple has been dominated by the Smooth Cayenne both for fresh and processing. However, in 1996 the world's pineapple fresh fruit industry went through a transformation when the Del Monte Corporation introduced hybrid 'MD-2' for the United States and European markets (Bartholomew, 2009). 'MD-2', produced from a cross between the PRI hybrids 58–1184 and 59–443 , is now grown by many companies and growers in the world and believed to be the most important pineapple cultivar for the fresh market. It is being exported to many countries including the United States, Europe, United Kingdom, Japan, Korea, Hong Kong, China, Singapore and the Middle East (Hassan *et al.,* 2011a). Pineapple production – 2022 (Millions of tonnes) Indonesia 3.2, Philippines 2.9, Costa Rica 2.9, Brazil 2.3, China 2.0, Thailand 1.7 and World 29.4 (Wikipedia, 2025). In 2022, world production of pineapples was 29 million tonnes, led by Indonesia, the Philippines, and Costa Rica, each producing about 3 million tonnesm (Wikipedia, 2025). The area under pineapple cultivation in India increased by 35% from 57 thousand ha. in 1991-92 to 77 thousand ha. in 2001-02 whereas the production increased by 54% from 8 lakh tonnes to 12 lakh tonnes. The states where pineapple is grown include Assam, Meghalaya, Tripura, Manipur, West Bengal, Kerala, Karnataka and Goa. The other states where it is grown on a small scale are Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, Orissa, Bihar and Uttar Pradesh (NHB, 2025). The fruit is a good source of vitamin A,B,C and also calcium, magnesium, potassium and iron. It is also a good source of bromelin, a digestive enzyme. It is consumed fresh or in the form of juice, jam, squash and syrup. Among all forms, canned slices and juice are in much demand in India, constituting about 70% of the production (NHB, 2025).

The state-wise growing belts are given in the following (NHB, 2025)

State	Growing belts
Karnataka	Shimoga, North & South Kannada, Chickmagalore, Kodagu
Kerala	Ernakulum, Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha, Kottayam, Idukki, Thrissur, Palakkad, Malappuram, Kozhikode, Wynadu, Kannur, Kasargodu
Nagaland	Kohima, Zunheboto
Assam	Nagaon, Kamrup, Karbi Anglong, N.C. Hills, Goalpara, Dhemaji, Sonitpur Dhubri
Manipur	Thoubal, Churchandpur, Imphal East
Meghalaya	Ri Bhoi, East Khasi, Garo Hills
West Bengal	Jalpaiguri, Siliguri sub-division of Darjeeling district, North Dinajpur, Cooch Behar

The pineapple (*Ananas comosus* (L.) Merr.), botanically a member of the ornamental Bromeliaceae family, originated in tropical South America but is now widely grown in all tropical and subtropical areas of the world (Smith, 2003). In Spanish-speaking countries the fruit is known as pina; in Portuguese-speaking countries as abacaxi; as ananas in Dutch- and French-speaking former colonies, and as nanas in southern Asia (Smith, 2003). More than 4.5 × 10 t, both fresh and canned, is marketed worldwide each year from at least nine major countries with the major cultivar by far being the large juicy-fruited smooth-leafed cultivar Smooth Cayenne (Smith, 2003). Wild pineapple varieties still grow in the tropical savanna of South America but most have small, seedy, fibrous fruits (Smith, 2003). Selection of crops to combine with pineapple cultivation can occur in the form of crop rotation or inter row cropping. This practice has been adopted recently in some parts of the world because it permits use of resources more efficiently during the long production cycle of pineapple and in addition reduces the dependency on one crop and spreads income along the cultivation cycle. The pineapple crop also offers protection against heavy rain and winds to the intercropped species. In turn growth of the pineapple crop is healthier due to frequent weeding, fertilizer and pesticide application to the inter row crops (CA, 2008). Pineapple cultivation is carried out routinely as a monocrop; as a result the crop is susceptible to many fungal diseases. Recent reports recommend crop rotation in pineapple farms as a means of controlling fungal diseases. Crop rotation using legumes like *Canavalia* spp. has decreased the incidence of root disease on pineapple in Mexico. However in Australia, crop rotation is not a common practice. After a crop is harvested the remaining plant material is slashed and ploughed and the field remains fallow for a period of time until new vegetative propagales are planted. Inter row cropping in pineapple plantations is gaining importance and popularity; in Queensland oats are intercropped with pineapple. This is mainly due to the beneficial effects of chemicals released from oats, which provide protection to the pineapple roots against fungal pathogens (CA, 2008). Ratooning is an agricultural practice of harvesting a second or additional crop from an original pineapple plant. Generally in Australia, the plant and one ratoon crop are harvested after approximately 3-4 years. The original plant is called the 'plant crop' while the fruit developed from the lateral, axillary branch attached to the axis of the plant crop is called the 'first ratoon'. A healthy root system is necessary to produce successful ratoon crops. Ratoon crops are fertilized, irrigated, forced, ripened and harvested in a way similar to the plant crop. The amount of fertilizer used however is reduced. In Queensland pineapple farmers avoid the use of ratoon crops to minimise carryover diseases and prefer to plant new vegetative propagules (CA, 2008). Ananas, commonly known as pineapple, is grown in large numbers throughout the tropics (Arora *et al*., 2013). In addition to its dietary use, it also possesses medicinal values. Bromelain, an extract of pineapple stem, has been reported to possess anti-inflammatory property (Arora *et al*., 2013). It is a general name for a family of sulfhydryl proteolytic enzymes obtained from *Ananas comosus*, the pineapple plant (Arora *et al*., 2013). Active components of bromelain are peroxidase, acid phosphatase, and several protease inhibitors. Studies have shown that bromelain was effective in reducing swelling and pain in nearly 72% of RA patients, thereby indicating its clinical utility (Arora *et al.,* 2013). There had been considerable confusion as to the identity and number of proteolytically active components in crude pineapple stem extract. A late-eluting protein fraction of stem extract was further purified and shown to contain two distinct enzymes. One of these was ananain while the other was termed comosain**,** the name being derived from *Ananas comosus.* Comosain may well be one of the glycine esterases (Rowan, 2013). *Ananas comosus* (L.) Merr (Bromeliaceae), known as pineapple, is a herbaceous, biennial, tropical plant that grows up to 1.0–1.5 m high and produces a fleshy, edible fruit whose flesh ranges from nearly white to yellow (Toyin *et al*., 2014). The juice contained tannins, cardenolides, dienolides, cardiac glycoside, and flavonoids (Toyin *et al*., 2014). The number and weights of live fetuses, number of implantation sites, corpora lutea, computed percent implantation index, resorption index, pre- and

postimplantation losses were not significantly (p>0.05) altered in comparison to the control (Toyin *et al.*, 2014). Neither fetal death nor provoked vaginal bleeding was observed in the pregnant rats. The maternal weight increased in all the experimental animals with that of the control augmenting least (Toyin *et al.,* 2014). The 250 and 500 mg/kg body weight increased (p<0.05) the serum concentrations of progesterone and estrogen in the pregnant rats (Toyin *et al*., 2014). The fruit juice of *A. comosus* did not exhibit abortifacient activity in pregnant Wistar rats but may be beneficial to reproduction as it may enhance the growth and development of the foetuses (Toyin *et al.,* 2014). Pineapple (Ananas comosus Merr.), native to South America, is a highly marketable tropical fruit in the Bromeliaceae family consisting of numerous fruitlets fused on a same inflorescence (Wongs-Aree *et al.,* 2014). The communication of fruitlet connection through the fruit core is crucial for fruit development and quality. Pineapple is a non-climacteric fruit as it does not ripen significantly postharvest (Wongs-Aree *et al.,* 2014). Since the pineapple fruit develops from the fusion of fruitlets, those fruitlets near the stem end mature earlier than those at the stylar zone, leading to uneven ripening of the whole fruit. When the stylar zone pulp ripens, the stem zone pulp is overripe (Wongs-Aree *et al.,* 2014). Pineapple, Ananas *comosus* L., is a monocotyledon, belonging to the large genus *Ananas* of the family Bromeliaceae, which includes many ornamental plants (Wijeratnam, 2016). It is an exotic fruit with origins from South America. It is mentioned in the chronicles of Pedro Martyr d'Anghiera in 1530 as being found in a tiny Indian village on the island of Guadeloupe during the second voyage of Christopher Columbus in 1493 (Wijeratnam, 2016). The name pineapple is thought to have originated because of the fruit's resemblance to a pine cone. The pineapple plant is a drought-tolerant herbaceous perennial plant, with a rosette of waxy leaves and a short stem (Wijeratnam, 2016). The pineapple fruit is a compound fruit that develops through the fusion of many individual fruitlets. These small fleshy fruitlets are fused together around the fibrous central stem referred to as the core. Each fruitlet develops from a hermaphrodite flower, which is self-sterile although it has both male and female parts (Wijeratnam, 2016). Self-sterility is advantageous in terms of fruit quality and palatability. Each fruit is borne on a peduncle, which is an extension of the stem of the pineapple plant (Wijeratnam, 2016). Fruits can vary in size. The flesh of the fruit is juicy, has an exotic sweet flavor, and can be pale cream to yellow in color. The top of the fruit is known as the crown. It is an extension of the apical meristem and can be used as planting material (Wijeratnam, 2016).

Into the 1600s, the pineapple remained so uncommon and coveted a commodity that King Charles II of England posed for an official portrait in an act then symbolic of royal privilege—receiving a pineapple as a gift (Wijeratnam, 2016b). As pineapple greenhouse cultivation expanded during the eighteenth and nineteenth centuries, many varieties were imported, mostly from the Antilles. Afterward, two of the most important varieties, 'Smooth Cayenne' and 'Queen', were taken from Europe to all of the tropical and subtropical regions (Wijeratnam, 2016b). Pineapple is now widely cultivated in tropical and subtropical areas, being the fourth most cultivated tropical fruit crop and the third commercial tropical fruit in the world. It is grown mainly for fresh and for canned fruit and juice (Wijeratnam, 2016b). It is the only source of bromelain, which is commonly used in pharmaceuticals. The total world production in 2012 was 23 million tons from 996,000 ha. The total world exported fresh and canned pineapple in 2011 were 3.15 and 1.23 million tons with exported values 172.7 and 130.7 million US dollars (FAOSTAT, 2014). Costa Rica, mainly operated by Del Monte Company, dominated the world fresh market. Thailand and the Philippines had been the largest producers and exporters of canned fruit and juice for several decades. Other main production areas include Brazil, China, Indonesia, and India (Wijeratnam, 2016b). The commercial production is mainly an intensive-based monoculture. Health and environmental risks are becoming a major concern for consumers. Consequently, pineapple producers, including large multinational companies, adopt more environmentally friendly practices and ensure good management practices with a series of certification systems adapted to agricultural production (ISO 14001, global GAP, Organic, HACCP, CO_2 footprint) (Wijeratnam, 2016b).

Pineapple (Ananas comosus (L.) Merr.), with excellent quality, special flavor, and nutritional richness, is favored by consumers worldwide (Sun *et al.,* 2016). It is the third most commercial important tropical fruit (Sun *et al*., 2016). Pineapple nutrient composition, soluble sugar, and organic acid contents in 18 traditional pineapple cultivars and 16 modern pineapple cultivars, dietary fibers contents in 12 pineapple cultivars, vitamin A, vitamin C, vitamin B_3, vitamin B_6, and vitamin B_{12} contents in 11 pineapple cultivars were analyzed. Aroma compounds and their odor activity for six pineapple cultivars were identified. Phenolics and flavonoid concentrations of 11 pineapple cultivars and the antioxidant capacity of 12 pineapple cultivars were also compared (Sun *et al.,* 2016). 'MD-2', an outstanding cultivar that dominates the world market for fresh pineapple, 'Smooth Cayenne', the most widely cultivated cultivar around the world, and 'Comte de Paris', the most important cultivar in China, were included (Sun *et al*., 2016). Pineapple (Ananas *comosus* (L.) Merr.), with excellent quality, special flavor, and nutritional richness, is favored by consumers worldwide (Sun *et al.,* 2016). It is the third most commercial important tropical fruit. In this chapter, in addition to reviewing pineapple nutrient composition, soluble sugar, and organic acid contents in 18 traditional pineapple cultivars and 16 modern pineapple cultivars, dietary fibers contents in 12 pineapple cultivars, vitamin A, vitamin C, vitamin B_3, vitamin B_6, and vitamin B_{12} contents in 11 pineapple cultivars were analyzed. Aroma compounds and their odor activity for six pineapple cultivars were identified. Phenolics and flavonoid concentrations of 11 pineapple cultivars and the antioxidant capacity of 12 pineapple cultivars were also compared (Sun *et al.,* 2016). 'MD-2', an outstanding cultivar that dominates the world market for fresh pineapple, 'Smooth Cayenne', the most widely cultivated cultivar around the world, and 'Comte de Paris', the most important cultivar in China, were included (Sun *et al.,* 2016).

Pineapple is native to Uruguay, Brazil, and Paraguay of South America, a tropical perennial herb with multiple fruit (TFN, 2016). It is the only common food plant in the Bromeliaceae (TFN, 2016). It is cultivated commercially in the tropics and parts of the subtropics of the world, with Hawaii producing one-third of the world's crop (TFN, 2016). Pineapple from *A. comosus* var. *ananassoides* was domesticated by the Tupi-Guarani Indians and accompanied them in their northward migrations to the Antilles, northern Andes and central America before the arrival of the Spanish (TFN, 2016). Unlike other edible plants from the new world, the pineapple discovered by Europeans in 1493 was quickly accepted by the Europeans (TFN, 2016). Following the discovery of pineapple, it was soon to be found in various foreign countries either by accident or by intent to introduce the species to a new land and is now grown in various parts of the world, including Australia (TFN, 2016). Spaniards introduced the pineapple into the Philippines and may have taken it to Hawaii and Guam early in the 16th Century (TFN, 2016). Portuguese traders are said to have taken seeds to India from the Moluccas in 1548, and they also introduced the pineapple to the east and west coasts of Africa. The plant was growing in China in 1594 and inSouth Africa about 1655. It reached Europe in 1650 and fruits were being produced in Holland in 1686 (TFN, 2016). Pineapple (*Ananas comosus* (L.) Merr.) is one of the most popular tropical and subtropical fruits (Kazeem and Davies, 2016). It is majorly taken as food while some parts of it are used in traditional medicine as antidiarrhoeal, antitussive and antitumour agent (Kazeem and Davies, 2016). The effect of ethanolic extracts of *A. comosus* leaves on insulin sensitivity in rats and HepG2 cells. These researchers found that administration of 0.4 g/kg ethanol extract of *A. comosus* to streptozotocin-induced diabetic rats caused significant decrease in the blood glucose level following treatment with insulin and tolbutamide (Kazeem and Davies, 2016). *A. comosus* treated diabetic rats also displayed more rapid decrease in blood glucose following insulin infusion than untreated diabetic controls, indicating enhancement of sensitivity to exogenous insulin. They also observed that pre-treatment of HepG2 cells with 10^{-5} and 10^{-6} g/kg extract of *A. comosus* and insulin significantly increased the consumption of extracellular glucose while decreasing intracellular glycogen (Kazeem and Davies, 2016). It was

therefore concluded that *A. comosus* could improve insulin sensitivity in type 2 diabetes model of rats. However, there is a need for bioassay guided isolation of the active components of this plant so that its nutraceutical effect can be maximized (Kazeem and Davies, 2016).

The botanical name of pineapple is *Ananas comosus*. It is considered an herbaceous, tropical, and monocot perennial plant. The size of the plant ranges from approximately 1–2 m tall and wide (Wali, 2019). Its leaves are spiral in arrangement and on the terminal ends has flowers which then produce edible fruit. The stem at its center is about 25–50 cm long (Wali, 2019). A mature pineapple plant has about 60–80 leaves, each being sword shaped. After bananas and citrus fruits, pineapple is the third most produced fruit in the world (Wali, 2019). Pineapple (*Ananas comosus*) is a tropical fruit that is highly relished for its unique aroma and sweet taste. It is renowned as a flavourful fruit since it contains a number of volatile compounds in small amounts and complex mixtures. Pineapple is also a rich source of minerals and vitamins that offer a number of health benefits. Ranked third behind banana and citrus, the demand for pineapple has greatly increased within the international market (Ali *et al.,* 2020). The growth of the pineapple industry in the utilisation of pineapple food-based processing products as well as waste processing has progressed rapidly worldwide (Ali *et al*., 2020). Pineapple contains considerable amounts of bioactive compounds, dietary fiber, minerals, and nutrients. In addition, pineapple has been proven to have various health benefits including anti-inflammatory, antioxidant activity, monitoring nervous system function, and healing bowel movement (Ali *et al.,* 2020). The principle amino acids in pineapple are tyrosine and tryptophan (Wen and Wrolstad, 2006). Other amino acids include asparagine, proline, aspartic acid, serine, glutamic acid, α-alanine, aminobutyric acid, tyrosine, valine and isoleucine. Amino acids and sugar content play an important role in the development of maillard reaction in the products (non-enzymatic browning) mainly during storage and processing. The organic acid content of pineapple also adds to the taste and flavour of pineapple products. Volatile organic acids found in pineapple fruit are citric, malic, quinic acids, etc. but citric acid remains as the chief organic acid. The increase in acidity is directly related to the increased concentration of citric acid in pineapple (Assumi *et at*., 2021). Titratable acidity (TA) in pineapple is a product of the total non-volatile acids that occur as free organic acids in the vacuoles. Total soluble solids (TSS) indicate the content of soluble sugars with a contribution from the fruit acids. The ratio of TSS/TA is considered to be the most dependable parameter index for evaluating pineapple fruit quality. High quality pineapple fruit have TSS/TA ratio from 20 to 40 (Assumi *et al.,* 2021).

Ananas comosus belongs to the Bromeliaceae family, which is widely distributed in the Neotropics, Mexico, Brazil, and the Amazons, from Guayanas to northern Argentina, as well as in Africa and Asia (Robledo-Márquez *et al.,* 2021). This fruit is consumed fresh and canned, but also in the form of juice, yogurt, ice cream, and jam (Robledo-Márquez *et al.,* 2021). Vinegar and refreshing beverages such as garapiña and tepache are produced from its juice. Tepache and garapiña are alcoholic beverages. Garapiña is made from pineapple pulp and peel while tepache is usually made from pineapple peel only, but it can also be made from other fruits such as apple, orange, guava, and tamarind (Robledo-Márquez *et al.,* 2021). Both beverages have been consumed since pre-Hispanic times and the etymology of the name is unclear. Some authors report that the name derives from the indigenous Nahuatl language: *'tépiatl'* or *'tepiatzin'* means water or beverage from maize, a variety named '*tépitl'* (Robledo-Márquez *et al.,* 2021). Tepache and garapiña have a low alcohol concentration and are consumed principally in Mexico City; however, variants can be found and consumed in the Mexican states of Hidalgo, Puebla, Morelos, San Luis Potosí, Oaxaca, Jalisco, and Nayaritm (Robledo-Márquez *et al.,* 2021). To be successful in pineapple cropping, the farmer has to be serious and fully committed to the crop, since this crop requires a continuous and intensive care over the entire cropping period (Kyle Stice**,** 2021**).** This cropping period with pineapple is generally quite longer than other root crops or vegetables; a pineapple plant crop can take up to 24 months to come into production while vegetables such as cabbage or tomato take only 1-3 months (Kyle Stic**e,** 2021**).** Pineapple being a slow developing plant is easily over grown by weeds and can be completely destroyed or, if not too long over grown and cleaned at least loses a number of month's growth time as well as producing lower yields (Kyle Stice**,** 2021**).** Continual weed control in pineapple cropping is an absolute necessity; chemical spray control as well as hand weeding several times per year. Total crop failure is expected if the fields are neglected for a number of months (Kyle Stice**,** 2021). Furthermore the farmer is required to have patience, since a pineapple crop takes 1 to 2 years before yielding a marketable harvest (Kyle Stice, 2021). The pineapple is a tropical and subtropical fruit grown in many countries in Africa (Kyle Stice**,** 2021**).** In Uganda it is mainly grown south of Lake Kyoga and western Uganda. Ii is a tradable crop and generates reasonable income (Kyle Stice**,** 2021**).** It is used as a fruit as well as for producing juice. It is also used for making jam (Kyle Stice**,** 2021**).** In addition it contains a protein digesting enzyme bromelain. Therefore it can be used as a meat tenderizer (Kyle Stice**,** 2021**).** Leaves are used for making ropes and coarse cloth. Waste products from the juice canning industry are used as animal feed (Kyle Stice**,** 2021**).** The pineapple (Latin: *Ananas comosus*) is a tropical plant with an edible fruit indigenous to South America, where it has been cultivated for many centuries (WWW, 2024). The introduction of the pineapple to Europe in the 17th-century made it a significant cultural icon of luxury. Since the 1820s, pineapple has been commercially grown in greenhouses and many tropical plantations (WWW, 2024). The wild plant is native to southern Brazil and Paraguay, especially the Paraná-Paraguay River area where wild relatives occur (WWW, 2024). Little is known about its domestication, but it spread as a crop throughout South America. Archaeological evidence of cultivation/use has been found dating to 1200 - 800 BC in Peru and 200 BC - AD 700 in Mexico, where it was cultivated by the Mayas and the Aztecs (WWW, 2024). By the late 1400s, cropped pineapple was widely distributed and a stable component of the diet of Meso- Americans (WWW, 2024). Pineapple (Ananas comosus) is a common fruit consumed in many diets. Adverse events attributable to pineapple include IgE-mediated systemic reactions as well as non-immune mediated reactions. Anaphylactoid reactions to pineapple have also been reported (Lan and Makhija, 2024). After consumption of pineapple these patients have anaphylactic shock-like presentations that require treatment with IM epinephrine but subsequently are not found to have detectable pineapple sIgE (Lan and Makhija, 2024). dditionally, pineapple contains a profilin allergen, Ana c 1, which has been associated with OAS/PFAS (Lan and Makhija, 2024). Bromelain is a proteolytic papain-like protease that naturally occurs in pineapple. Bromelain is also found as an ingredient in some cosmetics, pharmaceutical products, and meat tenderizers (Lan and Makhija, 2024). Consumption of fresh pineapple containing high amounts of bromelain may cause localized irritation (burning, soreness, pain, etc) because of the acidity of the fruit and/or proteolytic-induced injury of the mucosa attributable to bromelain (Lan and Makhija, 2024). Bromelain has also been associated with systemic allergic reactions, mostly after occupational exposures such as in pharmaceutical workers. Treatment strategies for localized irritation attributable to bromelain in pineapple include avoidance of the fruit, reduction in the amount of fruit consumed, or co-ingestion with dairy or salty foods to minimize symptoms (Lan and Makhija, 2024). Pineapple, also called *Ananas comosus*, is one of the tropical fruits (Ticomachinem, 2025). It is the most significant and economically plant in the Bromeliaceae family (Ticomachinem, 2025). Nowadays, pineapple is easy to be found in any grocery store, supermarket or fruit store (Ticomachinem, 2025). People like to eat pineapple because of its sweet taste (Ticomachinem, 2025). All over the world, there are more than 70 varieties of pineapple (Ticomachinem, 2025). Pineapples can be consumed fresh, cooked, juiced, or preserved. They are found in a wide array of cuisines (Ticomachinem, 2025). Pineapple is multiple types of fruit which develops form many small fruitlets fused together around central core. Each year, there are three times fruiting periods, but the best taste is pineapple which is ripe between June and August (Ticomachinem, 2025). Generally, pineapple is a short, stout stem with a needle-tipped rosette of waxy long leaves (Ticomachinem, 2025). Skin of outside is rough, tough and scaly rind. When eating pineapple, the outer skin must be cut down. And each pineapple measures up to 12 inches in length and weighs 1 to 8 pounds or more (Ticomachinem, 2025). Pineapple (*Ananas comosus*) is a tropical fruit known for its sweet and tangy flavor, spiky exterior, and juicy, fibrous

flesh. It is a good source of vitamins A, B, and C, as well as minerals like calcium, magnesium, potassium, and iron. Pineapples also contain bromelain, a digestive enzyme with anti-inflammatory properties. **:** Pineapples have a tough, scaly outer skin with "eyes" and a sweet, juicy, yellowish flesh (AI, 2025). They offer a combination of sweetness and tanginess (AI, 2025). Rich in vitamins, minerals, and bromelain (AI, 2025). Pineapple is enjoyed in various forms, including fresh, in fruit salads, desserts, juices, and as a savory ingredient in chutneys, pickles, and grilled dishes (AI, 2025). May aid digestion, reduce inflammation, and potentially lower the risk of certain diseases (AI, 2025). Pineapples were once rare and expensive, with only the wealthy able to afford them (AI, 2025). They are native to South America and have been cultivated for centuries (AI, 2025). The name "pineapple" comes from their resemblance to pine cones. Different varieties exist, including the 'Kew' and 'Queen' varieties grown in India. Pineapple is a commercially important fruit crop globally, with India being a major producer (AI, 2025).

ORIGIN AND DISTRIBUTION

It is likely that modern pineapple originated in pre-Columbian times in South America; a mutation for seedlessness and selection for large fruit size, increased sweetness and juiciness and improved flavour occurred over time. Chronicles of European explorers have described and mentioned pineapple domestication in parts of South America and in the Caribbean. Pineapples were already a part of the diet of the Native Americans before the arrival of Columbus (CA, 2008). Modern pineapples could have originated in the Parana-Paraguay river drainage area because of the occurrence of seeded relatives in the wild. Following the discovery of pineapple in South America, it was soon dispersed into other regions of the world by travellers and seafarers. Pineapple was introduced into the Philippines, Hawaii and Guam during the early 16th Century by the Spaniards, and reached India and the east and west coasts of Africa by 1548. In 1594, pineapple plants were reported growing in China and by 1655 in South Africa. Pineapple plants were reported in Europe in 1650 and pineapple fruits were being produced in Holland in 1686. It was not until 1719 that pineapple plants were successfully established in England in greenhouses (CA, 2008). In 1777, Captain James Cook planted pineapples on the Society Islands, Friendly Islands and elsewhere in the South Pacific. However, it was not until 1885 that the first sizeable plantation of 2 ha was established in Oahu. In 1838, Lutheran missionaries imported pineapple plants from India into Brisbane, Australia. Pineapple was grown on a small scale and in a scattered manner for some time and the fruit was sold locally in Queensland. In Australia, the commercial pineapple industry was established in 1924 and a canning plant was established at Rockhampton and Cairns in 1946. Later cultivation areas increased in size to cater to the fresh market and canning industry. Post war pineapple production increased and replaced some sugarcane cultivation areas in Queensland. The successful dispersion of pineapple on a world-wide basis can be attributed to its ability to tolerate drought and the relative ease with which vegetative propagules can establish under cultivated conditions. Pineapple is currently grown commercially over a wide range of latitudes from approximately 30ºN to 30ºS (CA, 2008). Pineapple (Ananas comosus L. Merr.) is believed to be originated from South America, in the region encompassing central and southern Brazil, northern Argentina and Paraguay. The fruit had already been domesticated by the native South Americans before the arrival of Christopher Columbus in 1493 (Hassan *et al.,* 2011). Currently, pineapples are grown commercially over a wide range of latitudes from approximately 30° N in the northern hemisphere to 33°58'S in the south. The word 'pineapple' was used by the European explorers to describe the fruit, which resembles pinecones. 'Ananas', the original name of the fruit, comes from the Tupi word for pine 'nanas', and *comosus* means 'tufted' referring to the stem of the fruit (Hassan *et al.,* 2011). Pineapple is believed to be indigenous to Southern Brazil and Paraguay (perhaps especially the Parana-Paraguay River) areas where its wild relatives occur. Pineapple is a native American plant first seen by Columbus and his shipmates when they landed on the island of Guadeloupe on November 4, 1493. He named it 'piña', due to its resemblance to a pine cone (Assumi *et al*., 2021). The pineapple is a tropical crop that originated from South America. It was first introduced to Europe and Asia by the Spaniards and Portuguese in the 16th and 17th centuries. In Europe, the pineapple gained the status of a luxury, premium dessert fruit, and was seen as a symbol of cordiality in high society (Annalisa, 2025). Pineapple is native to South America, Brazil, Paraguayan and the Amazon. In the sixteenth century pineapple was introduced into China from Brazil and is popular in South of China, as Guangdong, Guangxi, Fujian and Taiwan etc. Now, pineapples are cultivated almost all the tropical and subtropical zones (Ticomachinem, 2025). Pineapple is believed to have originated in southern Brazil and Paraguay, where wild relatives still thrive in abundance. The Tupi-Guarani Indians domesticated the plant and introduced it to South and Central America, Mexico, and the West Indies long before the arrival of Europeans (Agropedia, 2025). Cultivation of pineapple originated in Brazil and gradually spread to other tropical parts of the world. Pineapple cultivation was introduced to India by Portuguese in 1548 AD (NHB, 2025). Explorers and settlers, captivated by the fruit's allure, played a significant role in its widespread distribution across different regions. By the 15th century, Christopher Columbus encountered pineapples during his voyages to the Americas, sparking interest among Europeans. The Spaniards later introduced the fruit to the Philippines and Hawaii in the early 16th century, while the Portuguese traders are credited with bringing it to India from the Molucca Islands in 1548. By the mid-17th century, pineapples had reached China, South Africa, and even Europe, where successful cultivation began in 1712. Today, major pineapple-producing regions include Hawaii, Brazil, Malaysia, Taiwan, Australia, the Philippines, South Africa, Singapore, Puerto Rico, India, Java, Thailand, and Sumatra. In several countries, pineapple has become the leading commercial fruit crop, highlighting its global popularity and economic significance (Agropedia, 2025).

TAXONOMY

A. comosus is the most economically important plant in the family Bromeliaceae, which is divided into three subfamilies: Pitcarnioideae, Tillandsioideae and Bromelioideae. A. comosus belongs to the subfamily Bromelioideae, order Bromeliales, genus Ananas and species comosus. The family Bromeliaceae consists of approximately 2794 species and 56 genera that have adapted to a wide range of habitats ranging from terrestrial to epiphytic, shady to full sun and from hot humid tropics to cold dry subtropics. They can grow in moist to extremely dry situations and at varying altitudes from sea level to alpine conditions. Members of this family are characterised by a short stem, narrow stiff leaves arranged in a circular cluster, terminal inflorescences (racemes or panicles), hermaphroditic and actinomorphic trimerous flowers. Fruits are capsules or berries that contain small naked, winged or plumose seeds, with a reduced endosperm and a small embryo. The subfamily Bromelioideae, is the most diverse and consists of the largest number of genera but the lowest number of species. Most members are epiphytes characterised by a rosette like form, with spiny leaves and berry-like fruit containing wet seeds (CA, 2008). The genus *Ananas* is recognised among Bromeliaceae by the characteristic inflorescence, which is fused into a syncarp, a unique dense rosette of scape-wide leaves and medium to large fruits. Pineapple plants are set apart from other monocots by the characteristic star-shaped, scale-like multicellular hairs and unusual coiling stigmas, which fold together lengthwise. Cultivated pineapple was first described and named at the end of the 17th century by Charles Plumier on the island of Hispaniola part of Antilles (West Indies). In 1892 Mez recognized in the Flora Brasiliensis only one species *A. sativus* and five botanical varieties. Pineapple taxonomy underwent further modification several times and it was not until 2003 that the classification developed was internationally adopted (CA, 2008). Based on similarity in floral structure, biology and chromosome number (2n=50), the current classification identifies six botanical varieties of *A. comosus* that intercross successfully with *A. comosus* var. *comosus* to produce fertile offsprings. The six varieties of *A. comosus* include the former species given below:

• A. comosus var. ananassoides (formerly two species: A. ananassoides and A. nanus).
• A. comosus var. bracteatus (formerly two species: A. bracteatus and A. fritzmuelleri).
• A. comosus var. comosus (formerly A. comosus)
• A. comosus var. erectifolius (formerly A. lucidus (formely A. erectifolius)
• A. comosus var. parguazensis (formerly A. parguazensis)
• A. macrodontes (formerly Pseudananas sagenarius) (CA, 2008).

Ananas monstrous has been invalidated because the crownless fruit characteristic is not stable. Generally, varieties of pineapple are distributed throughout the tropics and seed production is rare because most varieties of *A. comosus* possess reduced fertility combined with self-incompatibility (CA, 2008).There are approximately 30 cultivars of *A. comosus* that are grown commercially in tropical and sub tropical countries around the world. However, for convenience in global trade, the numerous pineapple cultivars are grouped in four main classes: 'Smooth Cayenne', 'Red Spanish', 'Queen' and 'Pernambuco' (Abacaxi), despite much variation in the types within each class. The fifth group or class comprising of 'Motilona' or 'Perolera' is commercially important in South America. In Australia the most dominant cultivar used in commercial plantations for canning purposes is Smooth Cayenne followed by Queen (CA, 2008). Molecular markers are useful in establishing taxonomic relationships. F1 based genetic maps of DNA markers for *A. comosus* var. *comosus* and *A. comosus* var. *bracteatus* have been published. The map of var. *comosus* consists of 156 markers assembled in 30 linkage groups and covers over 31.6% of the genome; a dominant allele at locus P responsible for morphological traits 'piping', a silvery streak and the absence of spines along the margin of the upper leaf has been included in the latest map. The map of var. bracteatus gathers 335 DNA markers in 50 linkage groups and covers 57.2% of the genome length. Work is underway to complete the integrated genetic maps of these two varieties (CA, 2008).

Ananas comosus is one of the most popular tropical fruits and a leading edible member of the family Bromeliaceae which embraces about 2,000 species, mostly epiphytic and many strikingly ornamental. It is the most important economic plant of the Bromeliaceae family. From the first statement of the pineapple by European explorers to the present time, pineapple taxonomy has varied considerably. The first botanical description of cultivated pineapple was given by Charles Plumier at the end of the 17th century when he created the genus Bromelia for the plants called karatas and also described Ananas as *Ananas aculeatus fructuovato*, *Carne albida*. Linnaeus in 1753 in his Species Plantarum designated the pineapple as Bromelia ananas and *Bromelia comosa*. In the early 18th and 19th century, pineapple classification brings about in a number of different names. Merrill established the binomial *Ananas comosus* in 1917. In 1919, Hassler separated the genus Ananas into two divisions Euananas and Pseudananas. In 1930, Harms raised Pseudananas to genus. During 1934, L. B. Smith and F. Camargo again divided the genus Ananas and multiplied into different species. This produced two different genera and nine species recognized in 1979. This classification was evaluated on the basis of practicality and inconsistency with available data on reproductive performance and morphological, biochemical and molecular characterization. The present classifycation is on the basis of new data on reproduction, morphological, biochemical and molecular diversity (Assumi *et al*., 2021). The pineapple comprises five botanical varieties, formerly regarded as separate species. The genomes of three varieties, including the wild progenitor variety *bracteatus*, have been sequenced (Wikipedia, 2025).

Synonyms: Ananas ananas, Bromelia ananas, Bromelia comosa (Tabish, 2025).

BOTANICAL DESCRIPTION

Ananas comosus, or the pineapple plant, is a perennial, herbaceous monocot that grows to 1-2 meters tall. It has a short, stocky stem with tough, waxy leaves arranged in a spiral rosette. Each leaf is sword-shaped, fibrous, and has spiny margins. The plant produces a terminal inflorescence with numerous small, sessile flowers. The fruit is a multiple fruit formed from the fusion of these individual berry-like fruits on a thickened axis, resulting in a fleshy, cylindrical fruit with a hard rind and a crown of leaves. An herbaceous, perennial monocot, typically growing to 1-2 meters tall and wide.

Stem: A short, stocky central stem.

Leaves: A rosette of numerous, tough, and waxy sword-shaped leaves arranged spirally around the stem.

Leaf Characteristics: Each leaf is fibrous, grooved on the upper surface, and has spiny margins and a sharp, pungent apex.

Roots: Aerial roots develop from the stem base, some of which are specialized and penetrate the epidermis.

Inflorescence: A compact head of many sessile flowers, which form on a central spike that elongates into the peduncle after flower formation.

Flowers: The flowers are small, numerous (up to 200), and each is subtended by a pointed, colored bract.

Fruit: A "multiple fruit" or *coenocarpium*, formed by the fusion of individual berry-like fruits and the thickened, fleshy axis of the inflorescence.

Rind: The fruit's rind is formed by the persistent sepals and floral bracts, which fuse together.

Crown: The fruit is topped by a crown of short, stiff, spirally arranged leaves.

Flesh: The fruit's flesh is typically pale to golden yellow and is usually seedless in cultivated varieties.

Shoots/Suckers: Slips and suckers are shoots that grow on the stem and can be used for propagation. (AI, 2025).

The pineapple is a herbaceous perennial, which grows to 1 to 1.5 m tall on average, although sometimes it can be taller. The plant has a short, stocky stem with tough, waxy leaves. When creating its fruit, it usually produces up to 200 flowers, although some large-fruited cultivars can exceed this. Once it flowers, the individual fruits of the flowers join together to create a multiple fruit. After the first fruit is produced, side shoots (called 'suckers' by commercial growers) are produced in the leaf axils of the main stem. These suckers may be removed for propagation, or left to produce additional fruits on the original plant. Commercially, suckers that appear around the base are cultivated. It has 30 or more

narrow, fleshy, trough-shaped leaves that are 30 to 100 cm long, surrounding a thick stem; the leaves have sharp spines along the margins. In the first year of growth, the axis lengthens and thickens, bearing numerous leaves in close spirals. After 12 to 20 months, the stem grows into a spike-like inflorescence up to 15 cm long with over 100 spirally arranged, trimerous flowers, each subtended by a bract. The ovaries develop into berries, which coalesce into a large, compact, multiple fruit. The fruit of a pineapple is usually arranged in two interlocking helices, often with 8 in one direction and 13 in the other, each being a Fibonacci number (Wikipedia, 2025). The pineapple is a tropical plant and fruit, native to Uruguay, Brazil, Puerto Rico, or Paraguay. It is a medium tall (1–1.5 m) herbaceous perennial plant with 30 or more trough-shaped and pointed leaves 30–100 cm long, surrounding a thick stem. The pineapple is an example of a multiple fruit: multiple, spirally-arranged flowers along the axis each produce a fleshy fruit that becomes pressed against the fruits of adjacent flowers, forming what appears to be a single fleshy fruit. Pineapples are the only bromeliad fruit in widespread cultivation. In India, Pineapple is most popular in Kerala and North-East India (Tabish, 2025). The plant has 30 to 40 stiff succulent leaves closely spaced in a rosette on a thick fleshy stem. In commercial varieties about 15 to 20 months after planting, a determinate inflorescence forms on a flower stalk 100–150 mm (4–6 inches) in length. The originally separate light purple flowers, together with their bracts, each attached to a central axis core, become fleshy and fuse to form the pineapple fruit, which ripens five to six months after flowering begins. Botanically, a pineapple is considered a multiple fruit. Fruits of commercial varieties range from 1 to 2 kg (2 to 4 pounds) in weight (EEB, 2025)

.

The pineapple is a herbaceous perennial, which grows to 1.0 to tall, although sometimes it can be taller. The plant has a short, stocky stem with tough, waxy leaves. When creating its fruit, it usually produces up to 200 flowers, although some large-fruited cultivars can exceed this. Once it flowers, the individual fruits of the flowers join together to create a multiple fruit. After the first fruit is produced, side shoots (called 'suckers' by commercial growers) are produced in the leaf axils of the main stem. These suckers may be removed for propagation, or left to produce additional fruits on the original plant. Commercially, suckers that appear around the base are cultivated. It has 30 or more narrow, fleshy, trough-shaped leaves that are 30 to long, surrounding a thick stem; the leaves have sharp spines along the margins. In the first year of growth, the axis lengthens and thickens, bearing numerous leaves in close spirals. After 12 to 20 months, the stem grows into a spike-like inflorescence up to 15 cm long with over 100 spirally arranged, trimerous flowers, each subtended by a bract. The ovaries develop into berries, which coalesce into a large, compact, multiple fruit. The fruit of a pineapple is usually arranged in two interlocking helices, often with 8 in one direction and 13 in the other, each being a Fibonacci number. Pollination In the wild, pineapples are pollinated primarily by hummingbirds. Certain wild pineapples are foraged and pollinated at night by bats. Under cultivation, because seed development diminishes fruit quality, pollination is performed by hand, and seeds are retained only for breeding. In Hawaii, where pineapples were cultivated and canned industrially throughout the 20th century, importation of hummingbirds was prohibited (EW, 2025) (Fig. 1 & 2).

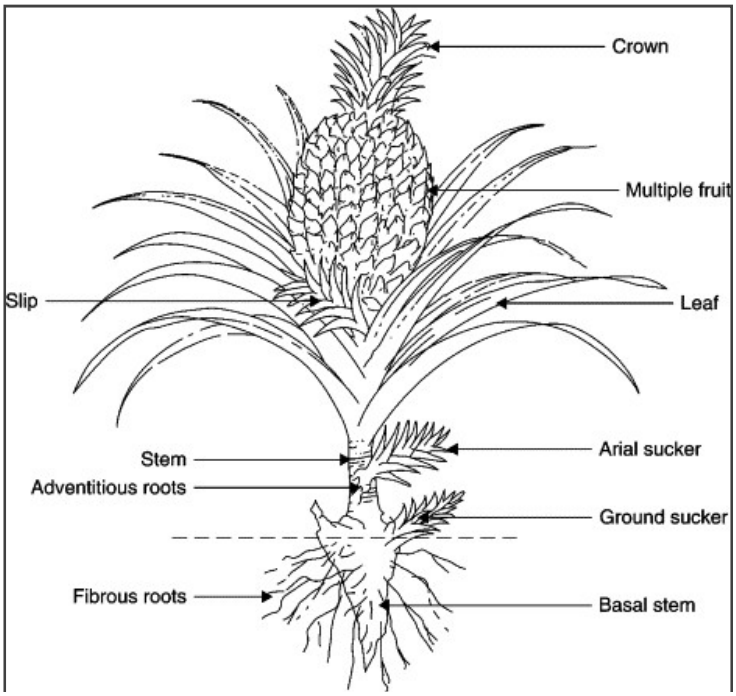


Fig. 1. Morphological structure of pineapple

GENETICS AND CYTOGENETICS

The pineapple taxonomy was recently revised and simplified. According to this new classification *A. comosus* is subdivided in five botanical varieties: var. *comosus*, var. *ananassoides*, var. *erectifolius*, var. *parguazensis* and var. *bracteatus*, which include the former (Smith and Downs, 1979) diploid species. *A. comosus* var. *comosus* is the domesticated form with largest fruits and the most widely cultivated and commercialized pineapple. *A. comosus* var. *bracteatus* is cultivated as living fences and for fiber production, and used in traditional medicine (de Sousa *et al.,* 2013).

Domestication of clonally propagated crops such as pineapple from South America was hypothesized to be a ‘one-step operation’. We sequenced the genome of *Ananas comosus* var. *bracteatus* CB5 and assembled 513 Mb into 25 chromosomes with 29,412 genes. We identified 25 selective sweeps, including a strong sweep containing a pair of tandemly duplicated bromelain inhibitors. Four candidate genes for self-incompatibility were linked in F153, but were not functional in self-compatible CB5. Our findings support the coexistence of sexual recombination and a one-step operation in the domestication of clonally propagated crops. This work guides the exploration of sexual and asexual domestication trajectories in other clonally propagated crops (Li-Yu Chenm *et al.,* 2019).

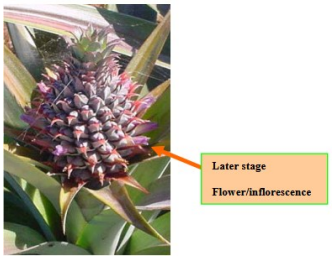
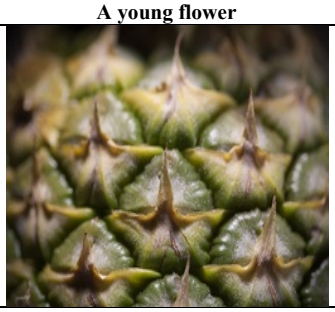
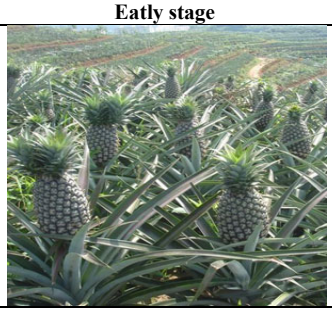
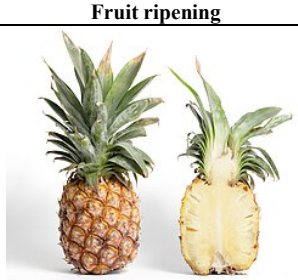
		
Pineapple fields	Youg Plants	Foliage
		
Inflorescence	Flowering	Inflorescence
		
A young flower	Eatly stage	Late stage
		
Rind	Field	Fruit ripening
		
Fruit	Farm workers on a pineapple farm	Fruit, whole and in longitudinal section
		
A hollowed-out pineapple with its core left intact	Cut Fruit	In a greenhouse

Fig. 2: Botanical Description

One explanation for this may be that the center of origin and diversity of this genus is located in the isolated regions of the upper Amazonian River basin. The chromosome number of *Ananas comosus* is n = 25; while it is normally diploid, some triploid and tetraploid types have been identified. Commercial cultivars have an essentially parthenocarpic fruit that is botanically a syncarp consisting of more than 100 almost completely fused individual fruitlets (Moore *et al.,* 2025). The cytogenetics of *Ananas comosus* (pineapple) shows it is a diploid plant with 2n=50 chromosomes. Its genome is characterized by a relatively large proportion of repetitive elements, including abundant DNA transposons and LTR retrotransposons. Due to high heterozygosity and self-incompatibility, pineapple is primarily propagated clonally rather than by seeds (**.** Pineapple was domesticated over 6 thousand years ago and distributed to Mesoamerica over 2,500 years ago. Cultivated pineapple is a clonally propagated, self-incompatible diploid (2n=2x=50) with CAM photosynthesis (AI, 2025a).

GENETIC DIVERSITY

Inter simple sequence repeat (ISSR) and simple sequence repeat (SSR) markers were used to assess the genetic diversity of 36 pineapple accessions that were introduced from 10 countries/regions. Thirteen ISSR primers amplified 96 bands, of which 91 (93.65%) were polymorphic, whereas 20 SSR primers amplified 73 bands, of which 70 (96.50%) were polymorphic. Nei's gene diversity (h = 0.28), Shannon's information index (I = 0.43), and polymorphism information content (PIC = 0.29) generated using the SSR primers were higher than that with ISSR primers (h = 0.23, I = 0.37, PIC = 0.24), thereby suggesting that the SSR system is more efficient than the ISSR system in assessing genetic diversity in various pineapple accessions. Mean genetic similarities were 0.74, 0.61, and 0.69, as determined using ISSR, SSR, and combined ISSR/SSR, respectively. These results suggest that the genetic diversity among pineapple accessions is very high. We clustered the 36 pineapple accessions into three or five groups on the basis of the phylogenetic trees constructed based on the results of ISSR, SSR, and combined ISSR/SSR analyses using the unweighted pair-group with arithmetic averaging (UPGMA) method. The results of principal components analysis (PCA) also supported the UPGMA clustering. These results will be useful not only for the scientific conservation and management of pineapple germplasm but also for the improvement of the current pineapple breeding strategies (Wang *et al.,* 2017).

Pineapple [*Ananas comosus* (L.) Merr.] is an important fruit crop cultivated in Tanzania. However, the knowledge on genetic diversity of the pineapple cultivars grown in Tanzania is limited. This study was aimed at determining the genetic diversity and identity of pineapple cultivars from different growing regions in Tanzania using microsatellite markers also known as simple sequence repeat marker (SSR). Ten of the 18 microsatellite markers were polymorphic and generated a total of 22 distinct reproducible bands with an average of 2.2 bands per primer pair. The number of polymorphic bands detected with each primer pair ranged from 1 to 3 with an average of 1.5 per primer pair. The polymorphic information content (PIC) values of each primer pair ranged from 0.17 to 0.79 with an average of 0.41. Two microsatellite loci TsuAC010 and TsuAC039 revealed PIC values higher than 0.50 thus suggesting that such primers have high discriminatory ability. The consensus tree derived from the unweighted pair-group method with arithmetic means (UPGMA) revealed four different groups. Kinole-SCT sub-population formed a distinct group from Madeke-SCT and MD2 hybrid cultivar. Kinole-SC, Mukuranga-SC, and Kiwangwa-SCcultivars were closely related on the cluster analysis. This study demonstrated the existence of low genetic diversity in pineapples cultivated in Tanzania implying that a well-thought-out breeding strategies should be employed for genetic improvements of pineapple. Introduction of exotic clones and employment of modern breeding strategies such as marker assisted selection (MAS) and genetic engineering technologies is recommended. This will widen the current genetic pool of pineapple in Tanzania (Makaranga *et al.,* 2018).

Assessments of genetic diversity have been claimed to be significantly efficient in utilising and managing resources of genetic for breeding programme. In this study, variations in genetic were observed in 65 pineapple accessions gathered from germplasm available at Malaysian Agriculture Research and Development Institute (MARDI) located in Pontian, Johor via 15 markers of simple sequence repeat (SSR). The results showed that 59 alleles appeared to range from 2.0 to 6.0 alleles with a mean of 3.9 alleles per locus, thus displaying polymorphism for all samples at a moderate level. Furthermore, the values of polymorphic information content (PIC) had been found to range between 0.104 (TsuAC035) and 0.697 (Acom_9.9), thus averaging at the value of 0.433. In addition, the expected and the observed heterozygosity of each locus seemed to vary within the ranges of 0.033 to 0.712, and from 0.033 to 0.885, along with the average values of 0.437 and 0.511, respectively. The population structure analysis via method of delta K (ΔK), along with mean of L (K) method, revealed that individuals from the germplasm could be divided into two major clusters based on genetics (K = 2), namely Group 1 and Group 2. As such, five accessions (Yankee, SRK Chalok, SCK Giant India, SC KEW5 India and SC1 Thailand) were clustered in Group 1, while the rest were clustered in Group 2. These outcomes were also supported by the dendrogram, which had been generated through the technique of unweighted pair group with arithmetic mean (UPGMA). These analyses appear to be helpful amongst breeders to maintain and to manage their collections of germplasm. Besides, the data gathered in this study can be useful for breeders to exploit the area of genetic diversity in estimating the level of heterosis (Ismail *et al.*, 2020).

BREEDING

Propagation: Two cultivars of A. comosus are grown commercially in Australia: a spiny leaved small fruit type ‘Queen’ and smooth-leaved medium fruit type ‘Cayenne’. In Queensland, clonal selection began in 1950 when 100 plants were selected from commercial fields. Four clones of Smooth Cayenne (C8, C10, C13 and C30) along with Hawaiian clone ‘Champaka F180’ were eventually released into the industry in 1975. Other clones selected by private growers and established include ‘Ripley Queen’, ‘Alexander’ and McGregor’ obtained from the cultivar ‘Queen’. After 20 years of breeding and testing, the Queensland Department of Primary Industries released a dual purpose cultivar named the ‘Queensland Cayenne’ in 1975. Other cultivars bred for the fresh fruit market include Mareeba Sweet, Mareeba Gold, Golden circle premium gold and Bethonga Gold which characteristically have low acid levels and true pineapple taste (QMPI&F 2007). ‘Aus-Jubilee’ is a new variety of pineapple (at its first stage of commercialisation) selected for its high sugar, vitamin C content (twice that of Smooth Cayenne), aromatic flavour, firm flesh and colour (CA, 2008).

Basic requirements: Pineapple is a tropical plant and grows best in temperatures between 23–32°C (73.4–89.6°F). The plant can tolerate colder temperatures for short periods but will be killed by frosts. Pineapple will grow optimally in well-draining sandy loam which is rich in organic matter. The optimum pH for pineapple growth is between 4.5–6.5. Established pineapple plants are tolerant of drought but will not tolerate waterlogged soil which quickly leads to root rot.

Propagation: Pineapple is propagated from crowns, slips or suckers, with slips or suckers being the preferred method for commercial growers. Pineapple suckers arise from leaf axils, while slips grow from the stalk below the fruit. These are cut from the parent plant and used to produce new plantings. The cuttings are usually cured for a day or two prior to planting by sitting them in the shade. Pineapple plantings are normally set

out in double rows with the material staggered 25–30 cm (10–12 in) apart within the double row and allowing a further 60 cm (2 ft) between double rows (Apsnet, 2025).

Propagation, Suitability of Different Planting Materials and Planting: Pineapple is propagated vegetatively through suckers, slips, crowns and discs. Plants grown from suckers produce fruits in 15– 18 months, plants grown from slips, and discs take 20– 22 months while plants grown from crowns take longest time of 24-26 months after planting. Suckers and slips are cured by stripping off the lower leaves followed by drying in the sun or in partial shade for about a week before planting. This curing is done to avoid rotting of plants after they are planted. There is large variation in size and weight of suckers and slips. Researches conducted at various research institutes and SAUs have shown that suckers weighing around 500g and slips weighing 350g are the best planting materials. Variation in size of planting materials can be usefully utilized for staggering the harvest period and making fruits available throughout the year. In this way by combining different sizes of planting materials, their planting time and induction of flowering, commitments of supplying fruit to the canneries or exports can be met easily (DMS, 2025).

Pineapple is commercially propagated through vegetative means. Its propagules are crowns (fruit top), shoots borne at the base of fruit (slips) and shoots borne at any position on stem (suckers). Genetic variation exists among clones and cultivars for the production of slips per plant. For 'Smooth Cayenne', plants having five or fewer slips had no effect on the slip numbers of their progeny. Slip and sucker production tends to be more productive in the warm climate of subtropical areas whereas slips are seldom produced and sucker development is delayed in tropical regions. Suckers weighing around 500 g are the leading source of propagules for 'MD-2' and 'Smooth Cayenne' in the tropics since these cultivars produce few or no slips in warm environments. 'Queen' clones can produce numerous slips in any environment so planting material is easy and inexpensively harvested. Production per plant of both propagules declines as planting density increases, although slip number decreases more rapidly than suckers. Crowns have the utmost number of root initials and usually root more rapidly than slips and suckers. Irrespective of the type of propagules, larger propagules have greater leaf area with extra storage reserves and reach the target weight for forcing more quickly than smaller ones. Low weight of propagules, poor nutrition, dry and cold environment all delay plant establishment and lengthens the time necessary for a plant to reach the target forcing weight (Assumi *et al.,* 2021). A plant having high numbers of slips or suckers, along with those that produce a fruit with more than two crowns should be rogued because the high resource demand can reduce average fruit yield. The presence of two or three crowns on a fruit is usually due to the result of high temperature injury during early in occorescence development. Planting material can be treated with a fungicide or 'air-cured' by drying the butt end, or both, before planting to prevent rots. Slips can be induced arti□cially by treating plants with morphactin chlorofeurenol (Assumi *et al.,* 2021). Planting material can also be created by gouging and dividing of stem and also through meristem culture. Somaclonal variation arising during production can produce off-types which should be rogued out (Assumi *et al.,* 2021).

Vegetative Growth: Soon after planting when conditions of growth like sunlight, temperature, nutrients and water are available, root initiation begins followed by the formation of new leaves. Theoretically, roots of Smooth Cayenne can reach a length of 1.8m and grow to a depth of 85cm (Sideris and Krauss 1934). Root growth decreases after flower induction and maximum root mass is achieved at anthesis. Growth continues in the root, stem and leaf meristem. Smooth Cayenne exhibits strong apical dominance. Stem weight gradually and progressively increases from the time of planting. Plants accumulate starch reserves in the stem and the amount of starch varies with plant age, size and environment. Climatic conditions determine active growth of the plant. Leaf length, mass and numbers differ depending upon the propagules (sucker, crown etc) used to produce the plant. Leaves grow from the base and attain maximum length several months after initiation. Under equatorial conditions the pineapple plant takes approximately 4 months to attain full growth (temperature of approximately 30 ºC) (Sideris and Krauss 1936). The maximum length and width of an individual leaf is approximately 100cm and 7cm, respectively. Leaves constitute nearly 90% of the plant fresh weight (CA, 2008).

Crop Improvement: Pineapple is largely vegetatively propagated. Sexual reproduction is rare in nature because pineapple is self sterile; seeds if produced by self fertilization germinate slowly with low vigour and young seedlings are fragile due to inbreeding depression. However, since pineapple is heterozygous, hybridisation is possible between *A. comosus* var. *comosus* and other varieties as mentioned in Section 1. Hybrids are valuable material in pineapple breeding and breeders can generate a wide variety of genotypes. Many important fruit characteristics such as high ascorbic acid and carotene content, low acidity, increase in total soluble solids, size increase and high translucency were obtained by clonal selection. Small scale hybridization programs aimed at clonal selection of Smooth Cayenne were also carried out during 1970s in Australia. Conventional breeding has disadvantages due largely to the domination of a single variety Smooth Cayenne in the markets and the low level of molecular diversity between varieties of *A. comosus*. This has resulted in poor success in varietal improvements. In addition, hybridization programs are resource intensive; an estimated 15 years is required to produce hybrid varieties (CA, 2008).

Crop improvement in pineapple aims to incorporate desirable fruit characteristics such as high mean weight, uniform ripening, high sugar and ascorbic acid content, pleasant flavor, and cylindrical shape with attractive color, shallow eyes, less fiber, firm and sweet flesh, and a small to medium crown. Additionally, plant vigor, disease resistance, and reduced leaf spines are also targeted. Clonal selection is a common practice in pineapple improvement, with examples like 'Queensland Cayenne' (a dual-purpose cultivar selected from Smooth Cayenne), 'Cumanesa' (a selection from Red Spanish), and 'Alexandra' (a selection from Ripley Queen). Hybridization is another approach to improvement, although it is time-consuming due to the plant's self-sterility and the need for careful seed germination and evaluation. Notable hybrids include 'P.R. 1-67' and 'P.R. 1-56' from the University of Puerto Rico, 'Typhone No.1' and 'Typhone No.3' from Taiwan, 'Josapine' from the Malaysian Agricultural Research and Development Institute (MARDI), and 'Amritha' from the Kerala Agricultural University in India . Biotechnological interventions, such as biolistic techniques and somaclonal variation, have also been explored to produce transgenic Smooth Cayenne plants and evaluate genetic diversity among accessions (Agropedia, 2025).

Normally, pineapple flowers after the attainment of vegetative growth and ripeness-to-flower stage after 11 to 12 months of planting and formation of at least 40 leaves. A pineapple plant can produce only one fruit during its life time and it is often seen that even after 15 to 18 months of growth under optimal nutritional and environmental conditions, only 50 to 60 percent plants comes to flowering. Hence, for induction of flowering besides the use of optimal nitrogen and potash fertilizers, use of growth regulators is required. Forcing of plants helps to synchronize fruit harvest, reduce harvesting costs, excites uniform sucker development required for a good ratoon crop and also makes possible to predict harvest dates. Plants are forced to flower when they have reached a suffcient size and a physical maturity to bear a fruit that can accomplish the desired market size. The induction of flowering with auxin was first reported in 1939 (Assumi *et al*., 2021).

Reproduction

Asexual reproduction by vegetative propagation is the predominant form of reproduction. The different vegetative parts of the pineapple plant.

- **Slips**: leafy branches attached below the fruit on the peduncle, grouped near the base of the fruit; sometimes produced from basal eye of the fruit.
- **Collars**: these structures are commonly preferred; may produce fruit within 14-16 months after planting
- **Ground suckers (ratoon**): shoots produced from the stem just above the ground; will produce fruit in 12-14 months after planting
- **Side shoots or suckers/stem shoots**: shoots produced from the above ground portion of the stem; will produce fruit in 18-20 months after planting
- **Crown**: the short stem and leaves growing from the apex of the fruit; not commonly used; may take up to 24 months after planting to produce fruit (CA, 2008).

In Queensland, tops and slips from the summer crop of Smooth Cayenne are stored upside down, close together, in semi-shade for planting during autumn. Some farmers use crowns from the best fruits to obtain high quality planting material. Some plants may lack a crown or may produce multiple crowns. Crownlets can also grow at the base of the main crown or from some of the upper fruitlets (CA, 2008).

The time taken from planting to harvest depends on the type of planting material used and is 15 to18 months for shoots, approximately 20 months for slips and 22-24 months for crowns. Crowns produce more uniform crops when compared to shoots. Large planting material produces large plants, earlier fruiting and higher yields. The average rate of production of propagules in Cayenne is approximately two per year. When planting material is limited, cutting the dormant axillary bud at the axil of the leaf on the stem induces the formation of new plants (CA, 2008).

Fruit/Seed Development and Seed Dispersal: The pineapple blossom develops parthenocarpically into a large fruit formed by the complete fusion of 100-200 berry-like fruitlets. The edible part of the fruit consists mainly of the ovaries, the bases of sepals and bracts, and the cortex of the axis. The fruit shell is primarily composed of sepal and bract tissues and the apices of the ovaries. As individual fruits develop from the flowers they fuse together forming a cone-shaped compound, juicy, fleshy fruit approximately 30cm or more in length, with the stem serving as the fibrous but fairly succulent core. The tough, waxy/glossy rind, made up of hexagonal units or eyes become flattened and the colour of the fruit changes from dark-green to yellow or orange-yellow or reddish when the fruit ripens (CA, 2008). Colour development usually starts from the base and moves toward the top of the fruit. The flesh of the fruit ranges from white to yellow depending on the stage of maturity. Biochemical changes such as accumulation of sugars and carotenoids occurs mainly in the last week of fruit maturation. Generally, pineapple fruits take a long time from flowering to maturity; in south-east Queensland it normally takes at least 5 months. It is difficult to judge when the pineapple is ready to be harvested as size and colour are not reliable indicators. In general, for the fresh fruit market, the summer crop is harvested when the eye shows a light pale green colour. The winter crop on the other hand matures slowly and the fruits are picked when there is a slight yellowing around the base. The winter fruit tends to be more acidic and has a lower sugar level when compared to summer fruit. Fruits for canning can be harvested at a latter stage of maturity. Overripe fruits lack flavour and are highly perishable (CA, 2008). Depending on whether the flowers have been pollinated or not, small hard seeds or traces of undeveloped seeds may be present. Fruits are not normally dispersed and in commercial plantations seeds are not produced. Seeds are desired only in breeding programs and are usually the result of hand pollination. Seeds when produced naturally or by artificial pollination remain within the fruit and do not get dispersed naturally. Such seeds are ready for harvest 5-6 months after cross pollination. They are usually obtained by slitting the fruit in longitudinal sections and removing the fruit flesh around the carpel cavities and then washing and drying them. Under natural conditions since the fruit develops parthenocarpically, undeveloped, whitish transparent seeds may be present. Seeds are small, approximately 3-5x1-2mm in size with a rough and tough brown testa, hard and firm endosperm and a tiny embryo (CA, 2008).

Seed Dormancy and Germination: Pineapple seeds exhibit significant dormancy due to an impermeable seed coat. They are usually treated with a fungicide and concentrated sulphuric acid to reduce seed dormancy and improve the uniformity of germination. This process is called chemical scarification. Untreated seeds can take up to 10 days to initiate germination. Temperatures from 24ºC to 35ºC are used to germinate seeds. Under artificial conditions a seed germination rate of 80-90% can be achieved. Longevity of hybrid seeds has been estimated to be less than six months in storage in Cote d'Ivoire (Loison-Cabot 1990). However, seeds can be stored for up to 2 years when placed in sealed plastic bags with silica gel at 4-5ºC (CA, 2008). After 3 months of growth at the 6-8 leaf stage the seedlings are transferred to nurseries. Seedlings are transferred from the nursery to the field when 15-18 months old and require 16-30 months to reach the mature fruiting stage; in comparison vegetatively propagated plants fruit within 15-22 months. Given that seeds are produced rarely in the fruit with no natural means of dispersal, there is only a remote chance of seed persistence in the environment during commercial cultivation (CA, 2008).

Cultivation: Optimum temperature for pineapple growth is between 22-32°C. Leaf growth is best at 32°C and root growth at 29°C. Growth ceases below 20°C and above 36°C. Pineapple requires a minimum annual rainfall of 76 cm, with optimal precipitation ranging from 100-150 cm. However, excessive rainfall can be detrimental, as the crop is shallow-rooted and susceptible to waterlogging. Good drainage is essential, especially in areas with heavy rainfall or impervious subsoil. Prefers well-drained, sandy loam soils with a pH range of 4.5 to 6.5. High organic matter content is beneficial. Choose sites with good air drainage to reduce the risk of frost damage and waterlogged conditions (Agropedia, 2025). Suitable for areas without soil erosion issues. Ensures proper irrigation and drainage. Used in low-lying lands for better drainage. Involves planting in lines on raised beds. Appropriate for regions with moderate rainfall. Involves planting in double lines within furrows. Common in India, involves planting in trenches to provide good anchorage and prevent lodging. Used to prevent soil erosion on slopes. Involves planting along contour lines to catch runoff and serve as drainage channels. Pineapple plants remove significant amounts of soil nutrients, necessitating regular fertilization. For instance, 1 tonne of pineapple requires 1.8 kg of nitrogen, 0.5 kg of phosphorus, and 6.3 kg of potassium. Varies by region, with general recommendations available. For instance, Brazil recommends 120 kg N, 60 kg P2O5, and 120 kg K2O per hectare (Agropedia, 2025). Applied as basal dressing during field preparation. Nitrogen should be given in six split doses starting from the second month after planting. Potash is given in two splits. Zinc, manganese, iron, and boron are crucial. Deficiencies are corrected through foliar sprays. Essential during early growth stages. Can be managed manually or using herbicides like diuron and bromacil. Organic mulching can also be effective in reducing weed growth. Includes paddy straw, pineapple trash, paper, bagasse, sawdust, and polythene sheets. Commonly used in countries like Hawaii, Australia, and Taiwan. Mulching is less common in India due to high-density planting reducing weed growth. Involves pushing soil to the base of plants to increase anchorage and prevent lodging. Essential in regions with heavy rains or during fruit development

periods. Regular irrigation is necessary, especially during dry periods. Efficient drainage systems are equally important to prevent waterlogging (Agropedia, 2025).

Intraspecific Crossing

There are a number of factors that limit intraspecific crossing in pineapple including:

• pineapples are not naturalised in Australia
• the main pollinator of pineapple (hummingbirds) is absent in Australia
• pollen is short lived and not wind dispersed
• inbuilt self incompatibility mechanism
• only one variety of pineapple dominates in commercial cultivation in Australia

Given that pineapples are not naturalised in Australia and are an introduced crop, intraspecific gene transfer relates only to commercially and domestically grown pineapple varieties and cultivars/clones. In this context it is important to note that approximately 70% of commercial cultivation of pineapple in the world and approximately 94% in Australia comprises of the clones of the cultivar Smooth Cayenne (CA, 2008). In the pineapple growing areas of Queensland occasional pollinators like honeybees (*Apis mellifera*), pineapple beetles, native bees (*Trigona* spp.) and ants play a minor role in pollination when compared to Hummingbirds in Hawaii and therefore do not pose a major problem. Pollen grains are sticky, heavy, not wind dispersed and remains viable for very short periods of time. Therefore even if pollinators carried pollen, it would be transported only over short distances and would become non-viable quickly. It is the practice in commercial cultivations to plant one cultivar (monoculture) to avoid cross pollination/gene transfer and the remote chance of seed production. In Australia only one cultivar of one variety is almost exclusively cultivated. The related varieties (refer Section 1 for details of varieties) of Ananas are not present in agricultural ecosystems. Therefore intraspecific gene transfer can potentially only occur within this variety/cultivar and its clones. However even within a single plantation the cultivars and clones of A. comosus are naturally self incompatible forming fruits parthenocarpically without seeds (CA, 2008). The cultivars and varieties of *A. comosus* are sexually compatible and can potentially outcross to produce seeds artificially under breeding conditions. Therefore hybridization between other Ananas spp. including varieties, cultivars and clones can be achieved artificially. Although A. comosus var. comosus exhibits low levels of fertility the crosses exhibit high fertility due to crosses with other varieties. Hand pollinated crosses between A. comosus var. comosus (diploid, 2n=50) and *A. macrodontes* (tetraploid, 4n=100) produced 5-10% fertile seeds (the remainder having mostly flat empty seed coats), most of which were tetraploids that grew vigorously to be fully fertile, while the triploids were sometimes self sterile (CA, 2008).

Genetic Modification: A range of useful traits viz improved fruit quality, flowering control, pathogen resistance and herbicide tolerance are being developed using genetic techniques. Attempts have been made by scientists in Australia to inactivate the Polyphenol Oxidase (PPO) gene to reduce or eliminate discolouration (black heart) of the pineapple fruits. The inactivation is expected to reduce or eliminate the discoloration of the fruit pulp. Fields trials of this GMO have been successfully conducted in Queensland in which the PPO gene expression was reduced. Sripaoraya and co workers have successfully transformed the 'Phuket' cultivar of pineapple by introducing the herbicide (bialophos) tolerance bar gene that are tolerant to commercial herbicide basta and could potentially reduce residual herbicides in the plant and environment (CA, 2008). Flowering control to achieve synchronous natural flowering is another important aim pursued by the Hawaiian Pineapple Genetic Engineering Consortium in collaboration with Queensland Department of Primary Industries. They have successfully transformed pineapple by down regulating the 1-aminocyclopropane-1-carboxylate (ACC) synthase gene or over expressing the ACACS2 in pineapple to achieve suppression due to methylation of the same endogenous gene. ACC synthase is a key enzyme responsible for the biosynthesis of ethylene (which can cause early flowering). Preliminary results of field trials conducted in Queensland indicate a low incidence of natural flowering in the both types of GM pineapple (CA, 2008). *Nematode types like root knot* and reniform and mealby wilt virus are significant pathogens of pineapple. The ban on use of nematicides such as methyl bromide has encouraged scientists to develop transgenic nematode resistant pineapple. Bakhetia's group at the University of Leeds have successfully developed nematode resistant pineapple plants using anti-feeding defence strategy. Two Ampeloviruses, Pineapple mealybug wilt associated virus-1 & 2 (PMWaV1 & 2) have been identified in pineapples grown in Hawaii. The coat protein gene PMWaV-2 was introduced into pineapple as an inverted repeat; glass house testing of such modified pineapple produced five putative transgenic lines resistance to the virus (CA, 2008). Neither *A. comosus* var. *comosus* nor any variety of *A. comosus* nor any species of *Ananas* are naturalised in Australia. In addition wild varieties of pineapple are not present in Australia. It is mostly a cultivated species with one variety (var. *comosus*) and cultivar (Smooth Cayenne) dominating the Australian commercial plantations. Therefore there is no chance of gene transfer from cultivated pineapple to naturalised pineapple species (CA, 2008).

Varieties

Many cultivars are known. The leaves of the commonly grown "Smooth Cayenne" cultivar and its various clones are smooth, and it is the most commonly grown worldwide. Many cultivars have become distributed from its origins in Paraguay and the southern part of Brazil, and later improved stocks were introduced into the Americas, the Azores, Africa, India, Malaysia and Australia. Varieties include:

"Hilo" is a compact, 1.0- to 1.5-kg (2– to 3-lb) Hawaiian variant of smooth cayenne; the fruit is more cylindrical and produces many suckers, but no slips.

"Kona sugarloaf", at 2.5 to 3.0 kg (5–6 lb), has white flesh with no woodiness in the center, is cylindrical in shape, and has a high sugar content but no acid; it has an unusually sweet fruit.

"Natal queen", at 1.0 to 1.5 kg (2 to 3 lb), has golden yellow flesh, crisp texture, and delicate mild flavor; well-adapted to fresh consumption, it keeps well after ripening. It has spiny leaves and is grown in Australia, Malaysia, and South Africa.

"Pernambuco" ("eleuthera") weighs 1–2 kg (2–4 lb), and has pale yellow to white flesh. It is sweet, melting in texture, and excellent for eating fresh; it is poorly adapted for shipping, has spiny leaves, and is grown in Latin America.

"Red Spanish", at 1–2 kg (2–4 lb), has pale yellow flesh with a pleasant aroma, is squarish in shape, and well-adapted for shipping as fresh fruit to distant markets; it has spiny leaves and is grown in Latin America and the Philippines. It was the original pineapple cultivar in the Philippines grown for their leaf fibers (piña) in the traditional Philippine textile industry.

"Smooth cayenne", a 2.5- to 3.0-kg (5- to 6-lb), pale yellow– to yellow-fleshed, cylindrical fruit with high sugar and acid content, is well-adapted to canning and processing; its leaves are without spines. It is an ancient cultivar developed by Amerind peoples. In some parts of Asia, this cultivar is known as Sarawak, after an area of Malaysia in which it is grown. It is one of the ancestors of cultivars "73-50" (also called "MD-1" and "CO-2") and "73–114" (also called "MD-2"). Smooth cayenne was previously the variety produced in Hawaii, and the most easily obtainable in U.S. grocery stores, but was replaced over the course of the mid-1990s and 2000s by MD-2. The success of Del Monte's MD-2 caused Dole to obtain & grow its own MD-2 pineapples, leading to Del Monte Fresh Produce Co. v. Dole Food Co (Wikipedia, 2025).

There are different pineapple varieties including the Singapore Spanish pineapple. By the mid-1800s, the pineapple fruit was so easily available in Singapore that there arose complaints of pineapples obstructing landing places and staircases. In 1861, slices of pineapple was reportedly sold for one cent each at Raffles Place (Commercial Square) (Annalisa, 2025). Five varieties of pineapple are grown in North-eastern region: Kew, Giant Kew, Queen, Mauritius and Jaldhup and Lakhat (DMS, 2025).

The horticultural classification of pineapple varieties is currently followed across the globe. According to characteristics, varieties of pineapple have been divided into 5 main groups viz. Spanish, Queen, Cayenne, Abacaxi and Maipure groups. Of which, Cayenne group is by far the most important group. Most of the varieties in India may be accommodated into one of these groups. For example, Kew or Giant Kew, synonymous with Smooth Cayenne, represents Cayenne group. It the most widely grown cultivar which is also known by 'Cayenne Lisse', 'Maipuri', 'Kew', 'Sarawak', 'Esmeralda', 'Claire', 'Typhoon' and 'Saint Michel'. The leading fresh fruit clone for export is the 'Smooth Cayenne' hybrid 'MD-2'. The varieties of Cayenne and Spanish group are dual-purpose ones whereas varieties of Queen are grown exclusively for fresh fruit market, as they are not suitable for canning due to deep eyes. 'Singapore Spanish' is the second most important cultivar in importance, especially for canning purpose. The main cultivar of Brazil for fresh fruit consumption is 'Pernambuco' or 'Branco de Pernambuco' but in Florida it has also been named 'Abacaxi', 'Abakka' and 'Eleuthera' (Assumi *et al*., 2021).

Chief characteristics of major cultivars have been described as under:

Kew: It is the leading commercial variety in India and valued particularly for canning. It is from the Cayenne group. Fruit weights 1.5 to 2.5 kg. The shape of the fruit is cylindrical with slight tapering at the crown with broad and shallow eyes. The colour of unripe fruit is dark blackish green but orange-yellow with some green mottling when ripe. Flesh colour is light yellow, it is very juicy with pleasant flavour. Leaves have short sector of spine at the tip and also at the base. It is susceptible to mealy bug wilt and nematodes. 'Giant Kew' grown in states of West Bengal, Goa and Meghalaya of India also belongs to this group. Kew cultivated in the Northeastern states and in the Southern region of India also belongs to Cayenne member (Assumi *et al.,* 2021).

Queen: It is also known as common Queen which is mainly used as a fresh fruit but also for processing and export. It is widely grown in Australia, India and South Africa. In India, it is grown in Tripura, Assam and Meghalaya. The fruit weights 0.9 to 1.3 kg which is rich yellow in colour. When fully matured, the fruit is golden yellow and its internal flesh is deep golden-yellow. The flesh, although less juicy than Cayenne, is crisp, transparent with pleasant aroma and flavour. The plants are characterized by dwarf, compact habit of growth (Assumi *et al.,* 2021).

Mauritius: It is a mid-season variety of Queen group. It is grown in some parts of Meghalaya and Kerala in India. Fruits are of medium size and are of 2 types, deep yellow and red. Fruits of yellow variety are oblong, fibrous, and medium sweet compared to red type. Mauritius is exclusively grown for table purpose for short distant marketing. Leaves are yellowish green, spiny throughout the margin and crown also is spiny (Assumi *et al.,* 2021).

Jaldhup and Lakhat: These two varieties belong to India and are from Queen group. Indigenous to Assam, both being named after the place of production. Fruits are a little smaller than Queen. Lakhat is strikingly sour in taste whereas Jaldhup has its sweetness blended with acidity. One characteristic feature of Jaldhup variety is that it has alcoholic flavour and can be easily distinguished from other fruits of the Queen group. Indigenous types of India also include Simhachalam, Baruipur Local and Haricharanvita (Assumi *et al.,* 2021).

Red Spanish: It is widely cultivated in West Indies, Cuba, Puerto Rico and Mexico. The plant and fruit size is in between Cayenne and Queen. Fruit is rather square in shape and weighs between 0.9 to 1.8 kg. Flesh is pale yellow, fibrous with pleasant penetrating aroma and spicy acid flavour. The leaves are long, about 1.2 m and spiny. Peduncle is long (20 to 25 cm) and slender and is often not able to support the fruit upright (Assumi *et al.,* 2021).

PR 1-67: This is also an important cultivar of Puerto Rico, originated from an open pollinated cross of Red Spanish. The outstanding characteristics of this cultivar are excellent flavour as a fresh fruit, resistance to mealy bug wilt, gummosis and good size and shape (Assumi *et al.,* 2021).

MD-2: This is an important hybrid of pineapple originated in the breeding program of the now-defunct Pineapple Research Institute in Hawaii. MD-2 is the standard for the international market. This is because of its excellent fruit qualities like high brix value (17 for ripe fruit), low acidity (0.4 to 0.45%), medium fruit size (1.5 to 2.0 kg), cylindrical shape, small core size, exhibit very long shelf life (about 30 days) as against 21 days for the normal varieties and is able to endure in cold storage for up to two weeks. MD-2 is resistant to internal browning, however susceptible to fruitlet core rot and more sensitive to Phytophthora than Smooth Cayenne. MD-2 variety fetches a premium price than other varieties. Hence, it will be the best pineapple variety that can be imported in India for increasing the export share of the pineapple produced in the country (Assumi *et al.,* 2021).

PQM-1 (It is a pineapple Queen Mutant-1): It is a clonal selection of Queen developed from Lembucherra Farm, ICAR Research Complex for NEH Region, Tripura Centre. Plants are more vigourous than Queen and Mauritius, with spiny reddish leaves, similar suckers but with fewer slips than Queen. Flowering time (July to August) and fruit maturity is late compared to Queen. Fruitlets are lesser (24% lesser eyes per fruit) but larger than Queen, fruit is cylindrical in shape weighing about 1.3 kg slightly heavier than Queen. Fruit colour is deep orange with yellowish golden flesh. Total soluble solids (TSS) is 17% and titratable acidity is 0.6%. Yield is 50 to 55 tonnes/ha (Assumi *et al.,* 2021).

Important varieties cultivated in different states of India are given below (NHB, 2025)

State		Varieties mostly grown
Assam & other N.E. states	-	Kew, Queen, Mauritius
Kerala	-	Mauritius, Kew, Queen
West Bengal	-	Giant Kew, Queen

Pineapple varieties are classified into five main groups based on their characteristics: Cayenne, Spanish, Queen, Pernambuco, and Mordilona. Some notable varieties within these groups include;

Cayenne group: ***Smooth Cayenne, Hilo, Kew, Charlotte Rothschild, Perolera, Monte Lirio.***

Spanish group: ***Red Spanish, Singapore Spanish, Masmerah, Cabezona, Valera, Valera Amarilla***.

Queen group: ***Queen, Mauritius, Ripley Queen, Mac Gregor, Natal Queen***.

Pernambuco group: ***Abacaxi, Sugar Loaf***.

Mordilona group: ***Perolera, Milagrena, Mariquita, Manzana, Tachirense, Maipure, Randon, Monte Lirio.***

Uses: Pineapple is cultivated predominantly for its fruit that is consumed fresh or canned. The fruit is a good source of manganese and contains significant amounts of vitamins C and B1. Approximately 95% of canned pineapple comes from the cultivar Smooth Cayenne. Pineapple is used as an ingredient in a variety of foods including pizzas, condiments, sweets, savouries, cakes, pastries, yoghurt, punches, ice creams. Pineapple contains the proteolytic enzyme bromelain, which is used as a meat-tenderising agent and for medicinal purposes. It has been reported to have valuable biological properties such as interfering with the growth of malignant cells, inhibiting platelet aggregation, fibrinolytic and anti-inflammatory action, enhancing drug absorption and removing skin (debridement). Pineapple leaf juice is used as a purgative (agent that cleanses the bowel), emmenagogue (agent that induces menstrual bleeding) and vermifuge (agent that expels intestinal worms). Pineapple products have also been marketed as a 'digestive aid' in health food stores (CA, 2008).

The stems and leaves of the pineapple plant are a source of fibre, which can be processed into paper. Fibres are approximately 60cm in length, white and easily dyed. The cloth made from pineapple fibre is known as 'pina cloth' and was in use as early as 1571. Even today in the Philippines small scale cottage industries make high quality clothes from pineapple fibre. Pineapple fibre has potential in paper production and the development of low density polyethylene composites. Parts of the pineapple plant are used for silage and hay for cattle feed. Processing wastes in the form of shell, core materials and centrifuged solids from juice production are used as animal feed. Alcoholic beverages can also be made from the juice. World pineapple production reached 15.5mt in 2004, with Asia contributing 50% and Americas contributing 31.6%. The international fresh-pineapple market pproximately 670,000 t) is dominated by Costa Rica, the Philippines and the Cote d`Ivoire (CA, 2008). Pineapple is cultivated predominantly for its fruit that is consumed fresh or as canned fruit and juice. Pineapple is the only source of bromelain, a complex proteolytic enzyme used in the pharmaceutical market and as a meat-tenderising agent. The stems and leaves of pineapple plant are also a source of fibre that is white, creamy and lustrous as silk. Pineapple fibre has been processed into paper with remarkable qualities of thinness, smoothness and pliability. Parts of the plant are used for silage and hay for cattle feed. Processing wastes in the form of shell, core materials and centrifuged solids from juice production are also used as animal feed. Alcoholic beverages can also be made from juice (TFN, 2016).

The flesh and juice of the pineapple are used in cuisines around the world. In many tropical countries, pineapple is prepared and sold on roadsides as a snack. It is sold whole or in halves with a stick inserted. Whole, cored slices with a cherry in the middle are a common garnish on hams in the West. Chunks of pineapple are used in desserts such as fruit salad, as well as in some savory dishes, including Hawaiian pizza, or as a grilled ring on a hamburger. Traditional dishes that use pineapple include hamonado, afritada, kaeng som pla, and Hawaiian haystack. Crushed pineapple is used in yogurt, jam, sweets, and ice cream. The juice of the pineapple is served as a beverage, and it is also the main ingredient in cocktails such as piña colada and in the drink tepache. In the Philippines, a traditional jelly-like dessert called nata de piña has also been produced since the 18th century. It is made by fermenting pineapple juice with the bacteria Komagataeibacter xylinus. Pineapple vinegar is an ingredient found in both Honduran and Filipino cuisine, where it is produced locally. In Mexico, it is usually made with peels from the whole fruit, rather than the juice; however, in Taiwanese cuisine, it is often produced by blending pineapple juice with grain vinegar. The European Union consumed 50% of the global total for pineapple juice in 2012–2016. The Netherlands was the largest importer of pineapple juice in Europe. Thailand, Costa Rica and the Netherlands are the major suppliers to the European Union market in 2012–2016. Countries consuming the most pineapple juice in 2017 were Thailand, Indonesia and the Philippines, having a combined consumption of 47% of the world total. The consumption of pineapple juice in China and India is low compared to their populations (Wikipedia, 2025).

The 'Red Spanish' cultivar of pineapples were once extensively cultivated in the Philippines. The long leaves of the cultivar were the source of traditional piña fibers, an adaptation of the native weaving traditions with fibers extracted from abacá. These were woven into lustrous lace-like nipis fabrics usually decorated with intricate floral embroidery known as *calado* and *sombrado*. The fabric was a luxury export from the Philippines during the Spanish colonial period and gained favor among European aristocracy in the 18th and 19th centuries. Domestically, they were used to make the traditional barong tagalog, baro't saya, and traje de mestiza clothing of the Filipino upper class, as well as women's kerchiefs (*pañuelo*). They were favored for their light and breezy quality, which was ideal in the hot tropical climate of the islands. The industry was destroyed in the Second World War and is only starting to be revived (Wikipedia, 2025).

Although it is usually served freshly sliced, there are many other ways of eating pineapples. A popular Asian dish is pineapple rice, which is traditionally served in a hollowed-out pineapple shell. The pineapple is also widely used to flavour "sweet and sour" dishes and fruit salads. *Nanas goreng* is a tasty Indonesian dessert made of pineapple slices that have been fried in batter and served with a generous helping of cinnamon sugar. The Malays make a pleasant appetiser of pineapple, chilies, ghee and sugar called *pacheri*, while *manisan* is pineapple served with only sugar. Apart from being canned or made into fruit juice, the pineapple is also processed to produce alcohol, pineapple vinegar and citric acid. Other pineapple foods include chutneys, pickles and jams. The pineapple tart is a popular gift among both the Chinese and Malays during their respective festive occasions (Annalisa, 2025). *Bromelin* or *bromelain*, an enzyme present in ripe pineapples, aids digestion and is

known to treat inflammation including joint pain. Partially developed pineapple fruits are believed to be poisonous and act as a purgative so violent that it can terminate a pregnancy. They are hence generally considered unsafe for consumption. Unripe fruit were previously used as a vermifuge, diuretic and treatment for venereal diseases (Annalisa, 2025). Pineapple leaf fibres are used in the textile and rope-making industries. The fibres are also used to weave the exquisitely intricate fabric of the *barong*, the national dress of Filipino men. Pineapples contain a protease, *papain*, which is used as a meat tenderiser. Pineapple juice was also used by the Malays as a cleaning agent when engraving the blade of a *kris*.[29] The Chinese embrace the pineapple as its Chinese name symbolises luck and wealth. It is one of the must-have foods during Chinese New Year. A live sample is grown at Singapore's Gardens by the Bay (Annalisa, 2025).

Nutritional Value: Fresh pineapple is a good source of carbohydrate, fibre and minerals especially Ca, P, Fe, Na and K. It also contains some vitamins including A, B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), B9 (folate) and C (ascorbic acid). The nutritional content is influenced by several factors including varieties, soil, climatic condition, maturity stage and handling. Processing may result in the nutritional components being altered in the final processed products (Hassan *et al.,* 2011a).

Pineapple is a vital source of sugars, organic acids, essential minerals, vitamins and fiber for human nutrition. Its fruits are also rich in health promoting antioxidants such as ascorbic acid, flavonoids and carotenoid compounds. The chemical composition of pineapple (sugars, organic acids, minerals, fiber, aromatic ompounds, vitamins, amino acids, carotenoids, etc.) depends greatly on the variety. Fresh fruit has small but substantial amounts of vitamin A, and flavonoid pigments such as ß -carotene, xanthin, lutein and ß-cryptoxanthin. collectively, these compounds play vital roles in antioxidant and vision functions. Vitamin A is also required for sustaining integrity of mucosa and skin. Consumption of natural fruits rich in vitamin A and carotenes has been found to protect from lung and oral cavity cancers. One healthy ripe pineapple fruit can supply about 16.2% of daily requirement for vitamin C. It is one of the rare fruits that are rich in B-complex group of vitamins. It contains very good 488 Tropical Fruit Crops: theory to Practical amounts of vitamin B6 (pyridoxine), niacin, riboflavin and folic acid. Moreover, pineapple fruit is rich in minerals with high biological activity. The key elemental components present in pineapple fruit are potassium (K) (125-178 mg/100 g fruit weight), calcium (Ca) (13 mg/100 g fw), magnesium (Mg) (12-20 mg/100 g fw) and phosphorus (P) (9-13 mg/100 g fw). Other important minerals found in pineapple in lower concentration are manganese (Mn) (0.818-1.593 mg/100 g fw), iron (Fe) (0.25-0.28 mg/100 g fw), copper (Cu) (0.081-0.113 mg/100 g fw) and zinc (0.08-0.20 mg/100 g fw). Also, pineapple is known for its low sodium content (Na) (1-2 mg/100 g fw) (Assumi *et al.,* 2021). There are many kinds of nutritional ingredients in pineapple, such as fructose, glucose, vitamin b and c, citric acid and protease etc. and one cup of fresh pineapple chunks almost contain 82 calories, 2 milligrams of sodium, 22 grams of total carbohydrate and 1 gram of protein. One day a cup of fresh pineapple chunks can provide 131% of vitamin C you need and 2% of vitamin A and calcium and iron. Now let's look at the ingredients of pineapple as the following form (Ticomachinem, 2025). Pineapple is a highly nutritious fruit, rich in vitamins A and C, as well as essential minerals like phosphorus, calcium, magnesium, potassium, and iron . It contains a proteolytic enzyme called bromelain, which aids in digestion and exhibits anti-inflammatory properties, making it valuable in modern therapy for reducing swelling and promoting healing after surgery or physical injuries (Agropedia, 2025).

Raw pineapple pulp is 86% water, 13% carbohydrates, 0.5% protein, and contains negligible fat . In a reference amount of 100 g (3.5 oz), raw pineapple supplies 209 kilojoules (50 kilocalories) of food energy, and is a rich source of manganese (40% of the Daily Value, DV) and vitamin C (53% DV), but otherwise contains no micronutrients in significant amounts (Wikipedia, 2025).

Health Benefits: Just as other fruits, pineapples are good for our health. The main ingredient bromelain has been used in studies to ensure the effectiveness of alleviating joint pain, arthritis, inhibit tumor growth and reduce inflammation etc. Apart from this, many studies have indicated that pineapples can decrease the risk of obesity and diabetes, heart disease and promote a healthy complexion, increase energy. The main benefits of pineapple include (Ticomachinem, 2025):

Asthma prevention: some certain nutrients are found to be help to reduce the risk of asthma, the most important one is beta-carotene which is rich in pineapples, mangoes, broccoli, papaya, etc. So people who consume more pineapples have the lower chance to get into asthma.

Help to lose weight: sounds ridiculous? Can pineapples help to lose weight? Absolutely true, there are almost all the vitamins our body needs and more than 16 natural minerals which can help digestive absorption. What's more, there is abounding of juice in pineapples which has the function of acidolysis. People can eat food matches pineapples or just drink the pineapple juice.

Help to clean intestines and stomach: people are always in trouble of eating too much meat. But now you can relax, the bromelain can disintegrate protein and promote healthy and regularity digestive tract which is helpful in constipation.

Help to keep your skin young and water wet. The antioxidant vitamin B and C which contains in pineapples can protect your skin from the damage of sun and pollution. What's more, eating pineapples can reduce wrinkles and improve skin texture. In addition, vitamin C plays a very important role in the formation of collagen which is vital to your skin.

Lower blood pressure: it is helpful to increase potassium intake for our body, but no more than 2% of US adults meet the recommended potassium intake of 4700mg every day, pineapples contains abundance of potassium which can lower blood pressure to make people keep fit.
Other diseases: apart from the above benefits, pineapples also have effect on some other diseases, such as: kinds of cancers, diabetes, inflammation and heart health etc.

Pineapple contains nutrients and beneficial compounds, such as vitamin C, manganese, and enzymes. Eating pineapple may help boost immunity, lower cancer risk, and improve recovery time after surgery. Pineapple (*Ananas comosus*) is a tropical fruit. It contains nutrients, antioxidants, and other compounds, such as enzymes that can protect against inflammation and disease. It's commonly eaten baked, grilled, or freshly cut. Pineapple and its compounds are linked to several health benefits, including improvements in digestion, immunity, and recovery from surgery (Ali *et al.,* 2020).

Highly nutritious**: Pineapples are low in calories (kcal) but highly nutritious. Just one cup (165 grams) Trusted Source of pineapple chunks contains the following nutrients:**

Vitamin C: 78.9 milligrams (mg), 88% of the daily value (DV)
Vitamin B6: 0.185 mg, 11% of the DV

Copper: 0.181 mg, 20% of the DV
Potassium: 180 mg, 4% of the DV
Magnesium: 19.8 mg, 5% of the DV
Iron: 0.478 mg, 3% of the DV

This fruit is particularly rich in vitamin C, which is essentialTrusted Source for immune health, iron absorption, and growth and development.

Contains antioxidants: Pineapples are not only rich in nutrients, but they also contain antioxidants — molecules that help your body ward off oxidative stress. Oxidative stress is caused by an abundance of free radicals, which are unstable molecules that damage cells. Pineapples are especially rich in antioxidants called flavonoids and phenolic compounds. One study of ratsTrusted Source showed that pineapple's antioxidants may have heart-protective effects, though human research is lacking.

Moreover, many of the antioxidants in pineapple are considered bound antioxidants, producing longer-lasting effectsTrusted Source.

May aid digestion: You'll often find pineapple served alongside meats and poultry in countries such as Brazil. This fruit contains a group of digestive enzymes called bromelain that may ease the digestion of meatTrusted Source. Bromelain breaks down protein molecules, meaning your small intestine can more easily absorb them. Pineapples are also a good source of fiber, which aids digestive health.

May reduce your risk of cancer: Cancer is a chronic disease characterized by uncontrolled cell growth. Its progression is commonly linked to oxidative stress and chronic inflammationTrusted Source. Several studies note that pineapple and its compounds, including bromelain, may reduce cancer riskTrusted Source by minimizing oxidative stress and reducing inflammation. However, further research in humans is still needed to confirm its exact effects**.**

May boost immunity and suppress inflammation: Pineapples have been used in traditional medicine for centuries. They contain various vitamins, minerals, and enzymes, such as bromelain, that may collectively improve immunityTrusted Source and reduce inflammation. However, further research is needed to support these findings.

May ease symptoms of arthritis: Arthritis affects more than 54 million U.S. adultsTrusted Source. Many types of arthritis exist, but most involve joint inflammation. Bromelain's anti-inflammatory properties may provide pain reliefTrusted Source for those with inflammatory arthritis. A 2020 studyTrusted Source found supplements containing bromelain and other enzymes to be as effective as regular pain treatment in easing osteoarthritis in the lower back.
May speed recovery after surgery or strenuous exercise: Consuming bromelain from pineapple may reduce the time it takes to recover from surgery or exerciseTrusted Source. While this fruit helps replenish carb stores after exercise, some of its benefits are also due to bromelain's anti-inflammatory propertiesTrusted Source. Several studies have shown that bromelain may reduce the inflammation, swelling, bruising, and pain that often occur after surgery, including dental and skin procedures. It may likewise reduce markers of inflammationTrusted Source. However, studies have used supplements containing high amounts of bromelain, so it's unclear whether eating pineapple would have the same effects.

Easy to add to your diet: Pineapples are sweet, convenient, and easy to add to your diet. The fresh fruit is easy to find in many grocery stores and markets, even out of season. You can buy it canned, dehydrated, or frozen year-round. You can enjoy pineapple alone, in smoothies, salads, or homemade pizzas. Here are a few fun recipe ideas that feature pineapple:

Breakfast: smoothie with pineapple, blueberry, and Greek yogurt

Salad: tropical roast chicken, almonds, blueberries, and pineapple atop lettuce or other greens

Lunch: homemade Hawaiian burgers (beef burgers with a pineapple ring)

Dinner: pineapple fried rice and seitan

Dessert: homemade pineapple whip (frozen pineapple chunks blended with a splash of coconut milk and a dash of lemon juice)

Are there any health risks to eating pineapple. Pineapples are not a common allergen. Eating them is considered very low risk unless you have a known pineapple allergy. In that case, you should avoid pineapple and its extracts. However, even in people without an allergy or diabetes, eating too much pineapple — more than a few servings per day — may have unintended side effects. Those sensitive to bromelain may experience tongue burning, itching, or nausea — though these downsides are anecdotal and haven't been studied scientifically. Some people say that eating a lot of unripe pineapple causes stomach upset, nausea, and diarrhea. Again, this hasn't been studied, but it's always best to select ripe pineapple. The flesh should be light to medium yellow (Ali *et al*., 2020).

CULTIVATION

Pineapple is a highly perishable fruit; therefore the stage of maturity of the fruit is important in determining. Pineapples are propagated vegetatively by planting crowns, slips or suckers; although seed can be used in breeding. Pineapple fruit and propagation materials. Tissue culture can also be used. The propagules are extremely resistant to desiccation and root readily when planted in the nursery or in the field. By planting various types of propagules the period of harvest can be extended since offshoots (suckers) fruit in about 17 months, slips in 20 months and crowns in 22-24 months. Planting takes place at the start of the rainy season or it can start any time in the irrigated areas. The propagule stem should be allowed to air dry for one week prior to planting so that the callus layer is formed over the damaged tissue thereby making them resistant to disease infection after planting. Scaly leaves should be removed from the lower portion of the propagule stem to expose the primodia (future roots). If this is not done, establishment will take long (Kyle Stice, 2021). Some farmers use double rows, others 3 rows, others more. For practicle purposes, however, pineapples are generally planted in double rows spaced at 2 ft (60cm) between the rows, 1 ft (30cm) between plants and 4 ft (120cm) between adjacent double rows. This gives an approximate plant population of 36,250 plants/h. The rows are marked using pegs,

string and tape. Holes are dug shallowly (7-10cm deep) using a small hoe or just insert a large stick in the ground and only the pedal part is planted and firmed. The propagules are planted on a level ground and later ridged. Ridge planting helps provide a deep bed for a better root growth and also creates water between the double spaces or draining away excess water in water logged areas. Nitrogen is the nutrient most used by pineapples. It can be applied at the rate of 50 kg per hectare top dressed one month after planting. Additional 41-670 kg per hectare applied three to six months interval is recommended before maturity. An additional 200 kg per hectare of nitrogen can be applied to each ratoon crop. Where phosphorus is lacking, plants have narrow brittle leaves with a dark red color spreading the entire leaf (**Kyle Stice,** 2021**).**

Potassium deficiency produces a poor quality fruit; few suckers and slips will be formed. The best method of application is preplant broadcast mixed with the top 15 cm of soil. Iron deficiency is identified by a general chlorosis (pale yellow or yellow-white colour) similar to that typical of nitrogen deficiency. Zinc deficiency causes a mottled yellowing of the leaves. Weeds can be controlled in three ways notably by: hand, use of mulch and use of herbicides. To obtain maximum production, perennial weeds should be dug out prior to planting and all newly germinating weeds should be controlled while in seedling stage. If a crop is planted with pineapples, weeding should be done in the early stages. It is advisable that after harvesting the intercrop hand weeding should not be continued. The pineapple has a shallow root system which should not be disturbed (**Kyle Stice,** 2021**).** Pineapple is suitable for cultivation in humid tropics. The fruit grows well near the sea coast as well as in the interior; so long the temperatures are not extreme. The optimum temperature required for successful cultivation is 22^0-32^0 C. High temperature at night is deleterious for the growth of the plant and a difference of at least 4^0 C between day and night temperature is desirable. It can be grown upto 1,000 m. above sea level, if the area is frost free. The rainfall requirement ranges between 100-150 cm. Sandy loam soils with pH between 5.0-6.0 is ideal for the growth of the plants. The cultivation of pineapple is confined to high rainfall and humid coastal regions in the peninsular India and hilly areas of north-eastern region of the country. It can also be grown commercially in the interior plains with medium rainfall and supplementary irrigations (NHB, 2025).

The land is prepared for planting by ploughing or digging followed by leveling. Depending on the nature of land, trenches of convenient length, about 90 cm width and 15-30 cm depth are prepared. Pineapple is usually propagated by sucker, slip and crown. These planting materials of 5-6 months age bear flowers after 12 months of planting except crowns which bear flowers after 19-20 months. Pineapple plants produced through tissue culture are also available for cultivation. Planting material is dipped in ceresan solution (4 g. in 1 l. of water) or 0.2 % Dithane M-45 before planting to protect the plants against bud rot. The ideal time of planting is 12-15 months before the peak flowering season under natural conditions, which varies from December to March in different regions. Time of planting also varies from place to place depending upon the time of onset of the monsoon and the intensity of its precipitation. In Assam, planting should be done during August-October, while in Kerala and Karnataka; the best time of planting is April-June. Planting is usually avoided during the period of heavy rains. The ideal time for planting in northern part of West Bengal is October-November and June-July for other parts. Delaying in planting as late as September, delays crop at least by 7-9 months. The peak flowering period is from January to March (NHB, 2025).

For commercial viability high density cultivation is recommended. Planting density of 63,400 plants/ha. (22.5 x 60 x 75 cm.) is ideal for sub-tropical and mild humid conditions, whereas for hot and humid conditions a plant density of 53,300 plants/ha spaced at 25 cm. from plant to plant within a row, 60 cm. from row to row and 90 cm from trench to trench (25 x 60 x 90 cm.) provides high yield. In rainfed, high fertile and hilly areas in north eastern states, a somewhat lower density of 31,000 plants/ha. is recommended (NHB, 2025). The yield of 70-105 tonnes/ha. may be obtained under high density planting , the increase in yield/unit area being 45-85 tonnes/ha. Less weed infestation , protection of fruits from sun burn, increased production of propagules (suckers and slips)/unit area and non-lodging of plants are added advantages of high density planting (NHB, 2025). Four different planting systems viz. flat-bed, furrow, contour and trench are followed. System of planting varies according to land and rainfall. In the slopes, terracing or contour planting is adopted which helps to check soil erosion. Trench planting is usually followed in Kerala (NHB, 2025). A dose of N, P_2O_5 and K_2O at 12,4 and 12 g./plant/year respectively is optimum under Jorhat conditions. No response to P application has been observed. However, in the ratoon crop 4 g. P_2O_5/plant increases fruit weight and yield. Plants receiving 12 g. K_2O/plant/crop give higher yield without any adverse effect on fruit quality both under irrigated and rainfed conditions. For medium fertile soils in West Bengal, N (12-16g.), P_2O_5 (2-4g.) and K_2O (10-12 g.)/plant are optimum. It is recommended to apply N and K_2O each @ 12g./plant. There is no need for P application. However, if the soils are poor in P, 4g. P_2O_5/plant can be applied. N should be applied in 6 split doses. The first dose of N can be given two months after planting and the last one 12 months after planting. The K should be applied in two split doses. Entire P and half of K can be given at the time of planting and the remaining K, 6 months after planting. Application of fertilizers under rainfed conditions should be done when moisture is available (NHB, 2025).

Pineapple is mostly cultivated under rainfed conditions. Supplementary irrigation helps to produce good sized fruits in areas having optimum rainfall. Irrigation also helps to establish an off-season planting to maintain its year round production. In case of scanty rainfall and hot weather, irrigation may be provided once in 20-25 days. Weeding is done at least three to four times in a year. Hand weeding can be partially eliminated by application of weedicides. Earthing up is an essential operation in pineapple cultivation aimed at good anchorage to the plants. Soon after harvest, earthing up is done leaving one to two suckers only. Weeds are effectively controlled by application of diuron (@ 2 kg./ha.) or a combination of Bromacil and diuron @ 2 kg./ha. each as pre-emergent spray and repeated with half of the dose , 5 months after first application. Dry leaves or straw is used as a mulching material. Mulching with black polythene and saw dust has been found to be effective. The maturing fruits may be covered with rice straw or pineapple leaves in order to reduce both sun burn and damage caused by the birds (NHB, 2025).

Application of NAA and related compounds viz. Planofix and Celemone @ 10-20 ppm. induces flowering in pineapple. Application of NAA (200-300 ppm.), two to three months after fruit set increases 15-20% fruit size. To get year round availability of pineapple it should be planned at regular intervals round the year. The application of 50 ml. solution/plant containing calcium carbide (20g./litre) or Ethrel (0.25 ml./l.) causes flower induction. Suckers start growing with the emergence of inflorescence, whereas slips grow with the developing fruits. The fruit weight increases with increasing number of suckers/plant, while the increased number of slips delays fruit maturity. Crown size has no bearing on the fruit weight or quality. Hence desuckering can be delayed as much as possible, while the slips are recommended to be removed as soon as they attain the size required for planting. Removal of crown is not required as it mars the appeal of the fruit and also makes handling difficult. Partial pinching of crown consisting of the removal of the innermost whorl of leaflets along with growing tips 45 days after fruit set is ideal to get fruits of better size and shape (NHB, 2025).

Maturity

Pineapple plant flowers at 10 to 12 months and fruits become ready for harvest in about 15 to 18 months after planting. In India, under natural conditions, pineapple comes to harvest during May to August. With the application of ethephon and fertilizers, the first yield is Pineapple

(*Ananas cosmosus* L. Merr.) obtained within 11 to 12 months. Fruits which mature in winter are commonly acidic in taste. Ripening and senescence of the fruit on the plant is indicated by the reduction in shell chlorophyll, starting from the base of the fruit. Generally, the half-yellow stage is considered as ripe and at this stage, the total soluble solids, a measure of sugars, has reached a maximum and the titratable acidity has begun to decline. Observing the colour change is the most commonly followed indices of maturity in pineapple. It is judged by yellowing of the basal portion as follows:

1. ½ to 2/3rd portion yellowing for local market.
2. 1/3 to 1/4th portion yellowing for distant market.
3. 1/3 to ½ portion yellowing for canning purpose.
(Assumi *et al.,* 2021).

Stripping for Ratoon Crops: A number of ratoon crops can be taken if management is good but fruit size decreases. They give profit to the undertaking as the main crop plant pays for crop establishment. Stripping involves the removal of all slips and all unwanted suckers. Only one sucker should remain as the basis of the ratoon crop. It should preferably arise from below the ground. Stripping should start at around the time of harvesting. If correct sized suckers and slips are needed as propagation materials from the main crop, two to three operations at monthly intervals will be needed (Kyle Stice, 2021).

Harvesting Pineapple fruit is mostly hand harvested. Small farmers generally harvest the fruit by hand with a sharp knife making a clean cut at the fruit stalk (retaining 2 to 3 cm long stalk) and place in to a basket on their back. The crown is left attached and care is taken to avoid injury to these leaves. Fruit maturity uniformity governs harvest peak and the number of harvest rounds needed to achieve maximum yield from a held. Attempts have been made to mechanically harvest the fruit but in vain, with problems being found in localizing the fruit and evaluating stage of ripeness and overall appearance. For canning purpose, fruits are harvested with a slight colour change at the base of the developing fruits. For table purpose, fruits could be retained till they developed golden yellow colour. Fruits for fresh fruit market are often marketed with crowns. The fruits harvested with the crown can be kept for 10 to 15 days (Assumi *et al.,* 2021).

It takes about 15–20 months for the crop to mature. Usually flowering takes place from February to April and the fruit is ready between July to September. Sometimes off-season flowers appear and they produce fruit during winter, which is of poor quality. The fruit is harvested when it just becomes yellow, the angularities of eyes start reducing and the bracts wither (DMS, 2025).

Yield: The yield in pineapple varies depending on the variety, climatic conditions, cultivation techniques employed, type of planting material used and the planting density (spacing). The average yield of pineapple in India is 10 to 15 tonnes/ha, an estimate given by the Indian Institute of Foreign Trade, New Delhi (Radha and Mathew, 2007). This low productivity is mainly attributed to wider spacing in commercial plantations. However, by increasing the population density per hectare yield is reported to increase does not have adverse effect on fruit size, quality and canning recovery. The yield of 70 to 105 tonnes/ha may be obtained under high-density planting, the increase in yield per unit area being in the tune of 45 to 85 tonnes/ha. Enhanced yield of more than 50 tonnes/ha can be achieved by population density of above 40,000 plants/ha. A large proportion of assimilates is allocated to the inflorescence and the crown which means that the more assimilates are available at flower induction the higher would be the fruit weight. Plant growth characteristics can be a basis for predicting yield of pineapple crop. The indices used are the numbers of leaves one year after planting and number of suckers in a plant. Size of the fruit can be predicted with the equation mentioned as follows:

1. Fruit weight in kg = 1,3978 + (0.0028 × No. of leaves).
2. Fruit weight in kg = 1,238 + (0.2520 × No. of suckers).
(Assumi *et al.,* 2021).

Average yield is 10–15 tonnes per hectare in NER states. But this can be increased to 25-30 tons/ha with good organic management practices using manure mixtures, foliar feeding and irrigations during dry periods (DMS, 2025).

Physiological Disorder And Their Management

Fasciation: Fruits and crown becomes deformed. It is a non-pathogenic physiological disorder and caused mainly due to high vigour of plants, warm weather and high soil fertility. Normally pineapple bear a single crown, but in some cases it bears more than one, sometimes even up to 25 crowns. Consequently, the top of the fruits get attened, broad and becomes for use. The incidence of fasciation increases with advancing ratoons. Occurrence of fasciation can be avoided by restricting the growth (Assumi *et al.,* 2021).

Sunscald: The peduncle bearing the fruit leans or falls on one side which exposes the fruit to direct sunlight. Thereby the cells under the peel of the exposed surface get damaged. It is very serious in widely spaced plants compared to dense plants. It can be reduced by shading of branches, painting of exposed surfaces with lime paste and by wrapping straw or hay around the tree trunk. This disorder does not occur in high-density plantings (Assumi *et al.,* 2021).

Black heart: It is also known as internal browning or endogenous brown spot. Initially, some brown translucent spots are developed at the base of fruit, close to the core. Later, these spots turn black and may cover the entire center of the fruit. Exogenous applications of gibberellic acid and low temperature have been reported to induce this disorder (Assumi *et al.,* 2021).

Flesh translucency: It is also called as porosity. Such fruits are more sensitive to mechanical injury. Its incidence is high when the maximum and minimum temperature of the preceding three months before harvest is lower i.e., 23 and 15°C, respectively. Waxing of fruit can reduce the rate of translucency developed after the harvest. Other abnormalities and diorders of pineapple includes Crown without fruit, Multiple crowns, Collar of slips, Long Tom, Deep eye, Shell surface pitting, Seediness, Broken and hollow core, Crown dehydration, Dry fruit and Bottle neck (Assumi *et al.,* 2021).

Insect Pests: Nematodes, particularly the root knot nematode may become a problem and is a serious pest in many pineapple growing regions. Soil fumigation (if funds allow) should be carried out to reduce nematode damage. Furadan, Nemacur, or Temik can be used. Infestations by

pineapple mealy bug result in yellow spots appearing on the leaves but, more importantly the insects spread black spot (Penicilium funiculosum and Fustrium moniliforme).

Insecticides such as Salut, Decis, Rogor etc. can be used to kill mealybugs. Dipping pineapple planting material before planting in a fungicide-insecticide solution can help to eliminate them e.g. mix about 30 ml sumithion in 20 litres of water (Kyle Stice, 2021).

Wilt of leaves due to infestation with mealybug: Thrips may be important as vectors of yellow spot virus which causes deformed fruits or the production of fruits with several dead fruitlets. Hosts of the virus other than pineapple are weeds such as Black jack, Datura stramonium, Emila sonchfolia and vegetables such as pepper, tomato egg plant, broadbean, spinach and peas. Yellow spot of pineapples is usually more severe when these plants are grown nearby (Kyle Stice, 2021).

Yellow spot virus spread by thrips: Heart and root rots caused by the fungus Phytopthora cinnamon and P. parasitica are sometimes serious. The leaves rot from the tips and the base of the heart resulting in an offensive odour. It is common in young plants of 3-8 months. Splashing rain, irrigation water and biting insects act as agents to spread disease. For effective control of the disease one has to ensure good drainage, avoid overhead irrigation and control insect pests. Soil should be prevented from entering the hearts by covering lightly with grass and removing the grass later. Planting materials can be dipped in copper fungicides before planting or use resistant plants. Fungicides can be used to control any fungal complications (**Kyle Stice,** 2021**).**

Diseases

Mealy bug wilt: Mealy bug wilt is one of the most serious and devastating diseases in pineapple. It is a complex and multi-component disease involving mealy bug, ants and a virus. The linkage of ants and mealy bug with wilt disease, wherein he noted that ants, the natural enemies already present in the held might aid in multiplication of mealy bugs and suggested that controlling ants might be an effective way of preventing mealybug wilt disease of pineapple. Experimental results have confirmed that ant control reduces mealy bug population and hence reduce mealy bug wilt disease. The ants nourish on the mealy bug honeydew, guard the mealy bugs from natural enemies and carry them to new areas. A closterovirus was identified over 50 years after mealy bugs were associated with wilt from an infected pineapple. The mealy bug not only vector the virus but their nursing is required for mealy bug to develop. It is believed that mealy bug inject an agent while feeding that suppresses the pineapple plant's tolerance to the virus. It is mostly susceptible to Cayenne and Red Spanish while Queen being the resistant. Mealy bug cause wilting of the plants either by feeding, injecting toxins or by introducing virus into the plants. Most prominent symptom is the wilting of leaves at the tips with reddish yellow colour in the wilting areas (Assumi *et al.,* 2021).

Heart rot or Stem rot or Root rot: Heart rots are caused by several pathogens such as *Phytophthora nicotianae, Phytophthora cinnamomi* and *Phytophthora palmivora*. Heart rot caused by these oomycetes are associated with wet environmental conditions and more prevalent in high rainfall areas. Plant damage due to heart rot can reach up to 100% depending on the soil type, pH and rainfall. *P. nicotianae* and *P. palmivora* causes heart rot at warmer and lower elevations compared to *P. cinnamom* that occurs at cooler and higher elevations. Infected plants will primarily show a failure of young leaves to elongate, progressing to yellowing of the leaves that can be easily pulled from the plant. The tips of leaves turn brown and their basal portions show signs of rotting with a foul odour. Eventually the entire center and growing point of the pineapple rots away. It is a common disease in the north-eastern hilly region of India. It can be controlled by dipping the planting material in 0.4% difolatan at the time of planting and maintenance of proper drainage of yields. Affected plantations should be sprayed with difolatan or captan. Application of fosetyl aluminum is an effective pre-plant dip and as post-plant foliar application (Assumi *et al.,* 2021).

Base rot or Fruit rot or Butt rot or Black rot or White leaf spot: The causal fungus is *Ceratostomella paradoxa* which is widespread in different pineapple growing areas of the world. It is associated with a soft rot and blackening of the basal portion of the pineapple stem tissue. White leaf spot are found on the tips of the pineapple shoots. The growth of infected planting material occurs slowly and plant remains stunted due to loss of stem tissue containing carbohydrate reserves and the initial roots. Control of rot can be achieved by proper postharvest handling to reduce injury. Dipping in an approved fungicide followed by refrigeration at 9°C reduce loss due to black rot. Substitutes to fungicidal dips include acetic acid dips, hot water treatments and application of biological control fungus, *Trichoderma* (Assumi *et al.,* 2021).

Fusariosis or Fusarium stem rot: Fusarium guttiforme is the causal organism of fusariosis or fusarium stem rot. Fusariosisis mainly causes losses in Brazil on cultivars such as 'Smooth Cayenne' and 'Perola'. Stem infection take place at leaf bases resulting in rosetting and curving of the plant due to portions of the stem being wounded or killed. Infections may spread into flowers and also to fruits through wounds created by the pineapple borer, Thecla basilides. As soon as the developing fruit is infected, there is a chance of secondary infections on the developing slips or suckers. The fungus is spread within infested yields by insects or wind but it cannot survive for longer period in the soil. Less susceptible cultivars should be used in areas where fusariosis is present. Moreover, using pathogen free planting material can limit disease introduction into the yield. Suitable insect control and fungicides can also be used to control the disease. Lately, yeasts such as Candida krusei and Kloeckera apis have proven to inhibit *F. guttiforme* which can be used as biological control agent (Assumi *et al.,* 2021).

Bacterial heart rot: Bacterial heart rot of pineapple is caused by *Dickeya* sp. (formerly called as *Erwinia chrysanthemi*). Dickeya sp. is the only strain of bacteria that is known to cause disease in pineapple. Infected young leaves in the central appear water-soaked. These water-soaked areas will form brown streaks and eventually transform into blister like lesions. After a few days, the meristem will be dead. Inoculum is assumed to have come from the infested juice of collapsed fruit. Ants, wind and wind-blown rain brings the bacteria into the stomata of nearby pineapple plants. Losses due to bacterial heart rot differ from cultivar-to-cultivar with 'Smooth Cayenne' being more resistant than the Spanish type cultivars. Sanitation is one of the most important measures for preventing the introduction of the bacteria into new areas and in avoiding low incidences of bacterial heart rot in a field from creating an epidemic. Infected plants should be destroyed or removed fully from the field. Crowns or slips from plants with symptoms of heart rot or from an area having high incidence of heart rot should not be used as planting material. Chemical control is reportedly not an option (Assumi, Singh and Jha, 2021). Leaf blotch (*Pestalotia microspora*), anthracnose (*Colletotrichum ananas*), leaf spot (*Phytophthora* spp.), yellow spot (tomato spotted wilt virus transmitted by thrips from alternate weed host like Emilia sanchifolia) are some other diseases infecting pineapple (Assumi *et al.,* 2021).

Pre-cooling and cold storage (DMS, 2025).

Pineapples are very sensitive to temperature. Before storing in cold store, fruit needs to be pre-cooled by forced air cooling at below mentioned temperature ranges:

Ripe or half ripe – 7-10oC
Mature green – 10-13oC
Humidity should be around 85-90%.
After pre-cooling, the fruits packed in CBF boxes need to be stored in cold store in temperatures mentioned for pre-cooling (DMS, 2025).

Post-Harvest Handling

Includes careful handling to prevent bruising, proper storage conditions, and efficient transportation to markets to maintain fruit quality (Agropedia, 2025). Shelf life of pineapple depends upon a number of factors like time of harvest, stage of harvest and method of cutting stem end. It has been observed that harvesting in the morning hours, cutting the stem end smoothly and harvesting at designated maturity stage help in providing better quality fruits. Pineapple must be harvested in cool hours either in the morning or in the evening. While harvesting, stem end must be cut smoothly and should not be more than 2 cm long (DMS, 2025).Pineapple is the second harvest of importance after banana, contributing to over 20 percent of the world production of tropical fruits. By definition, postharvest handling begins at harvest. The harvested fruit should be deposited in drawers and transported to the packing plant, where it is submerged in the disinfectant trays. Another alternative process consists of submerging the fruits completely in antifungal solution. This process is used especially for export to United States and Europe. A careful crop handling and postharvest contributes to the maintenance of the quality of the produce.

Selection and care: Pineapple fruit must be well ripened, good formation, well developed eyes, free of decomposition, scald caused by sun, free of injuries caused by contusions, burns, insects or mechanical injuries. The base should be well cut with a sharp knife. The leaves should be of the same colour, singular, more or less right, well stuck to the fruit, there 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 fruit is initially assessed by 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 colour, the crown must be very green and well developed (Assumi *et al.,* 2021).

Grading: After pre-grading, washing, waxing and fungicide treatment, the pineapple fruits are left to dry and then graded for packing. Graders remove any fruit that show signs of damage or any of the conditions that qualify the fruit for rejection in the pre-grading stage. Remaining pineapples are classi□ed for packing based on size, stage of ripeness and if applicable, shape (Assumi *et al.,* 2021).

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 corrugated fibre boards (CFB), this is not possible and fruit are laid horizontally in alternating directions where two layers of fruit are packed and a layer of card is placed between the layers depending on weight of the fruit mentioned as follows.
1. 6 count layer for 1.75 kg fruit (3.8 lb).
2. 12 count layer for 1.25 kg fruit (2.7 lb).
3. 12 count for 1.00 kg fruit (2.2 lb).
4. 20 count layer for 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). 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 emitted from the fruits. Fruits are also packed in woven bamboo baskets commonly cushioned with paddy straw. In Northeast India, pineapple fruits are rarely packed for marketing. The fruits are loaded in open truck and unloaded in to heaps/piles at market places and sold as such. Eventually, the post-harvest loss is very high. Improved corrugated fibre board boxes for pineapple has been developed for long distant transportation by truck (1000 km) and rail (2500 km). This CFB boxes drastically reduced the losses during transportation (Assumi *et al.,* 2021).
Storage: Fruits are pre-cooled to remove □eld heat and slow down the physiological processes. Low temperature storage extends the shelf life of fresh pineapple fruits. In tropical climate, pineapple could be stored for more than 20 days at 10 to 13°C. Fruits of Cayenne and Queen harvested at the optimum stage stored well at 10°C for 7 weeks with a shelf life of 10 to 14 days. The ascorbic acid content of pineapple fruits decreased with duration of storage at room temperature. Treatment of fruits with NAA at 100 ppm immediately after picking resulted in prolonged storage life even at unfavourable temperature (Assumi *et al.,* 2021).

Processing and Value Addition: Traditionally pineapple is consumed fresh or canned fruit. However, pineapple is now consumed in the form of single strength or concentrated juice, dehydrated and/or sugared, canned in slices or bits. 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. Pineapple pieces can be mixed with other fruits to prepare fruit cocktails, which entail another commercial alternative. Processing plants reject fruits with bruises, defective heart or multiple crowns. Porosity should be minimal, the total soluble solids (°Brix) to acidity ratio
should be near 20 and acidity should be kept close to 0.75%. In average, the yield in processing ranges from 45 to 55%. Adequate thermal treatment and final pH value of the product are key factors to assure product quality. There is a wide range of packaging materials that can be employed for packaging purpose viz. cans, glass jars, tetra packs, low density polyethylene, high density polyethylene, polypropylene, metalized polyester (Assumi *et al.,* 2021).

Pineapple is a versatile fruit with various processing possibilities. One of the most important products is canned pineapple slices, which are utilized as desserts or ingredients in other dishes. The canning process involves peeling, slicing, and heat treatment to ensure product stability and extend shelf life. Another popular product is pineapple juice, which can be consumed fresh or used as a base for other beverages. Pineapple juice can be obtained by extracting the juice from the fruit or by reconstituting from concentrates. Additionally, pineapple can be utilized in the production of jams, jellies, and other confectionery items, thanks to its unique flavor and aroma. These products have potential for both domestic and export markets, contributing to the valorization of the fruit (Agropedia, 2025).

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% which allows the dried fruit longer shelf life. Proper packing and storage is done in a fresh and cool place (Assumi, Singh And Jha, 2021).

Juice, nectar and concentrated frozen juice: Pineapple juice is obtained from crushing fruit pieces and proper physical separation of the solids. 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. Juice from other fruits can be blended with pineapple to make interesting mixtures for development of novel products. Concentrated frozen juice is prepared by direct application of heat to pineapple juice to reduce its water content. No chemical additives are used (Assumi *et al.,* 2021).

Concentrated frozen and aseptic pulp: It is the product prepared by thermal treatment of the pulp from which at least 50% of the initial water is removed. Concentration and freezing are applied to preserve the pulp for extended period 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 is the pulp that is heat-sterilized and packed aseptically. No chemicals are added and it has a long shelf life. There are specific equipments to perform these processes and it is considered to be at the cutting edge of technology (Assumi *et al.,* 2021).

Jelly, jam and marmalade: Jelly, jam and marmalade fall in the group of fruit preserve which are defined as semi-solid. Usually, jellies are prepared from fruit juice and a gel-type product is obtained. Jam is prepared from fruit pulp and marmalade is semi-fluid which contains fruit pieces. Final textural firmness is dependent of the type of gel-forming agent as pectin which is added under controlled acidity and solid content to assure the proper texture of the product. To assure proper shelf life at ambient temperature, preservatives may be added (Assumi *et al.,* 2021).

Filling, preserve and candy: Pineapple pieces mixed with bakery cream may be used as cake fillings for institutional service and large-scale production of bakery goods. Due to its high nutrient and water content, shelf life is not very long. Pineapple is very suitable to make preserve and candy which are impregnated with heavy sugar syrup and subsequently drained free from syrup and dried. In case of preserve, the fruit pieces become tender and transparent (Assumi *et al.,* 2021).

Wine and vinegar: Pineapple makes a flavourful wine which is obtained by fermentation of the juice. Peel and pineapple by-products from processing can be used as raw materials to prepare natural vinegar, by acetic fermentation which makes a proper use of residuals (Assumi *et al.,* 2021).

Valorizing waste: The waste from pineapple processing industry constitutes 50% of the total fruit and includes crown, peel, core, pomace (after juice extraction), trimmings and shreds. The solid waste and liquid sludge rich in organic material, carbohydrates and fibre poses an environmental problem with its disposal, and has been largely investigated for extraction of bromelain, ethanol, vinegar, citric acid, methane and antioxidant compounds. Pineapple bran, the dried rag of pulp after juice extraction is reported to be good cattle feed. Densification of pineapple waste with roughage based crop residues can be achieved to deveop compact blocks foe use as animal feed. This process has huge potential as an alternative livestock feed resource (Assumi *et al.,* 2021).

Industrial and Export Potential: Two cultivars of A. comosus are grown commercially in Australia: a spiny leaved small fruit type 'Queen' and smooth-leaved medium fruit type 'Cayenne'. In Queensland, clonal selection began in 1950 when 100 plants were selected from commercial fields. Four clones of Smooth Cayenne (C8, C10, C13 and C30) along with Hawaiian clone 'Champaka F180' were eventually released into the industry in 1975. Other clones selected by private growers and established include 'Ripley Queen', 'Alexander' and McGregor' obtained from the cultivar 'Queen'. After 20 years of breeding and testing, the Queensland Department of Primary Industries released a dual purpose cultivar named the 'Queensland Cayenne' in 1975. Other cultivars bred for the fresh fruit market include Mareeba Sweet, Mareeba Gold, Golden circle premium gold and Bethonga Gold which characteristically have low acid levels and true pineapple taste (QMPI&F 2007). 'Aus-Jubilee' is a new variety of pineapple (at its first stage of commercialisation) selected for its high sugar, vitamin C content (twice that of Smooth Cayenne), aromatic flavour, firm flesh and colour (CA, 2008).

Fruits harvested from the field are placed in trucks crown side down and up to 3 layers from top to bottom. It is essential to avoid fruit overheating both in the held as well as during transport and handling. Harvested fruits are brought to the packing plant, cleaned and coated with a mixture of fungicide and liquid wax. For global market, pineapple is categorized as:

Pineapple (*Ananas cosmosus* L. Merr.) 529

1. US select (10 fruits of 1.40 to 1.80 kg)
2. No. 1 (8 fruits of 1.81 to 2.00 kg)
3. No. 2 (6 fruits of 2.01 to 2.50 Kg)

Packing for export market is done in a one-piece box build of telescopic which is capable of holding 9 kg or 18 kg. To get better fruit strength during transport and prevent any mechanical damages, pineapple which are at 1/4th ripening stage (yellow colour at the base of the fruit covering around 25% of the surface) are selected. Transportation temperature and relative humidity should be 7 to 13°C and 85 to 90%, respectively. Care should be taken to avoid chilling injury which occurs at below 7°C storage temperature. Waxing can be done for the fruits to change internal O2 and CO2 concentrations of the fruit in such a way to reduce the occurrence and severity of endogenous brown spot. Marine transportation is the main form of managing pineapple for international trade. It is the most economical and specialized means for handling large amount of fresh produce. Refrigerated containers are constructed with standard dimensions of 8x8 feet wide and either 10, 20, 30 or 40 feet long. The most widely used containers are those with 40 feet long and then with piers 20 feet long. Transport by truck (shipping door to door) is a preferred way of handling pineapple but differing to the other systems in smaller volume and relatively shorter distances. Transportation of international cargo by ground is used for moving products between neighboring countries and as a supplement to sea transport to mobilize containers to/from shipping ports (Assumi *et al.,* 2021).

Trade and Marketing: Transnational's most often have their commercial representations in recipient countries or groups of recipient countries for their produce so they integrate to form an entire circuit, from production to marketing. This integration enables better control of quality and has a direct hold on recipient markets with large volume under their control, they will have different dealings with the big distribution groups. This market scheme covers the majority of pineapple volume on the market. Self-governing producers that do not market their fruits via big groups, follow a short circuit, shipping their produce and products to an importer which will handle distribution to the supermarket sector and

also to wholesalers. The processed produce market structure is different from the fresh produce market structure and marketing takes place downstream to the supermarket sector and also to the wholesalers (Assumi *et al.,* 2021).

Market Analysis and Strategy: Pineapple is mostly consumed fresh. There is large demand of pineapple products within the country. Bulk of the total production is consumed in institutional sector namely defence, hotels and airlines. Household consumption of these products is very limited. The major exporting countries of fresh pineapple are Philippines, Mexico, Brazil, Taiwan, Malaysia and South Africa. Leading importing countries are France, Japan, USA, Italy, Germany, Spain, UK and Canada. The trend in export of fresh pineapples from India has increased considerably from 138 tonnes in 1999-2000 to 837 tonnes in 2001-02. U.A.E., Saudi Arabia, Oman, Nepal are some of the important countries importing pineapple from India. Even though pineapple exports have been showing an upward trend, there is no consistency in our exports which is not a desirable feature, as continuous supply to a market is one of the foremost pre-requisites for successful exports. About 70% of the produce was exported during 2001-02 (NHB, 2025).

Storage: In Australia harvest is mechanically assisted and usually undertaken before ripening. Pineapples are harvested and placed in bins for cannery processing. Such collected fruits may be accumulated at roadways for transfer to trucks or loaded directly for transportation to canneries or to a central location for trade (Bartholomew *et al*. 2003). Once harvested, fruits are susceptible to sunburn and therefore should not be placed in direct sunlight for more than an hour. Fruits for the fresh market are harvested without crowns and a short length of peduncle attached. For the best fruit quality it is preferable to harvest fruits when ripe. To help retain fruit quality cut fruits may be waxed and treated with fungicide to reduce black rot (CA, 2008).

Transport: The main issues that affect pineapple fruit quality are damage due to bruising during loading, transportation, unloading and conveying. Air and road transportation up to 2 days does not require refrigeration; however fruit quality is retained and improved if refrigerated after picking. Fruits should be refrigerated at temperatures between 7.1ºC to 10ºC if they are to be transported for more than 3 days (Bartholomew *et al*. 2003). Fresh fruits are transported at 15ºC from Queensland to other states by rail or road with the major markets being Brisbane, Sydney and Melbourne. Significant quantities are also transported to Adelaide, Perth, Hobart and Darwin. Air transportation of pineapples is mainly to neighbouring countries like New Zealand and Hong Kong (CA, 2008).
Some buyers prefer green fruit, others ripened or off-green. A plant growth regulator, Ethephon, is typically sprayed onto the fruit one week before harvest, developing ethylene, which turns the fruit golden yellow. After cleaning and slicing, a pineapple is typically canned in sugar syrup with added preservative. A pineapple never becomes any riper than it was when harvested since it is a non-climacteric fruit (Wikipedia, 2025).

Products: Wine: Pineapple (*Ananas comosus*), a leading member of the family Bromeliaceae, comprises about 2000 species, mostly epiphytic and many strikingly ornamental, and varies from nearly white to yellow in color. It is an herbaceous perennial plant that grows to 1.0–1.5 m tall with 30 or more trough-shaped and pointed leaves, 30 cm long, surrounding a thick stem. It is a multiple fruit, forming what appears to be a single fleshy fruit. Pineapples contain good sugar proportions, which make it suitable for making wine. Pineapple juice generally has TSS in the range 12–15 °Bx; the sugar content is raised by the addition of sugar up to 22–25 °Bx to produce a wine having 12–13% alcohol. However, the flavor of pineapple is not stable and oxidation can occur easily. . Wine from two cultivars, Kew and Queen, was prepared and it was observed that nitrogen and phosphate are very important in the production of good quality pineapple wine. The wine produced from the Kew variety inoculated with Saccharomyces *ellipsoideus* 101 recorded the highest percentage of alcohol (8.40%) followed by wine from the Queen variety inoculated with the same strain (8.35%). An organoleptic evaluation was carried out by a selected panel of judges based on the 20-point scale. Wine produced from the Queen variety fermented with *S. ellipsoideus* 101, when supplemented with both N and P sources, recorded the highest score (16.75 of 20.00), followed by the SPQ4 yeast variety (14.75 of 20.00), whereas the lowest score was recorded by wine prepared from the Kew variety inoculated with SPQ3 (13.00 of 20.00). Produced a pineapple wine using single and mixed non-*Saccharomyces* yeasts and suggested that Queen pineapple juice could be a good substrate for yeast fermentation. The yeast isolates Saccharomycodes *ludwigii* and Hanseniaspora used as mixed starter cultures could perform appropriate alcoholic fermentation for Queen pineapple wine production (Wijeratnam, 2016a).

Juice: Pineapple (*Ananas comosus*) is a tropical fruit and it is the most economically significant plant in the Bromeliaceae family. The largest producer of pineapple in the world is Costa Rica, closely followed by countries like, Brazil, Philippines, Indonesia, and India. It is a rich source of vitamins, primarily vitamin C and vitamin B_6. Pineapple juice also contains a huge array of bioactive compounds, like gallic acid, tyrosine, genistin, chlorogenic acid, epicatechin, chavicol, and many others. Some studies for combined depectinization and subsequent membrane based clarification are presented herein. Clarified wild cherry and pineapple juice using Citrozym Ultra-L enzyme. The optimum enzyme concentration for pineapple juice was found to be 20 mg/L, at 40°C for 60 minutes. The resulted juice was then further processed using a ceramic tubular membrane and a PSF hollow fiber membrane of 100 kDa MWCO. It was observed that the recovery of ascorbic acid was much higher in the case of PSF membrane. Also, depectinization led to higher clarity and lower viscosity in case of pineapple and hence, the productivity had increased manifold in case of both hollow fiber and tubular membranes (Karmakar and De, 2019).

REFERENSES

Agropedia. 2025. Pineapple. https://theagropedia.com/fruit-science/pineapple/SA

AI. 2025. AI Overview. https://www.google.com/search?q=botanical+description+of+ananas+comosus& sca_esv=4046c 8606466af68 &sxsrf=AE3TifO8syH0PJYTtOV_kZU780hJmg9HSw%3

AI. 2025. AI Overview. https://www.google.com/search?client=firefox-b- Food Res Int Ali, M.M., *et al*., 2020. Pineapple (Ananas comosus): A comprehensive review of nutritional values, volatile compounds, health benefits, and potential food products. Food Research International, 137, Article ID: 109675.

Ali, M. M., *et al*., 2020a. Pineapple (*Ananas comosus*): A comprehensive review of nutritional values, volatile compounds, health benefits, and potential food products. Food Research International 137(3):109675

Annalisa, D. 2025. Pineapple. Singapore Infopedia. https://www.nlb.gov.sg/main/article-detail?cmsuuid=dffa2769-f0ca-489b-b292-135a3c3a9fb1

Apsnet . 2025. Pineapple. http://www.apsnet.org/apsstore/shopapspress/Pages/41620.aspx. *Available for purchase from APS Press*.

Arora, R., *et al*., 2013. Medicinal Efficacy of Indian Herbal Remedies for the Treatment of Arthritis.
Bioactive Food as Dietary Interventions for Arthritis and Related Inflammatory Diseases

Assumi, S.R., Singh, P.T. and Jha, A.K. 2021. Pineapple (Ananas comosus L. Merr.). In: In: Tropical Fruit Crops: Theory to Practical. SN Ghosh and RR Sharma (Eds.). (pp.pp. 487-541.

CA. 2008. The Biology of Ananas comosus var. comosus (Pineapple). Commonwealth of Australia de Sousa, J., Carlier, J., Santo, T. and Leitão, J. 2013. An integrated genetic map of pineapple (Ananas comosus (L.) Merr.). Scientia

Horticulturae, 157:, 20 June 2013, Pages 113-118

DMS. 2025. Pineapple. https://www.jaivikkheti.in/DMS/training/PINEAPPLE.pdf

EEB. 2025. Pineapple. https://www.britannica.com/plant/pineapple

EW. 2025. *Ananas comosus* (L.) Merr. In: English Wikipedia - Species Pages<Gil, C.R. 2017. Ananas comosus. https://www.colegiobolivar.edu.co › 2017/06 › C...>Hassan,. *et al*., 2011. Pineapple (L. Merr.). Postharvest Biology and Technology of Tropical and Subtropical Fruits: Mangosteen to White SapoteA.

Hassan *et al*., 2011a. Pineapple (L. Merr.). Postharvest Biology and Technology of Tropical and Subtropical Fruits: Mangosteen to White Sapote

Karmakar, S. and De, S. 2019. Pectin Removal and Clarification of Juices. Separation of Functional Molecules in Food by Membrane Technology

Kazeem, M.I. and Davies, T.C. 2016. Anti-diabetic functional foods as sources of insulin secreting, insulin sensitizing and insulin mimetic agents. Journal of Functional Foods

Kyle Stice. 2021. An Introduction To Producing Pineapples. https://patricklepetit.jalbum.net/_agriculture/library/pineapple%20production.pdf

Lan, A. and Makhija, M. 2024. Encyclopedia of Food Allergy (First Edition). Volume 2

Li-Yu Chenm *et al*., 2019. The *bracteatus* pineapple genome and domestication of clonally propagated crops. Nature Genetics, 51: 1549–1558

Makaranga, A., *et al*. 2018. Diversity and genetic identity of pineapple [Ananas comosus (L.) Merr.] in Tanzania based onmarkers. African Journal of Biotechnology, 17(26): 811-817

Mokrini, F., *et al*., 2023. Nematode problems in tropical fruits and their sustainable management. Nematode Diseases of Crops and their Sustainable Management

Moore, G.A., DeWald, M.G. and Evans, M.H. 2025. Micropropagation of Pineapple (*Ananas comosus* L.). High-Tech and Micropropagation II. Part of the book series: Biotechnology in Agriculture and Forestry (AGRICULTURE,volume 18) pp 460–470

NHB. 2025. Pineapple. https://nhb.gov.in/report_files/pineapple/PINEAPPLE.htm

Pérez-López, A.V., *et al*., 2023. Humboldt Review: Tissue succulence in plants: Carrying water for climate change. Journal of Plant Physiology

Robledo-Márquez, K., *et al*., 2021. Research opportunities: Traditional fermented beverages in Mexico. Cultural, microbiological, chemical, and functional aspects. Food Research International

Rowan, A.D. 2013. Comosain.Handbook of Proteolytic Enzymes (Third Edition)

Sakthi vel. 2024. Pineapple. https://agriculture.vikaspedia.in/viewcontent/agriculture/crop-production/package-of-practices/fruits-1/pineapple-ananascomosus?lgn=en

Smith, L.G. 2003. Pineapples. Encyclopedia of Food Sciences and Nutrition (Second Edition)

Sun, G.M., *et al*., 2016. Nutritional Composition of Pineapple ((L.) Merr.). Nutritional Composition of Fruit Cultivars

Tabish. 2025. Pineapple. https://www.flowersofindia.net/catalog/slides/Pineapple.html

TFN. 2016. Pineapple – Introduction. https://www.itfnet.org/v1/2016/05/pineapple-introduction/

Ticomachine. 2025. Simple introduction of pineapple and the nutrition. https://www.ticomachine.com/faq/Simple-introduction-of-pineapple-and-the-nutrition.html

Toyin, Y.M., *et al*., 2014. Toxicity and Beneficial Effects of Some African Plants on the Reproductive System oxicological Survey of African Medicinal Plants

Wali, N. 2019. Pineapple (*Ananas comosus*). Nonvitamin and Nonmineral Nutritional Supplements. 367-373

Wang, J, S. , *et al*., 2017. Genetic Diversity in Various Accessions of Pineapple [Ananas comosus (L.) Merr.] Using ISSR and SSR Markers. Biochem Genet., 55(5-6):347-366.

Wijeratnam, W. 2016. Pineapple. Encyclopedia of Food and HealthS.

Wijeratnam, W. 2016a. Specific Features of Table Wine Production Technology. Science and Technology of Fruit Wine Production

Wijeratnam, W. 2016b. Nutritional Composition of Pineapple ((L.) Merr.). Nutritional Composition of Fruit Cultivars

Wikipedia. 2025. Description. https://en.wikipedia.org/wiki/Pineapple

WWW. 2024. Tastes Of History. https://www.tastesofhistory.co.uk/post/a-brief-history-of-foods-pineapple

****