Intl. J. Food. Ferment. Technol. 6(2): 219-231, December, 2016

DOI: 10.5958/2277-9396.2016.00045.3

REVIEW PAPER

Pre and Post-harvest Practices, Processing and Value Addition of Custard Apple

B.C. Khodifad*, Navneet Kumar, D.K. Vyas, Neeraj Seth and Manjeet Prem

College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra, Gujarat, India

Corresponding author: bhargavkhodifad@gmail.com

Paper No.: 131 Received: 8 June 2016 Accepted: 2 Dec. 2016

ABSTRACT

Custard apple is a delicious and commercially important fruit with pleasant flavor, mild aroma, sweet taste, good nutritional and medicinal values. However, the pre-harvest, post-harvest and processing and value addition practices have not been sufficiently developed. The pre-harvest practices like mulching, irrigation nutrition supplement and bio-fertilizers application play an important role on the development and shelf-life of fruits. The fruit has a short self-life due to high respiration and ethylene production. The temperature, type of packaging and chemical application have effect on storage life, however very low temperature storage is not recommended due to chilling injury. The shelf-life of custard apple fruit can be enhanced upto 12 days in modified atmosphere storage at 10°C, whereas pulp can be stored for six months with potassium meta-bisulphite. A number of value added products like ready-to-serve beverages, fermented beverage, ice cream, squash, and toffee can be prepared to exploit the nutritional potential and adding a new flavor/ taste in the market. This review attempts to outline some of the important findings on pre-harvest practices, post-harvest, processing value addition and storage of this fruits.

Keywords: Custard apple, pre-harvest practices, processing, value addition, storage

Custard apple is one of the delicious fruits relished by many for table purposes due to its pleasant flavor, mild aroma and sweet taste (Pilania *et al*., 2010). It is found wildly and cultivated throughout India and growing gregariously and widely in the hilly tracts, waste lands and has become completely naturalized in several districts of Gujarat (Middle, North Gujarat and Saurashtra), Andhra Pradesh, Punjab, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Assam, Maharashtra, Karnataka, Kerala and Tamil Nadu. It is a native of South America and West Indies (Kumar *et al*., 2015).

The fruit is rich in starch when firm but sugar increases marked by as it softens. The main sugars have been reported as glucose and fructose (80-90%) (Kumar *et al*., 2015). Compared to other fruits, custard apple fruit contains significant quantities of vitamin C, thiamin, potassium, magnesium and dietary fiber. The calorific value is high (300-450 kJ per 100 g) and is almost double than that of peach, orange and apple (Leung and Flores, 1961; Wenkam, 1990; Janick and Paull, 2006). However, despite its high sugar content the glycemic index of custard apple is low (54) and

the glycemic load moderate (10.2) (Brand-Miller *et al.,* 2003) and is desirable.

Custard apple is also a source of the medicinal and industrial products. It is also used as an antioxidant, anti-diabetics, hepatoprotective, cytotoxic activity, gene-toxicity, antitumor activity and used as antilice agent (Pandey and Barve, 2011). The fruits is also being used in various recipes viz. jam, nectars, ice creams etc. (Singh *et al.,* 2006, Shrivastava *et al.,* 2013 and Yadav *et al.,* 2010). There is a need to utilize the nutritional potential of custard apple and to develop various new value added products, which will also reduce the post-harvest losses of this perishable food. The pre-harvest and post-harvest practices are briefly reviewed in the manuscript.

PRE-HARVEST PRACTICES

The physical, chemical and nutritional properties of any fruits and vegetables are also depend on the pre-harvest practices performed during the growth of plants. Below are some of the pre-harvest factors that can affect the post-harvest shelf-life and qualities of harvested custard apple fruits are summarized in Table 1 and discussed here.

Nutrient supplements

Chattopadhyay and Ashutosh (1993) studied the influence of N, P and K nutrition in physico-chemical characteristics of custard apple by applying annual rate of 0, 120 and 240 g of N, P_2O_5 and K_2O/plant. The number of fruits/tree, number of seeds/fruit, specific gravity and total sugar content were significantly higher, and the peel weight was significantly lower, with 240 g/plant of each fertilizer. The application of fertilizer caused a significant increase in the diameter, Dry Matter, TSS, vitamin C and reducing sugars compared with the control.

Irrigation

Kulkarni *et al.* (1997) studied the effect of cultural practises on yield and physico-chemical characteristics of custard apple. The average fruit weight was found higher using irrigation (148.0 g), followed by mulching (138.8 g) and the controls (137.0 g). Fruit composition however, was not significantly affected by the practises.

Bio-fertiliser

Balakrishnan *et al.* (2001) studied the effect of bio-fertilizers (*Azotobacter*, *Glomus fasciculatum*, *Azospirillum*) and NPK in custard apple. One hundred and fifty grams of bio-fertilizers was mixed with 10 kg sieved farmyard manure per tree. Application of bio-fertilizers and 50% of recommended dose of NPK recorded the highest fruit yield, fruit weight, pulp weight and total soluble solids of fruit in custard apple.

Mulching

The effect of three vegetable by-products for (mulching): sugarcane bagasse, coffee chaff and buffel straw, regarding their effects on the physical and chemical characteristics of custard apple was evaluated (Silva *et al.,* 2007). The total fruit mass, peel mass and seed mass per fruit were measured and found that the presence of this mulching provided an increase in the fruit mass and coffee chaff provided a greater level of soluble solids. The influence of wheat straw mulch and different plant growth regulators on fruit set, yield and quality of custard apple was also studied (Patel *et al.,* 2010). Maximum flowering duration and fruit retention was observed with wheat straw mulch (5 t/ha) + GA_3 (Gibberellic Acid) (50 ppm) treatments. Highest number of fruits, fruit yield, fruit diameter and fruit pulp were also recorded under the same treatments and wheat straw mulch gave 21% higher fruit yield of custard apple.

Effect of different location

Physical and chemical characteristics of custard apple fruit pulp from different locations was studied and results revealed that custard apple growth in organized orchards resulted in comparatively higher pulp yield and better chemical properties, justifying its suitability for commercial exploitation (Hashmi and Pawar, 2012). The average twice fruit weight (250

g) that of other cultivars and with high soluble solids content of custard apple in Guangzhou area was also reported (Xie *et al.,* 1999)

Cultivar Type

A study on 4-year-old grafted trees of custard apple cultivars Atemoya, Balanagar, Chance Seedling, Iceland Gem, Washington, and Jargham Local in West Bengal, India during 2000 was conducted (Ghosh *et al.,* 2001). 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 (October), and content of total soluble solids (27.0 degrees 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.

Harvesting

A study was conducted for suitable period for harvesting of custard apple and suggested that harvesting should be done 2 to 5 days earlier (soluble solid around 10%) followed by storage at 25-33°C and relative humidity of 85-90% and fruit were suggested to harvest at 15-20% soluble solid for immediate consumption (Chen, 1999). A high respiration rate was found with a climacteric maximum of 243.1 ml CO_2 kg^{-1} h^{-1}, 3 day after harvest (Bolivar *et al.* 2009). Typicalclimacteric peak (104.23 mg CO_2 kg^{-1} h^{-1}) was noticed on the second day of storage in fruits harvested at matured stage at ambient condition and the respiration peaks of 56.32 mg CO_2 kg^{-1} h^{-1} and 27.42 mg CO_2 kg^{-1} h^{-1} were reported at 20 and 15°C respectively (Mallikarjuna *et al.,* 2012). The custard apple fruit harvested at the commercial stage of maturity resulted in increase in total soluble solids, total sugar and acidity up to 4th day of storage, while further storage caused reduction in these parameters and organoleptic characteristics of fruit. The maximum score was observed in case of fruit storage till 4th day, while subsequent storage of fruit decreased in consumer acceptability of fruit (Pawar and Hashmi 2010).

Table 1: Summary of studies on Pre-harvest practices of custard apple

	Research activity	Finding/ Remark/ Treatment/Recommendation	Authors
•	Nutrient supplements	N , P_2O_5 & K_2O @ 240g per plant	Chattopadhyay and Ashutosh (1993)
•	Irrigation	Irrigation & mulching	Kulkarni *et al.* (1997).
•	Mulching	Mulching with coffee chaff wheat straw mulch and different plant growth regulators	Silva *et al.* (2007)
			Patel *et al.* (2010)
•	Bio-fertilizers on yield, weight	150 g bio-fertilizers and 50% NPK	Balakrishnan *et al.* (2001)
•	Effect of different locations	Organized orchards average twice fruit weight (250 g) @Guangzhou area	Hashmi and Pawar (2012)
			Xie *et al.* (1999)
•	Cultivar type	Cultivar Balanagar exhibited highest physico-chemical properties	Ghosh *et al.* (2001)
•	Harvesting	2 to 5 days earlier (soluble solid around 10%) Storage at 25-33°C, RH- 85-90%	Chen (1999)
		• Climacteric peak (243.1 ml CO_2 kg^{-1} h^{-1}) after 3 days of storage	Bolivar *et al.* (2009)
		• Typical climacteric peak (104.23 mg CO_2 kg^{-1} h^{-1}) on second day after harvesting at ambient conditions custard apple fruit harvested at the commercial stage of maturity	Mallikarjuna *et al.* (2012)
			Pawar and Hashmi (2010)

It can be observed from various studies reported that pre-harvest practices have significant effect on the growth, yield and physical properties of custard apple fruit. Pre-harvest practices and their effects are summarized in Table 1.

POST-HARVEST PRACTICES

Effect of temperature

The custard apple stored at 15 to 20°C temperatures, low oxygen and ethylene tensions coupled with 10% CO_2 and 85-90% RH showed increased rates of CO_2 and C_2H_4 production of sugar apple about 3 days after harvest at 20°C and the peak of the respiratory climacteric (at 7 days) about 1 day before the ethylene climacteric was reported (Broughton and Tan 1979). The custard apple fruit for storage was studied and recommended storage temperature at 8° C for 1 week and at 12°C for up to 2 weeks with minimal loss of quality (Brown and Scott, 1985). The effect of storage temperature on ripening, shelf-life and chemical composition of custard apple fruits stored at 10, 15, 20 and 25°C was studied and suggested the safe range of storage temperature between 15 and 20°C, with maximum shelf-life at 15°C (Prasanna *et al.,* 2000). The fruit was found to become harder with blackening of surface after storage at a temperature below 10°C. The effect of heat processing on discoloration of custard apple fruit pulp and changes in quality characteristics during storage was studied and reported that heating of pulp reduced the polyphenol oxidase activity at 83°C for 2 min, however resulted in lower sensory characteristics, which could be restricted adding 2000 ppm ascorbic acid (Pawar *et al.,* 2011).

The pulp from custard apples was extracted and stored for a period of 6 months by addition of 1500 ppm of potassium met bisulphite. All the products stored at cold storage were good physic-chemically as compared to the products stored at room temperature (Sravanthi *et al.* 2014).The combined effects of chemical and physical elicitors on pos-tharvest quality of custard apple was studied and reported hot water treatment at 45°C as effective and 50°C with salicylic acid and 1% calcium chloride was also reported to enhance the storage time by 8 days in comparison to 4 days in control (Vyas *et al.,* 2015).

The changes in volatile compounds of fruit pulp *of Annona squamosa*, as influenced by the conditions of processing was studied (Shashirekha *et al.,* 2008). Sweet and pleasant flavoured pulp from mature ripe fruits was subjected to treatments such as frozen and stored (for 12 months), heated to 55°C (critical temperature) and 85°C (pasteurization temperature) for 20 min each, and spray dried with skim and whole milk powders. Terpenes such as alpha-pinene, beta-pinene, linalool, germacrene-d and spathulenol, esters like sec-butylbutanoate, and methyllinolenate, along with benzyl alcohol and two oxygenated sesqui-terpenes were found to be the major volatiles of the fresh pulp.

Effect of Packaging material

The fruits held in polyethylene bags with wheat straw, the least loss in fruit diameter and weight occurred. However, fruit ascorbic acid content was higher in fruits held in paper bags and wheat straw, sugars were higher in fruits held in polyethylene bags with sawdust (Chaudhry *et al.,* 1985). Kadam and Karad (2007) found that the fruits packed in 100 gauge polyethylene with 2% vent did not show any loss in palatability after 5 days, and showed less weight loss, softening rate and changes in external appearance than unpacked fruits. Less TSS and sugar content increase, and less chlorophyll content decrease was observed in packed than unpacked fruits. The fruits could be stored up to 6 days under ambient storage, when wrapped with tissue papers and kept in cardboard boxes (Patil *et al.,* 2011). The shelf-life of custard apple fruits was 9 days when wrapped with tissue papers and kept in cardboard boxes when stored in zero energy cool chamber. The shelf-life of custard apple fruits was 6 and 8 days at 20°C and 8 and 10 days at 15°C in ventilated polyethylene package and silicone membrane with

diffusion channel systems respectively (Mallikarjuna *et al.,* 2012). The custard apple fruits stored at 10°C and packed in PVC film was reported for reduction in mass loss. The modified atmosphere packaging also resulted in decreased loss of firmness, providing about a 12 day postharvest life at 10°C (Silva *et al.* 2012). Soluble solids and total titratable acidity concentrations did not increase significantly during storage. The use of packaging films significantly reduced weight loss, preserved firmness as well as colour of the treated fruits. Higher shelf-life (12.28 days) at 15±1°C using polypropylene bags flushed with air was also reported (Venkatram *et al.* 2013). Chilling injury was also restricted by packing of fruits in LDPE or Cryovac PD-961 film during storage at 12°C (Patil *et al.* 2013)

Effect of chemical treatments

Various treatment of custard apple packed in polyethylene bags, wax emulsion coating, fungicidal, growth regulator dips and $KMnO_4$ as an ethylene absorbent were studied and were found to enhance the shelf-life upto 9 days in comparison to 5 days in control samples by dipping fruits in 500 ppm Bavistin and placing in polyethylene bags has been reported (Babu *et al.,* 1990). The effect of various treatments on marketability, weight loss, total soluble solids (TSS), total sugar (TS), titratable acidity (TA) and ascorbic acid contents till 10 days storage at 32°C and 70-75% RH were observed and paper wrapping followed by dipping in gibberellic acid (GA_3) and polyethylene bagging with $KMnO_4$ was reported as most effective with maintained high sugar, ascorbic acid with low acidity (Bhadra and Sen 1997). The minimal processing of custard apple pulp by treating with 0.1%-0.5% ascorbic acid was performed and acceptable quality throughout the storage period of 4 weeks at 0°C of custard apple pulp was reported (Gamage *et al.,* 1997). Custrad apple treated with ascorbic acid and packed in polyethylene was frozen at -25°C and followed by storage at -18°C and 2% glycerol +1% propylene glycol + 10% glucose syrup + 10% maltodextrin formulation was reported as pourable even on frozen storage and also had the highest half-life of 75.33 days for ascorbic acid degradation as compared to 34.82 days for the control (Chikhalikar *et al.,* 2000). The fruits treated with 30 or 90 ml/litre of 1-Methyl cyclopropane ripened faster than fruits treated at higher concentrations (Benassi *et al.* 2003). Custard apple fruits treated with 6% Waxol and 30 ppm NAA, and wrapped individually in polyfilm recorded the slowest weight loss in comparison to unpacked fruits (Kamthe *et al.,* 2004). The slower weight loss in fruits stored in the cool chambers than under ambient conditions was also reported. The shelf-life of custard apple fruits up to 7 days after treating with waxol or waxol+$KMnO_4$ or waxol+NAA (30 ppm) and packed in individual wrapping polyfilm of 75 gauge at ambient storage conditions as against 4 days in untreated and unpacked fruits was reported (Masalkar and Garande 2005). The highest sensory qualities after treatment of waxol+NAA (30 ppm) was also reported.

The rot rate and ascorbic acid of 50.0, 38.4, 34.6% and 26.6, 42.7 and 34.6% respectively after treatment with 0.9, 1.8 and 3.6 micro L/L 1-MCP after storage of 12 days were also reported (Gong *et al.* 2006). The peak amylase activity in fruit pulp and polygalacturonase activity in fruit skin was recorded on the 7th day of storage in treated fruits with comparison to 3rd day in untreated fruits (Jholgiker and Reddy 2007). The treated fruit using 0.3% gelatins, 0.4% NaCL and 0.2% lemon acid extracted liquid of rhizome of Chinese gold thread coating agent could keep its eating quality for 6 days without rot, while the control stored for 4 days starting rot and reaching 25% at the 6th day stored (Guo *et al.,* 2010).

The fruits treated with 2% calcium chloride and packed in 150 gauge 0.5% ventilation were found in better shelf life (9.80 days) and retention of quality of fruits (Nagaraja *et al.,* 2011). The chemical treatments of NAA 100 ppm as well as GA_3 50 ppm were found effective in extending the shelf-life, respectively over control (by 1.75 and 1.42 days) in maintaining the marketability (Patel

Table 2: Summary of studies on post-harvest practices of custard apple

Research activity	Finding/ Remark/ Treatment/Recommendation	Authors
• Effect of temperature during storage	• Temperature- 15 and 20°C, low oxygen, ethylene tensions coupled with 10% CO_2, 85-90% RH	Broughton and Tan (1979)
	• Temperature- 8°C and 12°C for 1 week and 2 weeks respectively with minimal loss of quality	Brown and Scott (1985)
	• Safe range-15 and 20°C and maximum shelf life at 15°C	Prasanna *et al.* (2000)
	• Hot water treatment at 45°C as effective and 50°C with salicylic acid and 1% calcium chloride was also reported to enhance the storage times by 8 days in comparison to 4 days in control	Vyas *et al.* (2015)
• Respiration study	• Clear climacteric peak at 25 and 20°C and no distinct rise in respiration rate at 15 and 10°C	Prasanna *et al.* (2000)
• Ripening and storage conditions	• Wrapped in polyethylene bags with wheat straw (ripening media) for least loss in fruit diameter and weight	Chaudhry *et al.* (1985)
	• 100 gauge polyethylene with 2% vent for good palatability till 5 days wrapped with tissue papers and kept in cardboard boxes for storage life of 9 days	Kadam and Karad (2007) Patil *et al.* (2011)
	• Ventilated polyethylene package and silicone membrane with diffusion channel systems for shelf-life 6 and 8 days at 20°C and 8 and 10 days at 15°C respectively	Mallikarjuna *et al.* (2012)
	• Modified atmosphere ic storage extended shelf-life of 12 days at 10°C.	Silva *et al.* (2012)
	• Fruits packed in polypropylene bags flushed with air for higher shelf life (12.28 days) at 15±1°C	Venkatram *et al.*(2013)
	• Minimize chilling injury of fruits by packing in LDPE or Cryovac PD-961 film at 12°C.	Patil *et al.* (2013)
• Chemical application	• Doubled the storage life (9 days) of fruit by dipping 500 ppm Bavistin with polyethylene bags containing $KMnO_4$	Babu *et al.* (1990)
	• Frozen storage at -18°C and treated with ascorbic acid and added with 2% glycerol + 1% propylene glycol + 10% glucose syrup + 10% maltodextrin	Chikhalikar *et al.* (2000)
	• Increased ripening by treatment- 30 or 90 ml/litre 1-methylcyclopropen for reduction in weight loss 6% Waxol + 30 ppm NAA, and wrapped individually in polyfilm	Benassi *et. al.* (2003) Kamthe *et al.* (2004)
	• Waxol or waxol+KMnO4 or waxol+NAA (30 ppm) and packed in individual wrapping polyfilm of 75 gauge for shelf life 7 days	Masalkar and Garande (2005)
	• Rot rate of fruit treated with 0.9, 1.8 and 3.6 micro L/L 1-MCP were 50.0, 38.4, 34.6% respectively PG activity, 7^{th} day of storage in treated fruits	Gong *et al.* (2006) Jholgiker and Reddy (2007)
	• Addition of 0.3% compound gelatins, 0.4% NaCL, 0.2% lemon acid, 0.2% Vc and extracted liquid of rhizome of Chinese goldthread coating agent for good eating quality till 6 days	Guo *et al.* (2010)
• Storage life	• Ascorbic acid with paper wrapping followed by dipping in gibberellic acid (GA) and polyethylene bagging with $KMnO_4$ for 10 days storage life 2% calcium chloride and packed in 150 gauge 0.5% ventilation for 9.8 days storage life	Bhadra and Sen (1997) Nagaraja *et al.* (2011)
	• NAA 100 ppm, GA3 50 ppm most effective in extending the shelf-life	Patel *et al.* (2011)
	• Increases-storage life of fruit by 29.41% (2.5 days) with antioxidants application of benzyl adenine (100 or 50 ppm)	Venkatram and Bhagwan (2013)
	• Radiation dose of 1.5 kilo Gray along with 50 ppm benzyl adenine enhanced in shelf-life of custard apple fruits by 6 days at ambient temperature	Chouksey *et al.* (2013)

• Pulp storage	• Treatment-0.1%-0.5% ascorbic acid and 0°C temperature for 4 weeks	Gamage *et al.* (1997)
	• Replaced heating by adding 2000 ppm ascorbic acid for minimizing the discolouration	Pawar *et al.* (2011)
	• Pulp-stored for a period of 6 months by addition of 1500 ppm of potassium metabisulphite and good physic-chemically in cold storage compared to the products stored at room temperature	Sravanthi *et al.* (2014)
	• frozen and stored (for 12 months), Heating at 55°C, 85°C (pasteurization) for 20 min each, and spray dried with skim and whole milk powders	Shashirekha *et al.* (2008)

et al., 2011). Application of NAA 100 ppm was also reported as more economical. Post-harvest antioxidants application of benzyl adenine (BA) (100 or 50 ppm) increased the storage life of custard apple by 29.41% (2.5 days) over untreated fruits (Venkatram and Bhagwan 2013).The radiation dose of 1.5 kilo Gray along with 50 ppm benzyl adenine enhanced in shelf-life of custard apple fruits by 6 days at ambient temperature with good pulp texture, flavour, colour and nutritional quality as compared to control (Chouksey *et al.* 2013). Some of the important studies on post-harvest practices of custard apple are also summarized in Table 2.

NUTRITIONAL COMPOSITION

Mazumdar (1977) studied the differences between seeded and seedless berries of custard apple and reported that seeded berries were larger and had a higher sugar content. Liu (2000) studied the performance of custard apple cultivar and reported that fruits matured mainly in September to November, were large, weighing 326 g on average, with white, tender flesh with a sugar content of 18.3%, 400 μg ascorbic acid/g, a very sweet flavour, and had very good eating quality and good transport quality. The presence of lactose, sucrose, galactose and glucose in the edible rind portion of custared apple was also reported (Chandraju *et al.* 2012). The limited availability of minerals in custard apple in comparison to ripe and green papaya, grape fruit, sweet orange and guava was also reported (Chauhan *et al.* 1991). Nutritional facts of custard apple juice are summarized in Table 2.

Fifty-three compounds identification, 29 as volatile constituents of in custard apple with major compounds were alpha-pinene, beta-pinene, limonene, bornyl acetate and germacrene D was also documented (Pino and Rosado 1999). The ascorbic acid in custard apple fruits was reported as 1.10 mg/100g (Singh *et al.*, 1977). The influence of different solvents (water, methanol, ethanol and acetone) on the antioxidant properties of the custard apple fruit pulp (CAFP was studied and highest amount was found by using acetone as a solvent (Jagtap and Bapat 2012).

Table 3: Nutritional facts of custard apple fruit juice

Various Nutrients	
Protein	4.48%
Fat	1.56%,
Crude fibre	7.53%
Carbohydrate	10.52%
Food energy	74.04 Kcal
Invert sugar	161.84
Fructose	167.27 mg/100g
Hydrated maltose	268.13 mg/100g
Vitamins A	16.63 μg/100 g R.E.
Vitamins C	43.38 mg/100 g
Fixed acidity	0.023%
Volatile acidity	0.004%
Total solid	27.25%
Soluble solid	10.00%

Source: Amoo *et al.* 2008 and Singh *et al.* 2008.

PROCESSING AND VALUE ADDITION

The jam, fruit-flavoured yoghurt, fruit drinks and syrups etc. with fruit extracts from custard apple have been suggested (Hoyos 1980). New products from the arid and semi-arid fruits such as juices, candies, and wines were also proposed by Kadam (2001).

Jam

Custard apple jam prepared with 50% pulp based on sensory score was found to be the best. The jam was fit for consumption up to 4 months of storage and the amount of TSS, total sugars, and reducing sugars increased continuously during the storage period of 150 days while the amount of ascorbic acid and non-reducing sugars decreased during storage (Singh *et al.*, 2006).

Toffee

It was found that the toffees prepared using 55% custard apple pulp scored the maximum for colour, appearance, texture and overall acceptability, the toffees can be an ideal supplement to the diet of young children (Mundhe *et al.*, 2008).

Milk shake

The custard apple milk shake prepared from 90 parts of buffalo milk and 10 parts of custard apple pulp was the most acceptable and ranked between like very much to like extremely (Poul *et al.*, 2009). The composition and economics of custard apple milk shake revealed that the custard apple pulp was cheaper compared to other fruit pulps and was easily available in season and make good potential value added milk product. The cost of production of custard apple milk shake for treatments was found to be ₹ 30.65 (Poul *et al.*, 2010).

Ice-cream

The chemical composition, quality and cost of ice-cream was evaluated and it was inferred that ice-cream prepared with incorporation of 15% custard apple pulp and 15% sugar level had overall acceptability of 8.05 scores of hedonic scale. The production cost and energy value per kg of custard apple pulp ice-cream was ₹ 61.42 and 97.27 Kcal/100 g, respectively (Yadav *et al.*, 2010). Low fat custard apple ice-cream from 15% custard apple pulp, 15% sugar, 10% fat in different combination of ascorbic acid and reported that 0.3% level of ascorbic acid was the most acceptable and rated between like very much to like extremely for all sensory attributes (Pawar *et al.*, 2011).

Alcoholic Beverage

Nutrient rich fermented products were also prepared. The alcohol percentage of the distillate prepared from custard apple was 8.2, which were within the range of the values of alcohol percentage of the fruit wines 8% to 13% (Deshpande *et al.*, 2010).

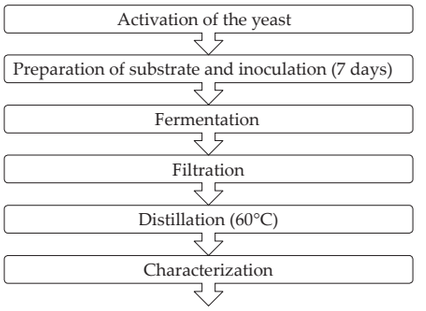

Fig. 1: Process for preparation of custard apple fruits wine. (Source: Deshpande *et al.* 2010)

Potential of custard apple in the production of a beverage fermented using *Saccharomyces cerevisiae* (NCIM 3282) yeast was made and assessed the antioxidant capacity, total phenolic content and DNA damage-protecting activity of custard apple fruit wine (CAFW). It was revealed that CAFW was not only effective in scavenging DPPH- and DMPD-free radicals but also has good ferric-reducing antioxidant capacity. Three hydroxybenzoic acids (gallic acid, protocatechuic acid, gentisic acid) and two hydroxycinnamic acids (caffeic acid, p-coumaric acid) were also identified. The results also suggested that CAFW may have potential health applications and therefore, could contribute to the economy of the wine industry (Jagtap and Bapat, 2015).

Enzyme

The use of polyphenol oxidase enzyme extracted from ripe custard apple pulp on the cocoa (*Theobroma cacao L.*) nibs in taste improvement was also performed (Lima *et al.* 2001). Treatment of non-autoclaved unfatted cocoa nibs with enzyme for 210 min resulted in 15, 15, 10 and 18% reductions of

total phenol, tannin, flavan-3-ois and anthocyanins, respectively. Nibs of autoclaved unfatted cocoa had 25, 26, 23 and 51% reductions of total phenols, tannins, flavan-3-ois and anthocyanins after treatment.

Non-alcoholic beverages

Ready-to-serve beverage of custard apple and lime was attempted and was found that blended juice of custard apple and lime (3:2) with 15% TSS and 0.2% acidity was found best with respect to colour (off white), taste, over-all acceptance and ascorbic acid (Pilania *et al.,* 2010). The effect of chemical preservative of potassium meta-bisulphite was studied on the microbial and sensory quality of the custard apple RTS beverage stored at ambient temperature (28-32 °C) for 180 days with an interval of 1 month and mean score of taste panel for colour, taste, flavour, appearance and overall acceptance significantly ($p<0.05$) decreased, whereas, the microbial contamination was found maximum at 30 days of storage (Markam and Singh, 2012). The recipes for squash, keeping quality and acceptability of prepared squash through sensory evaluation in custard apple cv. Balanagar was carried out and reported that maximum increase in the TSS level of the custard apple squash was observed during a storage period of 32 days. The acidity, ascorbic acid and sugar content of the custard apple squash increased with storage, while the tannin content and organoleptic score decreased as the storage length increased (Patil *et al.,* 2011). The best recipe

Table 4: Summary of reviews on processing and value addition of custard apple

	Research activity	Finding/ Remark/ Treatment/Recommendation	Authors
	Products	• Suggested to prepare jam, fruit-flavoured yoghurt, fruit drinks and syrups etc.	Hoyos (1980), Kadam (2001)
•	Jam	• 50% custard apple pulp with high sensory score	Singh *et al.* (2006)
•	Toffee	• Prepared using 55% custard apple pulp achieved maximum sensory score	Mundhe *et al.* (2008)
•	Milk shake	• Buffalo milk & Custard Apple Pulp ratio - 90:10, cost effective	Poul *et al.* (2009, 2010)
•	Ice-cream	• 15%- Custard apple pulp and 15%- sugar, cost and energy per kg was ₹ 61.42 and 97.27 Kcal/100 g	Yadav *et al.* (2010)
		• Low fat ice-cream-15% pulp, 15% sugar, 10% fat in different combination, ascorbic acid 0.3%	Pawar *et al.* (2011)
•	Alcoholic beverages	• Fruit wine - Alcohol percentage in distillate -8.2%	Deshpande *et al.* (2010)
		• Fermented beverage - using Saccharomyces cerevisiae (NCIM 3282) yeast	Jagtap and Bapat (2015)
•	Taste enhancer	• Use of polyphenol oxidase enzyme on the cocoa nibs	Lima *et al.* (2001)
•	Non-alcoholic beverages	• Custard apple and lime (3:2) with 15% TSS and 0.2% acidity	Pilania *et al.* (2010)
	Pulp	• Keeping quality and acceptability of prepared squash through sensory evaluation for 32 days storage	Patil *et al.* (2011)
		• Effect of chemical Preservative of potassium metabisulphite on microbial and sensory quality	Markam and Singh (2012)
		• Nectar-20% pulp, 0.3% acidity, 25% TSS	Shrivastava *et al.* (2013)
	Custard apple pulp powder	• Custard apple pulp powder as Binding agent in pharmaceutical tablets	Thube *et al.* (2011)

of beverages having a maximum shelf-life was determined and found that the nectar prepared with the treatment (20% pulp, 0.3% acidity, 25% TSS) contained the highest acidity, T.S.S., total and reducing sugar with moderate amount of non-reducing sugar and TSS: acid ratio, thus, found to be suitable for preparation of custard apple nectar at commercial scale (Shrivastava *et al.,* 2013).

Custard apple pulp powder

Custard apple pulp powder as an excipient on the properties of acetaminophen tablet and disintegration test showed that the tablets containing CAPP in presence of PVP as a binder had two folds increase in the disintegration time. Moreover, the disintegration time for the tablets prepared by replacement of PVP with Custard Apple Pulp Powder (CAPP) in presence of starch as a disintgrant was reduced drastically. Dissolution studies further confirmed the enhancement of binding potential of PVP and disintegrating potential of starch by CAPP. Performance of the binder and the disintgrant in the tablet has been modified by the presence of CAPP (Thube *et al.,* 2011).

Some of the important studies on processing and value addition of custard apple are also summarized in Table 4.

CONCLUSION

Various per-harvest practices influenced the yield and other physico-chemical characteristics of fruits. The yield of fruits increases with the use of fertilizer (240 g NPK/plant), wheat straw mulch, irrigation and bio-fertilizer. The Balanagar cultivar has good yield and effect of location was also reported. The climacteric peak after harvesting was observed 2 to 3 days, therefore harvesting of fruit was recommended 2 to 5 days earlier before commercial stage for better consumer acceptability. The safe storage temperature range for the fruit is 15 to 20°C and maximum shelf life (12 days) could be attained at 15°C in polyethylene bags.

The fruit retains organoleptic qualities after treating with waxol, Naphthaleneacetic acid till 12 days. The custard apple pulp treated with 0.1%-0.5% ascorbic acid has storage life of 4 weeks at 0°C. The custard apple has good acceptability in various value added products viz. ice cream, toffee, milk shake, Ready to serve beverage, jam and nectar etc. with 10 to 55% contribution. The RTS beverage stored at ambient temperature has shelf life of 180 days with the addition of preservative. The studies in the area of value addition using the pulp and powder utilization has a good potential in future.

REFERENCES

Amoo, I.A., Emenike, A.E., and Akpambang, V.O.E. 2008. Compositional evaluation of Annona cherimoya (custard apple) fruit. *Trends in Applied Sciences Research.,* **3**(2): 216-220.

Babu, K.H., Zaheeruddin, M., and Prasad, P.K.1990 Studies on postharvest storage of custard apple. *Acta Horticulturae.,* 269-299.

Balakrishnan, S., Selvarajan, M., and Siddeswaran, K. 2001. Effect of biofertilizers in custard apple. *South Indian Horticulture,* **49**(Special): 185-186.

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

Benassi, G., Correa, G.A.S.F., Kluge, R.A., and Jacomino, A.P.2003. Shelf life of custard apple treated with 1-methylcyclopropene - an antagonist to the ethylene action. *Brazilian Archives of Biology and Technology.,* **46**(1): 115-119.

Bolivar, F.N., Solis, P.C., Sauri, D.S., and Saucedo, V.E. 2009. Ripening of sugar apple fruits (*Annona squamosa L.*) developed in Yucatan, Mexico. *Agrociencia.,* **43**: 133-141.

Brand Miller, J., Foster Powell, F and Colaguira, S. 2003. The New Glucose Revolution. Publisher: Headline. ISBN: 9780733616440.

Brown, B.I., and Scott, K.J. 1985.Cool storage conditions for custard apple fruit (*Annona atemoya Hort.*)." *Singapore Journal of Primary Industries.*,23-31.

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

Chattopadhyay, P.k., Mandal, A.A. 1993. Physico-chemical characteristics of custard apple as influenced by N, P and K nutrtion. *Journal of tropical agriculture* **31**(2): 237-238.

Chauhan, K.S., Pundir, J.P.S., Singh, S. and Singh , S. 1991. Studies on the mineral composition of certain fruits. *Haryana-Journal-of-Horticultural-Sciences,* **20**(3-4): 210-213.

Chandraju, S., Mythily, R., and Kumar, C.S.C. 2012. Qualitative chromatographic analysis of sugars present in non-edible rind portion of custard apple (*Annona squamosa L.*). *Journal of Chemical and Pharmaceutical Research.* **4**(2): 1312-1318.

Chaudhry, A.S., Singh, G.N. and Singh, A.R. 1985. Effect of wrapping materials and ripening media on the physico-chemical compositions of custard apple (*Annona squamosa Linn.*). *Indian Journal of Agricultural Research,* **19**(2): 90-92.

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

Chikhalikar, N.V., Sahoo, A.K., Singhal, R.S. and Kulkarni, P.R. 2000. Studies on frozen pourable custard apple (*Annona squamosa L.*) pulp using cryoprotectants. *Journal of the Science of Food and Agriculture.* **80**(9): 1339-1342.

Chouksey, S., Singh. A., Thakur, R.S. and Deshmukh, R. 2013. Influence of gamma irradiation and benzyl adenine on keeping quality of custard apple fruits during storage. *Journal of Food Science and Technology Mysore.* (New Delhi, India: Springer (India) Private Limited.) **50**(5): 934-941.

Deshpande, K.G., Kshirsaoar, A.B., Maithilee, K., Prashant, N., Suvarna, G. and Pujari. V. 2010.Rare fruits as a source of nutrient rich fermented products." *Asian Journal of Bio Science.* 4 (2): 300-303 http://www.hindagrihorticulturalsociety.co.in.

Gamage, T.V., Yuen, C .M .C., and Wills, R.B.H. (1997)Minimal processing of custard apple (*Annona atemoya*) pulp. *J food process preserv. Trumbull, Conn. : Food & Nutrition Press Inc,* **21**(4): 289-301.

Ghosh, S.N., Mathew, B., and Subrata, M. 2001. Studies on physicochemical characteristics of fruits of custard apples grown under rainfed semi-arid region of West Bengal. *Orissa-Journal-of-Horticulture.* **29**(1): 66-68.

Gong, D., Zhang, X., and Wang, J. 2006. Study on the effect of 1-MCP on the storability of custard-apple (*Anona squamosa*) under low temperature storage.*South China Fruits.* (Chongqing, China: Citrus Research Institute, CAAS.) **5**: 42-44.

Guo, S., YongLi, Y., XianHui. P., Li, W., Ji, X., and Feng, X.2010. Experiment of using compound coating agent for storage of custard apple. *China Fruits.* (Xingcheng, China: Research Institute of Pomology.) **2**: 12-15.

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

Hoyos, P. 1980. Fruit mixture. German Patent 800464003.

Jagtap, U.B., and Bapat, V.A. 2012.Antioxidant activities of various solvent extracts of custard apple (*Annona squamosa L.*) fruit. *Nutrafoods* **11**: 137-144.

Jagtap, U.B., and Bapat,V.A. 2015.Phenolic composition and antioxidant capacity of wine prepared from custard apple (*Annona squamosa L.*) fruits. *Journal of Food Processing and Preservation.* (Boston, USA: Wiley-Blackwell.) **39**(2): 175-182 http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1745-4549.

Janick, J. and Paull, R. 2006. The Encyclopedia of Fruit and Nuts. Publisher: CABI.

Jholgiker, P. and Reddy, B.S. 2007. Dynamics of hydrolytic enzymes activity and associated carbohydrates transformation in custard apple fruits as influenced by fruit surface coating and storage conditions. *Indian Journal of Horticulture.* **64**(4): 381-384.

Kadam, S.S. 2001. New products from the arid and semi-arid fruits. *Indian Journal of Horticulture.* **58**(1/2): 170-177.

Kadam, D.D., and Karad, S.R. 2007. Influence of wrapping material on physico-chemical characters during storage of custard apple. *International-Journal-of-Agricultural-Sciences.* (Muzaffarnagar, India: Hind Agri-Horticultural Society.) **3** (1): 1-3 www.hindagrihorticulturalsociety.com.

Kamthe, P.V., Masalkar, S.D., Kashid, N.V., Kamble, M.S., and Marbhal, S.K. 2004.Physiological loss in weight of custard apple as affected by different chemicals and packaging materials at different storage conditions. *Annals of Agricultural Research.* **25**(4): 502-507.

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. *Journal of Maharashtra Agricultural Universities* **21**(3): 474-475.

Kumar, S., Kumar, N., Seth, N. and Jethva, K.R. 2015. A Study on Physical Properties and Drying Characteristics of Custard Apple. *National seminar on emerging trends in food quality and safety.*

Leung, W. and Flores, M. 1961. Food composition tables for use in Latin America. Joint Research Project, Institute of Nutrition of Central America, Panama and Guatemala, and National Institute of Health, Maryland.

Liu, S. 2000.The performance of African Pride custard apple cultivar. *China Fruits.* **3**: 29-30.

Lima, E.D.P.de.A., Pastore, G.M., Barbery, S.D.F., Garcia, N.H.P., Brito, E.S.de., and Lima, C.A.de.A. 2001.Obtaining and use of polyphenoloxidase enzyme extracted from ripe custard apple (*Annona squamosa L.*) pulp on the cocoa (Theobroma cacao L.) nibs in taste improvement." *Revista Brasileira de Fruticultura.* **23**(3): 709-713.

Markam, R., and Singh, V. 2012.Studies on microbial and sensory quality of custard apple RTS beverage. *Asian-Journal-of-Horticulture.* (Muzaffarnagar, India: Hind Agri-Horticultural Society.) **7**(2): 460-464.

Mallikarjuna, T., Ranganna, B., and Dronachari, M. 2012. Respiration studies of custard apple (*Annona squamosa*

L.) fruit under different maturity levels at ambient and refrigerated condition." *Journal of Dairying, Foods and Home Sciences.* (Karnal, India: Agricultural Research Communication Centre.) **31**(1): 25-27.

Mallikarjuna, T., Ranganna, B. and Sreedevi, M. S. 2012. Enhancement of shelf-life of custard apple (*Annona squamosa L.*) fruits by using different packages and storage systems. *Environment and Ecology.* **30**(3B): 975-977.

Masalkar, S.D., and Garande, V.K. 2005.Effect of postharvest treatments and packaging materials on shelf life and quality of custard apple fruits. *Acta Horticulturae.* **682**(2): 1037-1040.

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

Mundhe, S.A., Kshirsagar, R.B., Kulkarni, D.N. and Patil, B.M.2008. Studies on utilization of custard apple pulp in toffee. *Indian-Journal-of-Nutrition-and-Dietetics.* (Coimbatore, India: Avinashilingam University for Women.) **45**(11): 472-478.

Nagaraja, K., Chandrappa, H., Patil, R., Kumar, B.M.A. and Sannathimappa, H.G. 2011.Effect of calcium chloride for enhancing shelf life of custard apple fruits (*Annona squamosa L.*) during storage. *Environment and Ecology.* (Kolkata, India: MKK Publication) **29**(2): 487-493.

Patel, N., Naik, A.G. and Arbat, S.S. 2011. Response of post-harvest chemical treatments on shelf-life and quality of custard apple cv. Balanagar. *Indian Journal of Horticulture.* (New Delhi, India: Horticultural Society of India.) **68**(4): 547-550.

Pandey, N and Barve, D. 2011. Phytochemical and Pharmacological Review on Annona squamosa Linn. *International Journal of Research in Pharmaceutical and Biomedical Sciences.* **2**(4): 1404-1412.

Patel, N.M., Patel, D.K., Verma, L.R. and Patel, M.M. 2010. Effect of cultural and chemical treatments on fruit set and fruit yield of custard apple (*Annona sqamosa Linn*.) cv. SINDHAN. *Asian Journal of Horticulture* **5**(2): 498-502.

Patil, R., Sudhakar Rao, D.V. and Manasa, B. 2013. Effect of modified atmospheric packaging on chilling injury and shelf-life of custard apple fruits. *Journal of Applied Horticulture* **15**(2): 100-105.

Patil, S.B., Raut, V.U., Gadekar, A.K. and Patil, S.M. 2011. Effect of packaging and cushioning materials on shelf life of custard apple fruits under different storage conditions. *Asian Journal of Horticulture.* (Muzaffarnagar, India: Hind Agri-Horticultural Society.) **6**(1): 264-268.

Patil, S.M., Raut, V.U., Pushpendra, K. and Pankaj, L. 2011. Standardization of recipes for production of custard apple squash. *Progressive-Agriculture.* (Rawatpur, India: Society for Recent Development in Agriculture.) **11**(2): 472-474.

Pawar, V.N., and Hashmi, S.I. 2010. Changes in physico-chemical properties and organoleptic characteristics of custard apple (*Annona squamosa L.*) fruit during storage. *Food Science Research Journal.* (Muzaffarnagar, India: Hind Agri-Horticultural Society.) **1**(2): 146-149.

Pawar, S.L., Karanjkar, L.M. and Poul, S.P. 2011.Sensory evaluation of low fat custard apple ice-cream.*Journal of Dairying, Foods and Home Sciences.* (Karnal, India: Agricultural Research Communication Centre.) **30**(1): 32-34.

Pawar, V.N., Kardile, W.G. and Hashmi, S.I. 2011. Effect of heat processing on discoloration of custard apple (*Annona squamosa L.*) fruit pulp and changes in quality characteristics during storage. *Electronic Journal of Environmental, Agricultural and Food Chemistry.* (Ourense , Spain: Faculty of Science, University of Vigo et Ourense.) **10**(4): 2098- 2113.

Pilania, S., Dashora, L.K. and Singh, V. 2010. Standardization of recipe and juice extraction method for preparation of ready-toserve beverage from custard apple (*Annona squamosa L.*), *Internat. J. Proc. & Post-Harvest Technol.*, **1**(2): 65-72.

Pino, J.A., and Rosado, A. 1999 Volatile constituents of custard apple (*Annona atemoya*). *Journal of Essential Oil Research.* **11**(3): 303-305.

Poul, S.P., Sontakke, A.T., Munde, S.S., Adangale, A.B. and Jadhav, P.B. 2009.Process standardisation for custard apple milk shake. *Journal of Dairying, Foods and Home Sciences.* (Karnal, India: Agricultural Research Communication Centre.) **28**(3/4): 202-205.

Poul, S.P., Sontakke, A.T., Munde, S.S. and Adangale, A.B. 2010.Composition and economics of custard apple milk shake. *Asian Journal of Animal Science.* (Muzaffarnagar, India: Dr. R.K. Singh, Hind Agri-Horticultural Society.) **4** (2): 139-142.

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. *Journal of Horticultural Science and Biotechnology.* **75**(5): 546-550.

Shashirekha, M.N., Baskaran, R., Rao, L.J., Vijayalakshmi, M.R. and Rajarathnam. S. 2008. Influence of processing conditions on flavour compounds of custard apple (*Annona squamosa L.*). *LWT Food Science and Technology.* **41**(2): 236-243.

Shrivastava, R., Dubey, S., Dwivedi, A.P., Pandey, C.S. and Banafar, R.N.S.2013. Effect of recipe treatment and storage period on biochemical composition of custard apple (*Annona squamosa L.*) nectar. *Progressive Horticulture.* (Uttarakhand, India: Indian Society of Horticultural Research and Development.) **45**(1): 110-114.

Silva, J C.G.da., Chaves, M.A., Jose, A.R.S., Reboucas, T.N.H. and Alves, J.F.T. 2007. A influencia da cobertura morta

sobre caracteristicas fisicas e quimicas de frutos da pinha. *Revista Brasileira de Fruticultura* **29**(2): 287-291.

Singh, D , Prahalad, V.C., and Lobsang, G.2008.Lesser known arid and semi-arid fruits, in the fresh and processed form. *Environment and Ecology,* **26**(2A): 731-737.

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

Singh, P., Patel. D., Agrawal, S. and Panigrahi, H. 2006. Value addition of custard apple through jam for year round availability. *Proceedings of the national symposium on production,utilization and export of underutilized fruits with commercial potentialities.* Kalyani, Nadia, West Bengal, India.: Mohanpur, India: Bidhan Chandra Krishi Viswavidyalaya. 262-265.

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 squamosal L.*) in relation to packaging and storage period. *Acta Horticulturae.* (Leuven, Belgium: International Society for Horticultural Science (ISHS).) **934**: 707-712.

Sravanthi, T., Waghrey, K., and Daddam, J.R. 2014. Studies on preservation and processing of custard apple (*Annona squamosa L.*) pulp. *International Journal of Plant, Animal and Environmental Sciences*., **4**(3): 676-682.

Thube, R., Purohit, S., Gothoskar, A. 2011. Study of effect of Custard Apple Pulp Powder as an excipient on the properties of acetaminophen tablet. *World Applied Sciences Journal.* (IDOSI Publications) **12**(3): 364-371.

Venkatram, A., and Bhagwan, A. 2013. Storage life improvement of custard apple (*Annona squamosa L.*) fruits cv 'Balanagar' by post-harvest application of antioxidants. *Journal of Applied Horticulture Lucknow.* (Lucknow, India: Society for the Advancement of Horticulture.) **15**(3): 215-219.

Venkatram, A., Bhagwan, A. and Pratap, M. 2013.Effect of polypropylene packaging on shelf life and quality of custard apple Annona squamosa L. cv. Balanagar fruits stored at 15±1 °C. *Journal of Research ANGRAU.* (Hyderabad, India: Acharya N G Ranga Agricultural University.) **41**(3): 1-6.

Vyas, P.B., Rao, T.V.R. and Thakkar, V.R. 2015.Combined effects of chemical and physical elicitors on postharvest quality of custard apple (*Annona squamosa L.*, cv. Balanagar). *Scientia Horticulturae.* (Amsterdam, Netherlands: Elsevier Ltd.) 187: 50-57.

Wenkam, N. 1990.Foods of Hawaii and Pacific Basin. Fruit and fruit products. Raw, processed and prepared. Vol. 4, Composition. Research Extension Series 110. Hawaii Institute for Tropical Agriculture and Human Resources.

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

Yadav, C.M., Karanjkar, L.M. and Kashid, U.B. 2010. Effect of assimilation of custard apple (*Annona squamosa*) pulp on chemical quality and cost of ice-cream. *Journal of Dairying, Foods and Home Sciences.* (Karnal, India: Agricultural Research Communication Centre.) **29**(2): 86-91.