Evaluation, Flowering behavior Physico-chemical and Keeping quality of Custard apple: A Review

ABSTRACT

Custard apple, scientifically known as Annona squamosa L., and also referred to as Sitaphal or Sharifa, holds significant importance as a dry land fruit crop in India. Its flowers, either solitary or in small lateral clusters, measure around 2.4 to 2.5 cm long, appearing greenish-yellow atop a hairy, slender 2 cm long stalk. Each carpel bears a single, hard, smooth, shiny, dark-brown or black, glossy seed, oblong in shape, and less than 1.3 to 1.6 cm long. The fruit of the custard apple is renowned for its delicious whitish pulp and is a popular item in tropical markets. Comprised of loosely cohering carpels, the fruit forms a surface that is either squamose or tuberculated. Its pulp, tinged with white and yellow, is edible, sweetly aromatic, and contains a thick, creamy-white layer akin to custard, with somewhat granular flesh beneath the skin surrounding the concolorous, moderately juicy segments. The fruit typically contains around 55 to 60 seeds. Custard apple is rich in vitamin C and antioxidants, which are known to combat various diseases and bolster the immune system. Consumption of custard apple is beneficial for heart health, skin, bones, and maintaining blood pressure. It is also known for its therapeutic effects on boils, ulcers, and gum-related issues. Custard apple has undergone evolution through both natural processes and human selection across diverse elevation zones and under different cropping systems. Honey bees, serving as carriers of cross-pollination, have contributed to the wide variety of locally adapted landraces. Despite this diversity, there has been no systematic collection and evaluation of custard apple cultivars in various states. Therefore, there is an urgent need for the collection, characterization, and evaluation of high-yielding strains/lines suitable for commercial cultivation in regions like Chhattisgarh. Thus, the primary objective of this paper is to evaluate genotypes, flower behavior, and physico-chemical characteristics of custard apple, aiming to improve production and meet the satisfaction of farmers.

Key words:evaluation, flower behavior, physico-chemical, custard apple

INTRODUCTION

Custard apple (Annona squamosa L.), a member of the family 'Annonaceae' with a chromosome count of 2n = 14, has garnered considerable attention for its nutritional and medicinal properties worldwide. The immature fruits, seeds, leaves, and roots of custard apple hold significant medicinal value in both Ayurvedic and Yunani systems of medicine.

Rich in vitamin C and antioxidants, custard apple aids in combating various diseases and boosting the immune system. Its consumption is associated with curing numerous ailments and disorders, including heart conditions, skin issues, bone health, and maintaining blood pressure. Custard apple is also known for its efficacy in treating boils, ulcers, and gum-related problems. The leaves are believed to have anti-cancer properties, while the bark can alleviate toothaches and gum pain.

Moreover, custard apple offers several health benefits such as promoting a healthy heart, aiding in pregnancy, improving vision, relieving arthritis, combating fatigue, and preventing anemia. The edible portion, or pulp, is creamy and custard-like, with a pleasant flavor and mild aroma, making it universally appealing. It is rich in carbohydrates, with approximately 23.0 g per 100 g of fruit.

According to nutritional analyses, custard apple contains various essential nutrients such as moisture (70.5 g), protein (1.6 g), fat (0.4 g), minerals (0.9 g), fiber (3.1 g), calcium (17.0 mg), phosphorus (47.1 mg), iron (1.5 mg), thiamine (0.07 mg), riboflavin (0.17 mg), niacin (1.30 mg), and vitamin C (37.0 mg), with an energy content of 104 Kcal per serving.

The shedding of leaves during stress conditions serves as an escape mechanism, making custard apple cultivation feasible even in arid regions. However, organized orcharding of this crop is lacking. Thus, understanding the complexity of custard apple fruit yield and the association between yield component traits and yield itself is crucial for effective selection schemes.

Custard apple cultivation spans across various states in India, including Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Chhattisgarh, Karnataka, Bihar, Orissa, Assam, and Tamil Nadu, and is also common in China, the Philippines, Egypt, and Central Africa. Chhattisgarh and Maharashtra account for the majority of custard apple cultivation in India.

In Chhattisgarh, custard apple cultivation covers an area of approximately 7.990 thousand hectares, with an annual production of 39.73 metric tonnes and a productivity of 497.25 q/ha. The Kanker district stands out for its natural biodiversity of custard apple, hosting wild landraces distributed over an area of about 7.20 thousand hectares, with an annual production of 35.60 MT and a productivity of 494.45 q/ha.

The evolution of custard apple through natural and human selection, alongside the involvement of honey bees in cross-pollination, has resulted in a diverse array of locally adapted landraces. These landraces have evolved over time to suit local cropping patterns and various end uses, representing a broad spectrum of crop diversity. Understanding genetic variation and assessing genetic variability for yield and its components are crucial for planning future germplasm exploration missions and improving crop varieties.

Literature reviews focusing on the evaluation of genotypes, flower behavior, and physico-chemical characteristics of custard apple provide valuable insights into its cultivation and potential for improvement. In this chapter, we aim to present a comprehensive review of available literature in these areas.

1. Evaluation of genotypes

2. Flowering behavior

3. Physico-chemical characters of fruits

4. Keeping quality (Shelf life)

1. Evaluation of genotypes

The objectives encompass the development of new high-yielding commercial varieties of custard apple (Annona squamosa L.) with specific traits such as desired tree height and canopy spreading (dwarf/semi-dwarf), fruit weight (450-500g), optimal fruit size with a higher pulp-seed ratio and fewer seeds (30-35), seeded or seedless pericarp, enhanced keeping quality, and resistance/tolerance to biotic stress (mealy bug) and abiotic stress (fruit cracking, moisture stress, and climate changes).

Literature pertaining to the evaluation of genotypes relevant to these objectives has been thoroughly examined:

1. Cultivar Performance: Studies show that the mean marketable yields of custard apple cultivars, such as African Pride and Pinks Mammoth, vary based on rootstock and location. For instance, African Pride exhibits satisfactory yields without hand pollination, while rootstocks like sugar apple present dwarfing characteristics but are susceptible to certain pathogens.

2. Environmental Influence: Temperature and drought significantly affect custard apple growth, flowering, and fruit development. Optimal temperatures range from 17-22 ºC, while mild to moderate drought during flowering enhances flowering without adversely affecting fruit set, although it reduces fruit size.

3. Cultivar Evaluation: Various hybrid custard apple cultivars have been evaluated for fruit characteristics and quality. Promising hybrids exhibit desirable traits such as early maturity, high fruit weight, low seed content, and good shelf life, making them excellent choices for cultivation.

4. Cultural Practices: Investigative efforts have assessed the effects of irrigation, mulching, and hormonal treatments on custard apple yield and quality. Results indicate that irrigation and mulching positively influence fruit weight, while fruit composition remains largely unaffected by treatments.

5. Trait Evaluation: Several traits including fruit weight, seed number, pericarp weight, and fruit yield have been evaluated across cropping seasons, providing valuable insights into the variability and stability of these characteristics.

6. Organized Farming Suitability: Studies conducted at research centers suggest that custard apple cultivation in organized orchards results in higher pulp yield and favorable chemical properties, indicating its suitability for commercial farming endeavors, the comprehensive evaluation of custard apple genotypes and the factors influencing their growth, yield, and quality provide crucial insights for the development of improved cultivars and the optimization of cultivation practices in different regions.

2. Flowering behaviour

Flowering behavior plays a crucial role in custard apple fruit setting, primarily because Annona species are cross-pollinated due to protogyny, and flowering typically occurs from the last week of June to the last week of July. The intricate process involves numerous stamens and carpels, with pollination primarily facilitated by nitidulid beetles.

Studies on custard apple flowering behavior have yielded insightful findings:

1. Cv. Sahebganj Flowering: Observations on custard apple plants, particularly cv. Sahebganj, revealed a flowering period spanning from March to August, with peak flowering occurring in April and May. Buds transitioned into flowers within 35 days. Fruit set, albeit low (8%), commenced in August under optimal climatic conditions. Anthesis primarily occurred between 5:30 p.m. and 5:30 a.m., with maximum dehiscence observed between 11:30 a.m. and 2:30 p.m. The highest pollen germination rates (16-25%) were noted in a 20% sucrose-agar solution.

2. General Flowering Patterns: In custard apple, the flowering season typically extends from February to September. Flowers predominantly emerge from new flushes following the shedding of older leaves. Anthesis occurs between 02:30 hr and 18:30 hr, peaking around 05:30 to 06:30 hr. Pollen dehiscence initiates 10 hours post-flower opening and lasts for only 2 hours. Stigmas remain receptive from one day prior to anthesis until 2-3 days after anthesis, suggesting a protogynous condition.

3. Pollen Morphology and Fruit Set: Investigations into custard apple pollen morphology, pollination, and fruit set under northeast climatic conditions revealed variations in pollen grain size and viability across different months. Fruit set through open pollination ranged around 3.33%, while controlled self-pollination resulted in a significantly lower fruit set of 0.75%.

4. Supplementary Pollination: Low natural pollination rates in commercial orchards of custard apple cultivars led to few and poorly formed fruits. Supplementary pollination, particularly using pollen from cv. African Pride trees, significantly increased overall fruit production and quality. Interestingly, cv. African Pride pollen resulted in larger and more symmetrical fruits compared to cv. Hillary White pollen, without compromising quantity.

In summary, understanding custard apple flowering behavior, pollination dynamics, and fruit set mechanisms is essential for optimizing fruit production and quality in commercial orchards. Various factors such as pollen viability, pollinator activity, and supplementary pollination strategies can significantly impact fruit yield and quality in custard apple cultivation.**3. Physico-chemical characters of fruits**

Custard apple is no longer poor man's fruit as it fetches an even higher price than several other fruit because the fruits are very sweets, nutritious, very perishable in nature and other all parts are used as a medicine purposes.

compared two types of fruit of custard apple (*Annona squamosa*)with regard to berry weight, specific gravity, acidity and the content of total, reducing and non-reducing sugars and also that seeded berries were larger and had a higher sugar content (Mazumdar 1977). Assessed changes in the fruit size of *Annona squamosa*, at an intervals from 20th August to 18th November, and on the physical characteristics and chemical composition of mature fruits and reported that ascorbic acid content was 1.10 mg/100 g (Singh *et al*. 1977).Reported that the number of fruits per tree, number of seeds per fruit, specific gravity and total sugar content were significantly higher, and the peel weight was lower, with 240 g/plant of each fertilizer in custard apple. Both

rates of fertilizer caused a significant increase in the diameter, DM percentage, TSS, vitamin C and reducing sugar percentage, compared with the control (Chattopadhyay and Mandal 1993). Studied fruit ripening after harvesting in cherimoya and demonstrated a respiratory climacteric associated with rapid ethylene production. The increase in ethylene production was caused by an increase in the activities of ACC-synthase and ethylene-forming enzyme (EFE), which were very low in the freshly picked fruits, but increased rapidly over the second day e=reaching a maximum on the third day. During the climacteric there was also a low amount of I-aminocyclopropane-I-carboxylic acid (ACC) in its conjugated form. Rind browning increased after harvesting, but this was not related to decrease in chlorophyll, since the chlorophyll level remained stable throughout the entire post harvest period. The level of browning correlated well with the Hunter L Value. The onset of ethylene production, starch degradation, loss of firmness and acceleration of total sugar all coincide (Martinez *et al*. 1993). observed that the fruit growth and development of 10 year old*Annona squamosa* trees (cultivars Barbadose Seedling and Washington-97), grown at Hessaraghatta Experimental Station (Karnataka, India), was monitored at 15 days intervals from flowering to harvest maturity (120+or-5 days after flowering) and physiological maturity (2-5 days after harvest maturity). Fruits showed a double sigmoid growth curve and exhibited climacteric respiration. Changes in fruit weight and size, the pulp-peel ratio, DM accumulation, TSS, insoluble solids, sucrose, glucose, fructose, citric acid and peel chlorophyll and vitamin and mineral contents were observed. The sugar-acid ratio and the appearance of a yellow colour in the edible pulp appeared to be reliable harvest criteria of custard apple (Pal and Kumar 1995). Evaluated the custard apple (*Annona squamosa*) fruits harvested at the normal time or 2 or 5 days earlier and then stored at 25-33 degrees C and 85-90% RH. The soluble solids content, total acids and vitamin C content of stored fruits were determined. The results showed that for immediate consumption, the best harvest date was when the fruit soluble solids content reached 15-20%. Otherwise, the harvesting should take place 2-3 days earlier, when the fruit soluble solids content reached around 10% (Chen WeiHui 1999). Conducted physico-chemical studies of 4 year old grafted trees of custard apple (*Annona reticulata*) cultivars Atemoya, Balanagar, Chance Seedling, Iceland Gem, Washington, and Jargham Local in West Bengal, India during the year 2000. Balanagar exhibited the highest fruit weight (300 g), fruit length (8.3 cm), fruit diameter (9.0 cm), number of seeds per fruit (35), earliest maturity date i.e. October and content of total soluble solids (27.0 º Brix), reducing

sugar (11.8%), non-reducing sugar (4.7%), total sugar (16.7%) and ascorbic acid (54.4 mg/100 g pulp). Atemoya and Chance Seedling exhibited the highest acidity (0.32%) content and number of seedless berries per fruit (48), respectively (Ghosh *et al.*2001). reported that they identified high-yielding cultivars of custard apple (*Annona squamosa* L.) with quality and shelf life. Six existing promising hybrids were evaluated at the Fruit Research Station, Sangareddy. Among all the hybrids, maximum TSS ranged from 22 to 28 degrees B and was found to be maximum in Hybrid-2 (15/2 Red Sitaphal x Pond apple), while the seed content per fruit was also minimum (20) in this hybrid. Based on overall performance, the Hybrid-1 (17/4 Atemoya x Balanagar) and Hybrid-3 (15/3 Red Sitaphal x Atemoya') and Hybrid-2 (15/2 Red Sitaphal x Pond apple) were found to be excellent in quality with pleasant aroma, smooth pulp texture with less seed, good sugar acid blend and shelf life (Girwani *et al.*2011).

4. Keeping quality (Shelf life)

Custard apples are mostly consumed as table fruits. They are also used in ice creams and other milk products and preserved as jam, jelly or other products on limited scale. Edible portion or pulp is creamy or custard like, granular with a good blend of sweetness and acidity which vary with the species. The pleasant flavour and mild aroma have a universal liking. Custard apple fruit is nutritional rich and largely valued for its taste.

Revealed that the *Annonasquamosa* fruits ripened normally in storage at 15 to 30 ºC although fruits were susceptible to fungal attack at >25 ºC. Ripening was enhanced by removal of CO_2 and by addition of O_2 to the storage atmosphere and delayed by addition of CO_2 and removal of O_2. Ethylene had no apparent effect on ripening. Fruits stored at low RH ripened faster than those at high RH. Dipping the fruits in IAA at 10^{-4} to 10^{-2} M accelerated ripening. Levels of both ascorbic acid and glucose increased to a maximum at the climacteric, but decreased as the fruits became overripe. The stage of eating ripeness occurred at the climacteric. Recommended conditions for storing custard apple are: temperatures between 15 and 20 ºC, low oxygen and ethylene tensions coupled with 10% CO_2 and 85-90% RH (Broughton 1979). reported that the organoleptic evaluation is overall acceptability methods for quality evaluation of fruits and vegetable in which nine point Hedonic rating test is adopted for pulp, juice, Ready to Serve (RTS), nectar, jam, jelly and vegetable products fresh or in different interval of storages by the panel of five judges (Ranganna 1986). Concluded that the processed products

were evaluated for colour, appearance, aroma, taste and overall acceptability. The product with score of '7' (like moderately) or above for overall acceptability was considered acceptable (Rabbani and Singh 1988). Observed that custard apple ripened most quickly and with good flavor at 28°C while ripening was slower and the quality impaired at 32°C. Fruit stored at 4°C and high humidity developed symptoms of chilling injury after 2 days, although even after 5 days at 4°C fruits ripened at 20°C with very good flavor. Fruits withstood 5 days at 8°C without detectable deterioration in appearance or flavor, but the total post harvest life of 9 days hardly better than at 12°C (8.5 days). At 12°C, fruits deteriorated in appearance after >6 days, although the flavor remained very good up to 10 days. The maximum TPHL achieved without significant damage to fruit was 9.4 days, with 6 days at 12°C followed by ripening at 20°C or 9.1 days, with 5 days at 8°C. This compares with a ripening time of 4.8 days at 20°C (Batten 1990).Observed that the most effective treatments for prolonging the shelf life of fruits were; brown paper wrapping, followed by dipping in gibberellic acid (GA) and polyethylene bagging + KMnO4. Ethrel (ethephon) and hot water treatment enhanced ripening of fruits compared to the control and other treatments. The lowest fruit weight losses were recorded in polyethylene bagging + KMnO4, perforated polyethylene bagging and brown paper wrapping treatments. GA (100 or 200 ppm), brown paper wrapping and polyethylene bagging + KMnO4 also maintained high sugar and ascorbic acid contents and low acidity during storage for up to 10 days at 32 ºC and 70-75% RH, after a variety of treatments. Some fruits were also stored at 10 ºC and 85-90% RH (Bhadra and Sen 1997).Reported that the ripening of fruits was observed on 4, 6 and 9 days of storage at 25, 20, and 15 ºC, respectively. The colour of the pulp, texture, taste and flavour of ripe fruits held at 25 and 20 ºC were superior, followed by fruits stored at 15 ºC. At 10 ºC, the fruits became hard with surface blackening, messy pulp and less sweetness. The major changes during ripening were a continuous decrease in fruit firmness and starch content and a continuous increase in TSS and sugars, the changes being more rapid at 25 and 20 ºC than at 15 and 10 ºC. Custard apple fruits stored at 25 and 20ºC had a clear climacteric peak whereas those stored at 15 and 10 ºC did not show any distinct rise in respiration rate. Ethylene peak (2.40 micro kg^{-1} h^{-1}) coincided with the respiratory climacteric at 25ºC storage, corresponding with the peaks in TSS, sugars, ascorbic acid and acidity (Prasanna *et al*. 2000).revealed that fruits such as papaya, banana, ber (*Zizyphus mauritiana*), guava, mango, sapota (*Manilkara zapota*), citrus fruits, custard apple (*Annona reticulata*) and pomegranate can be stored safely for certain period under

ambient temperature as well as in cold storage with the help of postharvest treatment with certain ripening retardants such as fruit coating resin (Waxol), gibberellic acid (GA_3, $CaCl_2$, $KMnO_4$ and Cycocel (chlormequat) at their appropriate concentration. Ripening retardants prolong shelf life of fruits, reduce weight loss, spoilage and maintain higher percentage of marketable quality fruits up to a certain period of time thereby overcome glut in markets during peak season and give higher returns to growers and traders (Singh,2003).Reported that the Custard apple (*Annona squamosa* L.) is delicious fruit of the tropics and has been naturalized in the Deccan plateau due to its hardy nature.Under an *Annona* improvement programme, six existing promising hybrids were evaluated for different horticultural traits from 2001 to 2006 at the Fruit Research Station, Sangareddy. All the hybrids varied in fruit shape (round, conical and cordate), fruit colour (yellowish-green, grayish-green, light green and red), pulp colour (creamy white, light pink and white), areole shape (tuberculate, hexagonal) and texture (course, soft and meaty). Time of fruit maturity varied from September 2nd fortnight and lasted till the end of December. Hybrid-1 (17/4 Atemoya x Balanagar) was earliest to mature. Maximum fruit weight (250 g) was recorded in Hybrid-1 (17/4 Atemoya x Balanagar) followed by Hybrid-6 (15/3 Red Sitaphal x Atemoya) (225 g) and Hybrid-4 (1/6 British Guinea x Atemoya) (220 g). Among all the hybrids, maximum number of fruits per tree (94) was recorded in Hybrid-1 (17/4 Atemoya x Balanagar) followed by Hybrid-6 (15/3 Red Sitaphal x Atemoya) (67). The TSS ranged from 22 to 28 degrees B and was found to be maximum in Hybrid-2 (15/2 Red Sitaphal x Pondapple), while the seed content per fruit was also minimum (20) in this hybrid. Based on overall performance, the Hybrid-1 (17/4 Atemoya x Balanagar) and Hybrid-3 (15/3 Red Sitaphal x Atemoya) and Hybrid-2 (15/2 Red Sitaphal x Pondapple) were found to be excellent in quality with pleasant aroma, smooth pulp texture with less seed, good sugar acid blend and shelf life (Girwani *et al.*2011). conducted an experiment with custard apple (*Annona squamosa*) fruits dipped in cold water for 5 min, $CaCl_2$ at 2% for 10 min, $KMnO_4$ at 4% for 10 min and smeared with mustard oil, then placed in polyethylene bags (150 and 200 gauge) with (0.5%) or without ventilation. Untreated fruits served as the control. Data were recorded on fruit specific gravity, storage life, physiological losses in weight, taste, colour, flavour and acceptability (Nagaraja 2011).revealed that the custard apple fruits treated with NAA 100 ppm as well as GA_3 50 ppm were found most effective in extending the shelf-life, respectively over control (by 1.75 and 1.42 days), while they helped in maintaining the marketability and tended to reduce the fruit weight loss. The level of acidity and

ascorbic acid decreased, while reducing and total sugars increased with advancement of storage period. Application of NAA 100 ppm was more economical than other no chemicals (Nilam *et al.*2011).Conducted an experiment during 2006-07 to assess the effect of different packages and storage systems for enhancing shelf life of custard apple fruits. They reported that the shelf life of custard apple fruits was 6 days in ventilated polyethylene package and it was 8 days in silicon membrane and diffusion channel systems at 20 ºC. In 15 ºC, the storage life was increased 8 days in ventilated polyethylene followed by 10 days in silicon membrane and diffusion channel systems. The shelf life of custard apple fruits under ambient temperature in ventilated polyethylene package was 4 days and in silicon membrane and diffusion channel systems, it was 6 days compared to control which could be kept well for only 2 days under ambient temperature (Mallikarjuna *et al*. 2012). evaluated the postharvest quality of custard apple (*Annona squamosa* L.) fruits under different treatments *i.e.,* unpacked (control), individually packed in polyvinyl chloride (PVC) film, or packed in expanded polystyrene trays enveloped in PVC film and tested during five periods of storage (0, 4, 8, 12, and 16 days) at 10ºC. Data of mass loss, pulp hardness, soluble solids, titratable acidity, pH, vitamin C and water activity were recorded at harvest and every 4 days over the storage period. Custard apple fruits stored at 10ºC and packed in PVC film had reduced mass loss. The modified atmosphere packaging also resulted in decreased loss of firmness, providing about a 12 days postharvest life. Soluble solids and total titratable acidity concentrations did not increase significantly during storage. The modified atmosphere allowed for a shelf life of 12 days at 10ºC (Silva *et al*. 2012).

Conclusion

This study evaluates genotypes, flower behavior, and physico-chemical characteristics of custard apple, aiming to improve production and meet the satisfaction of farmers. Custard apple fruits stored at 10ºC and packed in PVC film had reduced mass loss. The modified atmosphere packaging also resulted in decreased loss of firmness, providing about a 12 days postharvest life.

REFERENCES

Anonymous. 2013. Indian Horticulture Database. *National Horticulture Board*, India. pp: 6-14.

Barda, S. and Sen, S.K. 1997. Post harvest storage of custard apple (*Annona squamosa* L.) fruit variety Local Green under various chemical and wrapping treatments. *J. Interacademicia*, **1**(4):322-328.

Nweze, C. C., & Muhammad, B. Y. (2023). Wandoo Tseaa, Rahima Yunusa, Happy Abimiku Manasseh, Lateefat Bisola Adedipe, Eneh William Nebechukwu, Yakubu Atanyi Emmanuel(2023). Comparative Biochemical Ef-fects of Natural and Synthetic Pesticides on Preserved Phaseolus vulgaris in Male Albino Rats. *Acta Botanica Plantae*, *2*, 01-10.

Baskaran, K. and Muthiah, A.R. 2007. Associations between yield and yield attributes in custard apple (*Annona squamosa* L.). *J. Chemical and Pharmaceutical Res.***, 7**(2) pp: 312-318.

Batten, D.J. 1990. Effect of temperature on ripening and post harvest life of fruit of atemoya (*Annona cherimola* Mill *x Annona squamosa* L) cv. African Pride, Scientia *Horticulturae*, **45**(1-2): 129-136.

Rahgu, K., Choudhary, S., Kushwaha, T. N., Shekhar, S., Tiwari, S., Sheikh, I. A., & Srivastava, P. (2023). Microbes as a Promising Frontier in Drug Discovery: A Comprehensive Exploration of Nature's Microbial Marvels. *Acta Botanica Plantae. V02i02*, *24*, 30.

Broughton, W.J. and Tan, G. 1979. Storage conditions and ripening of the custard apple *Annona squamosa* L. *Scientia Horticulturae,***10**(1):73-82.

Chandra, A. 2010. Participatory approaches in precision farming. In: *Souvenir of National Seminar on Precision Farming in Horticulture*, College of Horticulture and Forestry, Jhalawar, p: 650-657.

Unnisa, S. A., Rao, B. B., & Vattikoti, P. (2022). Biochemical parameters of selected plants as air pollution indicators. *Acta Botanica Plantae*, 43-50.

Chattopadhyay, P.K. and Mandal, A. 1993. Studies on nutrition of custard apple (*Annona squamosa* L.). *J. Potassium Res.*, **9**(4): 375-379.

Chen Weihui 1999. Effect of harvest time on the storage quality of custard apple fruit. *South China Fruits*, **28**(4): 27-29.

George, A.P. and Nissen, R.J. 2002a. Effects of drought on fruit set, yield and quality of custard apple (*Annona spp*. hybrid) "African Pride" plants. *J. Hort. Sci. Biotechnology*, **77**(4): 418-427.

Touseef, M. (2023). Exploring the Complex underground social networks between Plants and Mycorrhizal Fungi known as the Wood Wide Web. *Plant Science Archives. V08i01*, *5*.

Ogori, A. F., Eke, M. O., Girgih, T. A., & Abu, J. O. (2022). Influence of Aduwa (Balanites aegyptiaca. del) Meal Protein Enrichment on the Proximate, Phytochemical, Functional and Sensory Properties of Ogi. *Acta Botanica Plantae. V01i03*, 22-35.

George, A.P. and Nissen, R.J. 2002b. Control of tree size and vigour in custard apple (*Annona spp.* hybrid) cv. African Pride in subtropical Australia. *Australian J. Experimental Agri.,***42**(4): 503-512.

Salam, M. A., Islam, M. R., Diba, S. F., & Hossain, M. M. (2019). Marker assisted foreground selection for identification of aromatic rice genotype to develop a modern aromatic line. Plant Science Archives

George, A.P., Broadley, R., Nissen, R.J. and Hamill, S.D. 2005. Breeding and selecting new varieties and rootstocks of custard apple (*Annona spp*. hybrids) in subtropical Australia. *Acta Horticulturae,***69**(4): 125-128.

Okunlola, A. I., Opeyemi, M. A., Adepoju, A. O., & Adekunle, V. A. J. (2016). Estimation of carbon stock of trees in urban parking lots of the Federal University OF Technology, Akure, Nigeria (Futa). Plant Science Archives

Ghosh, S.N., Mathew, B. and Subrata Manna. 2001.Studies on physico-chemical characteristics of fruits of custard apples grown under rainfed semi-arid region of West Bengal. *Orissa J. Hort.,* **29**(1): 66-68.

Girwani, A., Madhavi, A., Kumar, T.S., Reddy, G.S., Sheikh, M.K., Mokashi, A.N. and Rokhade, A.K. 2011. Evaluation of custard apple hybrids for fruit yield and quality attributing characters. *Acta Hort.,***11**(7): 251-255.

Gopalan, C. R., Shastri, B.V. and Balasubramanin, S.C. 1987. *Nutritive value of Indian Foods*. NIN, ICMR, Hyderabad, p.93.

Idoko, J. A., Osang, P. O., & Ijoyah, M. O. (2016). Evaluation of the agronomic characters of three sweet potato varieties for intercropping with soybean in Makurdi, Southern Guinea Savannah, Nigeria. Plant Science Archives

Hashmi, S.I. and Pawar, V.N. 2012. Studies on physical and chemical characteristics of custard apple fruit pulp from different locations. *J. Dairying, Foods and Home Science*, **31**(2): 117-120.

Keny, H.M. and Paulo S.L.e.S. 2010. Relationship between fruit traits of custard apple trees (*Annona squamosa* L.). *Revists Ceres*, **57**(4): 231-233.

Kulkarni, S.S., Desai, U.T., Masalkar, S.D. and Desale, S.B. 1997. Effects of cultural and chemical treatments on yield and physico-chemical characteristics of custard apple.*J. Maharashtra Agri.*, **21**(3): 474-475.

Kumar, R., Hoda, M.N. and Singh, D.K. 1977. Studies on the floral biology of custard apple (*Annona squamosa* Linn.). *Indian J. Hort.*,**34**(3): 252-256.

Liu, ShiBiao and Chen JinRui. 2002. The effect of environmental factors on the growth, development and production of custard apple *China Fruits*, **7**(2): 47-49.

Mallikarjuna, T., Ranganna, B. and Dronachari, M. 2012. Respiration of custard apple (*Annona squamosa* L.) fruit under different maturity level at ambient and refrigerated condition. *J. Dairying, Food and Home Sci.*,**31**(1): 25-27.

Martinez. G.M., Serrano and M.T. Prretel,1993. Ethelene biosynthesis and physic-chemical changes during fruit ripening of cherimoya (Annona cherimola Mill). *J.Hort. Sci*.,68(4) : 477-483.

Mazumdar, B.C. 1977. Differences between seeded and seedless berries of custard apple (*Anona squamosa* L.). *Plant Science*, **9**(2): 103-107.

Nagaraja, K., Kumar, S.A. Sathish, A. and Chandrappa, H. 2011.Effect of post harvest treatments and polyethylene packages on shelf life of custard apple fruits (*Annona squamosa* L.). *J. Agri. Sci.*,**45**(2): 456-459.

Nilam, P., Naik, A.G. and Arbat, S.S. 2011. Response of post-harvest chemical treatments on shelf life and quality of custard apple (*Annona squamosa* L.) cv. Balanagar, *Indian J. Hort.*,**68**(4): 547-550.

Pal, D.K. and Kumar, P.S. 1995. Changes in the physicchemical and biochemical compositions of custard apple (*Annona squamosa* L.) fruits during growth, development and ripening. *J. Hort. Sci.*,**70**(4): 569-572.

Prasanna, K.N.V., Rao, D.V.S. and Krishnamurthy S. 2000. Effect of storage temperature on ripening and quality of custard apple (*Annona squamosa* L.) fruits. *J. Hort. Sci. Biotechnology*, **75**(5): 546-550.

Pritchard, K.D. and Edwards,W. 2006. Supplementary pollination in the production of custard apple (*Annona sp*.) the effect of pollen source. *J. Hort. Sci. Biotechnology*, **81**(1): 78-83.

Rabbani, P. Singh. S.C. 1988. Effect of chemical treatments on shelf life and quality of custard apple (*Annona squamosa* L.), *Indian J. Hort.*,**45**(4): 177-180.

Ranganna, 1986 "Rapid Titration" method. *International Journal of Plant, Animal and Environmental Sciences*, p. 677.

Sahoo, S.C., Panda, J.M. and Mohanty, D.2000a. Studies on floral biology of custard apple (*Annona squamosa)* under Bhubaneswar condition.*Orissa J. Hort*., **28**(1): 43-45.

Sahoo, S.C., Panda, J.M. and Mohanty, D. 2000b. A note on pollen morphology, viability, pollination and fruitset in custard apple (*Annona squamosa* L.). *Orissa J. Hort*., **28**(2): 109-110.

Silva, A.V.C., Muniz, E.N.,Rangel, J.H.A., Yaguiu, P., Souza, J.P.B. and Carnelossi, M.A.G. 2012. Quality of custard apple (*Annona squamosa* L.) in relation to packaging and storage period. *Acta Horticulturae*,934:707-712.

Singh, D.K. Hoda, M.N. and Kumar, R. 1977. Development and physico-chemical properties of custard apple. *Proceedings of Bihar Academy of Agricultural Sciences*, **25**(2): 66-67.

Singh, S.P. 1995. Commercial Fruits, *Kalyani Publishers*, Ludhiana, India. p.289.

Xie ZhuShen, Xie XiDong and Li Jing Yue. 1999. The performance of AP custard apple variety and its cultural techniques in Guangzhou area. *South China Fruits*, **28**(2): 24-26.