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Technological, Nutritional Approach, Processing and Storage of Custard Apple (*Anonna squamosa*) – Review

S.B. Solanke*, P.H. Bakane and A.B. Gawande

Department of Agricultural Process Engineering, Dr. PDKV Akola, M.S., India

**Corresponding author*

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A B S T R A C T

Custard apple (Sitaphal) is a yellowish green fruit of the family of plant species Annona. The postharvest system for these fruits is not yet adequately developed, and therefore several handling problems are still common. Rapid softening of fruits after harvest, especially during transportation and marketing is a major ongoing problem. 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. Therefore this review attempts to outline some of the important findings on especially post-harvest, processing value addition and storage of this fruits.

Introduction

Sitaphal (Custard Apple) is a fruit from the small tree named *Annona squamosa* which belongs to the Family Annonaceae of the order Magnoliales. It is also called custard apple. The genus name, '*Annona*' is from the Latin word 'anon', which means 'yearly produce'. *Annona squamosa*, *Annona cherimola* and *Annona reticulate* are the related species varieties. 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). Custard apple is a climacteric fruit and starts ripening soon after detached from the tree (Wills *et al.*, 2001). It is highly perishable fruit with short shelf life of 1 to 2 days after ripening. The steady increase in area under custard apple has enhanced the fruit flow into the markets which most of the time leads to glut in the markets. The lack of information on the post-harvest handling of this highly perishable fruit has resulted in huge losses. 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. It gives 104 kcal per 100gm of edible portion. Despite its high sugar content the glycemic index of custard apple is low (*i.e.* 54). The changes in volatile compounds of fruit pulp *of Annona squamosa*, as influenced by the conditions of processing was studied (Shashirekha *et al.,* 2008).

Custard apple is also a source of the medicinal and industrial products. The fruit has antioxidant activity making it suitable even for diabetic patients. Sitaphal also has good amounts of iron, phosphorous, potassium, and vitamin C. It has about 3.1% of fibre in the edible portion the sitaphal also contains traces of sodium, magnesium, pantothenic acid, ascorbic acid and B vitamins. The fruits are 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 fruit. The post-harvest practices are briefly reviewed in the manuscript.

Nutritional value and Physico-morphological characters and chemical composition of custard apple

Pareek *et al.,* (2011) reported that Annona comprises many species but 5 of them are of significant commercial importance namely, the custard apple, cherimoya, soursop, bullock's heart and atemoya (Table 1). The postharvest system for these fruits is not yet adequately developed, and therefore several handling problems are still common. Rapid softening of fruits after harvest, especially during transportation and marketing is a major ongoing problem. Annonas are climacteric fruit, generally characterized by high respiration and ethylene production, and are chilling sensitive. Custard apple (Sitaphal) is a yellowish green fruit of the family of plant species Annona. The fruit has established its medicinal properties for decades. Still it is not a fruit which is commonly consumed as this is a seasonal fruit (Dutta *et al.,* 2016). Khodifad *et al.,* (2016) studied that Custard apple is a delicious and commercially important fruit with pleasant flavor, mild aroma, sweet taste, good nutritional and medicinal values. 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. 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 general composition, adaptability, ripening, storage and marketing of custard apple were studied. Custard apple is considered as one of the delicious and

nutritionally valuable fruit. Custard apple contains about 28-55% of edible portion consisting of 73.30% moisture, 1.60% protein, 0.30% fat, 0.70% mineral matter, 23.90% carbohydrates, 0.20% calcium, 0.40% phosphorous, 1.0% iron, 12.4- 18.15% sugar, 0.26-0.65% acidity and with a calorific value of 105 calories / 100 g. 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 generally classified as semi wild fruit by virtue of its spontaneous spread in forests, wastelands and other uncultivated places. Custard apple ripens within four days after harvest. Fruits can safely store at room temperature with a shelf life of four days when treated with calcium carbide and further ripened in straw and fruit leaves (Jagdish Prasad *et al.*, 1995). Kachhadiya and Jethva (2017) found that the physicochemical properties of custard apple pulp in which the average weight, geometric mean diameter, arithmetic mean diameter, sphericity, surface area, volume, hardness for ripe and unripe fruits were 103.04 g, 57.63 mm, 60.52 mm, 0.88, 10579.27 mm2, 118.38 cm3, 1.27 kgf; 143.57 g, 62.39 mm, 65.60 mm, 0.85, 12283.54 mm2, 144.09 cm3, 3.66 kgf, respectively. The pulp content, seeded pulp content, seed content, peel content for ripe and unripe fruits were 35.08%, 47.63%, 11.38%, 51.50%; 31.98%, 40.20%, 7.52%, 59.29% respectively.

Storage of custard apple pulp

Salunkhe and Desai (1984) reported that canning of the custard apple pulp is problematic because of the development of bitterness and browning on heating beyond 55°C. The shelf life of guava pulp stored at 5°C by addition of potassium metabisulphite, ascorbic acid either alone or combination with heating at 85°C was studied. After 3 months, the unspoiled pulp was utilized for the preparation of ready-to serve beverage (Rouhangiz Hayati *et al.*, 1992). The frozen custard apple pulp without any additives displayed discoloration in 2 hour after exposure to ambient temperature (Prospero, 1993). Pardede *et al.,* (1994) reported that the custard apple pulp when exposed to air undergoes discoloration due to polyphenol oxidase activity. Discoloration occurs during storage in frozen state and continues throughout thawing and causes loss of quality value. The custard apple treated with 0.1% ascorbic acid can be stored up to 3 months in sealed nylon/LDPE bags at -16.3°C. Gohlani *et al.,* (2012) concluded that post-harvest treatment to custard apple fruits with edible coating material like sago at 5 per cent and 10 per cent concentration resulted in increase in shelf-life by 8 days as compared to untreated fruits (control) satisfactorily. This technology can be explored for improving post-harvest storage and market efficiency (Table 2).

Gamage *et al.,* (1997) studied the minimal processing of custard apple pulp. In this fresh custard apple pulp treated with 0.1 % - 0.5 % ascorbic acid and stored in modified atmosphere generating packages at 0°C for 4 weeks. The desired creamy color of custard apple pulp was retained during storage and after exposure to ambient conditions for 3 h, by the addition of 0.4% - 0.5% ascorbic acid and vacuum packaging in a 65 pm linear low density polyethylene (LWPE)/nylon/ LLDPE 5 layer co-extruded bag. Chikhalikar *et al.,* (2000) reported that custard apple pulp treated with 100 ppm ascorbic acid as anti-browning agent and packed in 200 gauge polyethylene was frozen at -25°C in an alcohol bath and stored at -18°C in a deep-freeze. It was found that formulation (2% Glycerol +1 % propylene Glycol + 10 % glucose syprup + 10 % malto dextrin) gave product that was probable even on the frozen storage and also had highest shelf life of 75.33 days for ascorbic acid degradation as compare to 34.82

days for the control. Shashirekha *et al.,* (2003) reported that custard apple pulp in frozen state was able to be stored for 12 months without discoloration. The custard apple pulp when exposed to air turns pink due to peroxidase activity and become bitter when heated above 55°C, which renders preservation by heat treatment in application. To preserve the pulp, it is necessary to add 1% of citric acid + 0.1% of sodium benzoate, while addition of 50-100 ppm of sulphure dioxide check the pink discoloration due to enzymatic activity (Bhatia *et al.,* 2006). Shashirekha *et al.,* (2008) studied the changes in volatile compounds of fruits pulp of *Annona squamosa* as influenced by condition of processing. The 12-months-stored frozen pulp did not differ from the fresh pulp in the flavour spectrum. Heating fresh pulp at 55 and 85 °C, tended to produced increased flavour spectrum.

Vanini *et al.,* (2010) evaluated the enzymatic activity of polyphenoloxidase and peroxidase in avocado pulps, from the Northwest area of Paraná-Brazil, in order to compare the varieties on their enzymatic activity for both, minimum and industrial processing. Enzymatic extracts were prepared from avocado pulp of Choquete, Fortuna and Quintal varieties, in green and ripe maturation stage.

Thermal treatment was applied with temperatures 60, 65, 70, 75 and 80 °C. A decline of polyphenol oxidase activity was observed in all of the varieties when both, temperature and time increased. Total inactivation of enzymes was not observed in the largest temperature. Pawar *et al.,* (2011) reported that polyphenol oxidase activity in custard apple pulp can be stopped by heat treatment and use of antioxidant. Among various heat treatments, treating pulp by steaming at the temperature of 82°C for 5 minute was satisfactory for 100% inhibition of polyphenol oxidase activity. Frozen storage at the temperature of -18°C was found to be promising. The rate of increase in TPC was found to be very slow at storage temperature of -18°C as compared to rate of increase in TPC at 5°C.

Sravanthi *et al.,* (2014) studied on preservation and processing of custard apple. In this the extracted pulp was stored for a period of six months by addition of 1500ppm of potassium metabisulphite. After six months, various products like squash and nectar were prepared. The products were stored at room temperature and cold storage for a period of four months to study the stability and consumer acceptability of the products. All the products stored at cold storage were good physic-chemically when compared to the products stored at room temperature. Bakane *et al.,* (2015) revealed that comparative storage study of custard apple pulp separated by machine and manual. In this the pulp was treated with ascorbic acid (0.25 %) and potassium metabisulphite (0.25%) to check the browning of pulp during storage at -20 °c for 6 months. Separated pulp could be stored at -20°C with 0.1% potassium metabisulphite (KMS) as anti-browning agent for 180 days. Brannan *et al.,* (2017) studied the effect of Frozen Storage on Polyphenol Oxidase, Antioxidant Content, and Color of Pawpaw (*Asimina Triloba* [L.] Dunal) Fruit Pulp. In this pawpaw pulp during frozen storage were measured for the main effect of month of storage at three levels (0, 4, 8 months) and treatment at four levels (vacuum, air, ascorbic acid or n-acetylcysteine). For the main effect of treatment, ascorbic acid and n-acetylcysteine treatment produced pawpaw pulp that was significantly different than samples to which air was not excluded for all seven dependent color variables. A strategy to inhibit enzymatic browning during frozen storage would be useful for the nascent pawpaw industry.

Table.1 Botanical or specific, common and vernacular names and their synonyms of the Custard apple studied (Source: Pinto *et al.*, 2005)

Botanical	Synonyms	Common	Other common names
A. squamosa L	*A. asiatica L.; A. cinerea* Dunal; Guanabamus squamosus Gomez	Sugar apple	Sweetsop, sugar apple, custard apple (English), ata, pinha or fruta do conde (Portuguese, Brazil), attire (French), saramuya and Aztec (Mexico), sitaphal (Tamil), seethapalam, athichakku (Malayalan), nona sri kaya (Malayasian), seethapandu (Tegelu), amritphala, seethaphala (Kannada), aatoa, shariffa, sitaphal (Hindi), ata luna (Bengali), noina (Thai)

Table.2 Summary of studies on storage of custard apple pulp

Research activity	Findings	Authors
Pulp storage	Treatment-0.1%-0.5% ascorbic acid and 0°C temperature for 4 weeks	Gamage *et al.*, (1997)
	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)
	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.	Sravanthi *et al.*, (2014)
minimal processing	custard apple pulp treated with 0.1 % - 0.5 % ascorbic acid and stored in modified atmosphere generating packages at 0°C for 4 weeks. The addition of 0.4% - 0.5% ascorbic acid and vacuum packaging in a 65 pm linear low density polyethylene (LWPE)/nylon/ LLDPE 5 layer co-extruded bag.	Gamage *et al.*, (1997)
Preservation and storage	In this the extracted pulp was stored for a period of six months by addition of 1500ppm of potassium metabisulphite.	Sravanti *et al.*, (2014)
Storage of pulp	custard apple pulp treated with 100ppm ascorbic acid as anti browning agent and packed in 200 gauge polyethylene was frozen at -25°C in an alcohol bath and stored at -18°C in a deep-freeze.	Chikhalikar *et al.*,(2010)

Table.3 Summary of studies on processing of custard apple

Research activity	Findings	Authors
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)
Custard apple pulp powder	Custard apple pulp powder as Binding agent in pharmaceutical tablets.	Thube *et al.,* (2011)
Milk shake	Buffalo milk & Custard Apple Pulp ratio - 90:10, cost effective	Poul *et al.,* (2009, 2010)
		Bakane *et al.,* (2015)
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)
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)

The combination treatment of chemical preservative and pasteurization treatment, to preserve the custard apple pulp in deep freezer for a period of three months (Swetha *et al.,* 2017).

Freezing process

Freezing is a physical phenomenon and the single most important concept in freezing of biological materials is that freezing involves the withdrawal of pure water from solution and its isolation into biologically inert foreign bodies, the ice crystals (Meryman, 1956). The number and size of these crystals are important in determining the subsequent quality of the product. These factors have been shown to depend on the rate of freezing (Woodroof, 1938 and Meryman, 1956). Sirijariyawat (2012) investigated the effects of the freezing process on the freezing profiles, texture, and drip loss of apple, mango, cantaloupe, and pineapple fruit samples. Mango had the highest total soluble solids content and the lowest freezing point, whereas pineapple showed the highest freezing rate. The highest firmness and crunchy texture were found in fresh apple, and these properties were absent in the other fresh fruits. The firmness of all frozen fruits significantly decreased by different percentages as compared to those of the fresh fruits.

The drip loss of each fruit type was also significantly different with apple samples having the highest firmness decrease and drip loss. Marin *et al.,* (1992) examined the chemical and biochemical changes in mango after air blast freezing at -40°C and during storage at -18°C for a 4 month period. They found that freezing mango slices did not lead to changes in moisture content or soluble solids content, however, the titratable acidity of the slices decreased due to the freezing process. Simandjuntak *et al.,* (1996) studied

changes in the composition, drip loss and color of cantaloupe and honey dew melon stored for 5 and 10 months at -23°C.

Processing of custard apple

It is usually eaten as a dessert fruit and finds immense applications in the preparations of beverages and ice creams (Chikhalikar, Sahoo, Singhal, & Kulkarni, 2000) custard apple fruit pulp has got many food applications as flavour enhancing ingredient in various desserts because of its delicious taste and flavour (Devatkal *et al.,* 2011). It is used also to prepare juices, jellies and compotes or made into sherbets and jams (pino *et al.,* 2010). Patil *et al.,* (2011) standardized the recipes for production of custard apple squash and reported that squash of custard apple prepared with 40% pulp had maximum scored. The decreasing score was observed for colored, flavor and texture with increasing storage period. Poul *et al.,* (2009) studied the composition and economics of custard apple milk shake and concluded that milk shake prepared from 90:10 blends of buffalo milk and custard apple pulp was most economical. Custard apple milk shake has good potential to capture popularity due to its therapeutic and nutritive benefits.

It was found that the toffees prepared using 55% custard apple pulp scored the maximum for color, appearance, texture and overall acceptability, the toffees can be an ideal supplement to the diet of young children (Mundhe *et al.,* 2008). 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). 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 color (off white), taste, over-all acceptance and ascorbic acid (Pilania *et al.,* 2010). 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. Some of the important studies on processing and value addition of custard apple are also summarized in Table 3.

Custard apple peel and seed processing

Custard apple is mainly grown in gardens for its fruits and ornamental value. It is considered as beneficial for cardiac disease, diabetes hyperthyroidism and cancer the root is considered as a drastic purgative. An infusion of the leaves is considered as efficacious in prolapsusani of children, the crushed leaves are sniffed to overcome hysteria and fainting spells, they are also applied on ulcer and wounds. The ripe fruits of this plant are applied to malignant tumors to hasten suppuration. The dried unripe fruit powder is used to destroy vermin. The seeds are acrid and poisonous powdered seeds serve as fish poison and insecticides. A paste of seed powder has been applied to the head to kill lice. It is also used for destroying worm in the wound of cattles.

Yathish *et al.,* (2013) reported that the transesterification of custard apple seed oil by means of methanol in presence of Potassium hydroxide catalyst at less than 65˚C. The viscosity of biodiesel produced from custard apple seed oil is nearer to that of the commercially available diesel. The custard apple seed oil is characterized by GC (gas chromatography) analysis the study encourages the production of biodiesel from Custard Apple seed (*Annona squamosa*) Oil and value addition of custard apple fruit.

Chitodkar *et al.,* (2014) reported that study was focused on the extraction of oil from custard apple seed and tested against head lices. The custard apple seeds contain 20% oil by weight. The oil was extracted from powdered seeds using organic solvent (Ethyl Acetate) at room temperature and concentrated by distillation process carried out at temperature higher than room temperature. The concentrate custard apple seed oil (CASO) blended with coconut oil and water to prepare ointment which was tested against head lice. Freshly prepared water base ointment(containing 20% custard apple seed oil by weight) kills about 90% head lices in three hours The same results shown by freshly prepared coconut oil base ointment (containing custard apple seed oil in ratio 1:1). The major component of oil is the oleic acid which kills the lices. The cream prepared remains stable for 6 months. Lydia *et al.*, (2017) investigated that the phytochemical composition, antimicrobial potential, antioxidant activity of the fruit peel wastes of custard apple. The phytochemical screening of the fruit peel revealed the presence of Carbohydrates, Saponins, Phenols and Terpenoids. The antimicrobial test results showed that the raw fruit peel extract had a great potential antimicrobial activity against all the bacteria and fungal species selected for testing.

Custard apple is a seasonal fruit, which has very limited shelf life of just two or three days, and it is generally eaten fresh after ripening. Custard apple is highly perishable crop and all possible post-harvest management has to be worked out to extend the shelf life. The preservation of pulp helps in the better utilization of custard apple through various value added product preparation. 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 have a good potential in future.

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