Journal of Agricultural Engineering and Food Technology
p-ISSN: 2350-0085; e-ISSN: 2350-0263; Volume 3, Issue 3; July-September, 2016 pp. 189-193

http://www.krishisanskriti.org/Publication.html

Physico-Chemical Properties and Post-Harvest Life of Litchi: A Review

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Abstract—*Litchi is one of the most relished fruits by virtue of it's colour and distinct taste. Litchi is rich in minerals and vitamins. During ripening fruit colour changes to red or rose or pinkish. A number of physiological and biochemical changes occurs in fruit to commence ripening. Since litchi fruit is non-climacteric in nature so harvested only after ripening. Litchi fruit having poor shelf life as like other fruits. After harvest several physiological changes including loss of weight, browning, etc. and also biochemical changes including total soluble solids, acidity, ascorbic acid etc. take place in fruit. Shelf- life of litchi fruit can be enhanced with certain postharvest treatments like application of edible coating or use of scavengers. The application of edible coatings on litchi fruits provides a partial barrier to the movement of moisture on the surface of fresh produce, thereby minimizing moisture loss during postharvest storage. Scavengers maintain the qualities of fruit by scavenging the different gases inside them. This review summarises the available research findings on various changes in litchi fruits after harvest and to reduce postharvest losses after harvest by adopting suitable postharvest novel technologies*

1. INTRODUCTION

The litchi (*Litchi chinensis* Sonn.) is an important tropical to subtropical evergreen fruit crop believed to have originated in China (Southern China) and the Northern Vietnam (Menzel, 2001). It belongs to the family *Sapindaceae,* that covers around 2000 species and 150 genera including Longan and Rambutan (Pandey and Sharma, 1989). Litchi fruit has bright red peel colour and is sweet, acidic, juicy and crisp pulp. It is a drupe or stone fruit and at maturity it's conical, heart shaped or spherical with a thick leathery, indehiscent pericarp (Revethy and Narasimhan, 1997). It is a non-climacteric fruit (Holocroft and Mitcham, 1996). Litchi is known for its pleasant flavour and juicy pulp (aril) with attractive red coloured pericarp. It is also an excellent source of vitamins and minerals (Chadha, 2001). The daily vitamin C requirement of an average adult can be met by consuming 14-17 litchis (Wall, 2006). Besides, the fruit is also medicinally known for treatment of diseases like dyspepsia and smallpox (CFTRI Monograph, 1991). Harvested fruits are highly perishable and lose their bright red skin colour and turn brown within 1-2 days at ambient temperatures (Zhang and Quantick, 1997).

Postharvest technologies which have been developed to reduce these disorders include heating and cooling units, the use of various packages and packaging materials and the application of fungicides and other ameliorative chemicals (Jiang *et al.*, 2006). The early research on postharvest litchi was aimed at establishing suitable storage conditions and packing materials, evaluation of various forms of plastic packaging and optimization of storage temperatures. Although significant progresses have been made from these postharvest researches but the physiological browning and disease development of litchi fruit after harvest are still the main limitations to the storage of the fruit. To know the physico-chemical properties and postharvest quality of fruits is important aspect for future research.

2. PHYSICO-CHEMICAL CONSTITUENTS OF LITCHI

Physico-chemical constituents of litchi fruit varies according to cultivar, place of cultivation, climatic conditions at the time of maturation and ripening (Ray, 1998). Physicochemical characteristics of important Indian cultivars of litchi from West Bengal (Ghosh *et al.*, 2001) with data collected from are given as below:

Cultivar	Fruit weight (g)	Seed weight (g)	TSS (degree brix)	Yield (Kg/tree)
Bedana	24.2	2.8	19.2	21.1
Bombai	22.0	3.7	18	38.1
China	23.7	3.1	18.2	22.1
Elaichi	17.6	2.4	17.8	14.3
Muzzaffarpur	21.4	3.7	17.9	37.3
Purbi	19.3	4.2	18.3	26.9
Rose Scented	20.1	3.6	18.4	35.6

The fruit weight varied from 13.96 – 28.19 grams among various cultivars under study (Singh *et al.*, 2010). The TSS values ranges from 15 per cent to 18.82 per cent in litchi at the

time of harvesting. Titrable acidity and total organic acids decrease during fruit development and ripening (Joubert, 1986). At maturity, malic acid accounted for 80 per cent of the acids, whereas citric, succinic, levulinic, glutaric, malonic and lactic acids were relatively minor constituents (Paull *et al*., 1984). Titrable acidity in the aril usually decreases rapidly after harvest. Analysis of pulp of China, Longia, Rose Scented and Bedana varieties (U.P.) by chromatographic methods have shown that malic acid is the most predominant organic acid present in litchi. Acidity content varies between 0.692 per cent and 0.695 per cent (Kumar, 2000) and 0.65 per cent (Pandey, 2003) in litchi at time of harvesting.

Litchi is a good source of vitamin C with an average vitamin C content of 27.6 mg/ 100 g pulp (Sivakumar *et al*., 2010). Ascorbic acid decreased with fruit development until two weeks before harvest but then increased again slightly at full maturity and ascorbic acid content may vary with type of cultivar due to microclimatic conditions such as warm days and cool nights (Wang *et al*., 2006). The longer day lengths and higher light intensities in summer months were reported to increase the concentration of glucose (the precursor to ascorbic acid); temperature also influences the accumulation of ascorbic acid (Lee and Kader, 2000). In Rose Scented cultivar ascorbic acid content was 28.8/100 g pulp (Pandey, 2003). Fruits of litchi are generally rich in sugar/carbohydrates and their value greatly depends on the quality and concentration of these sugars.

3. POST-HARVEST CHANGES DURING STORAGE

Even litchi originated thousands of years ago, there is a great shortcoming in the knowledge of its characteristics and behaviour after harvest needed to study more (RAP, 2002). Major post-harvest changes involved those which affect the overall quality of litchi fruit during storage. The first visible effect of storage on fruits is the change in the colour of the skin which begins to turn brown within 2-3 days at both ambient and low temperature storage (Chen and Hong, 1992).

i) Physiological loss in weight (PLW)

Bhullar *et al.* (1983) observed that the highest weight loss (27 % of the fruit weight) occurred in case of cultivar Seedless Late. About 30 per cent weight loss was found on 8th day of storage (Upreti, 1988). During storage of 3 days, litchi fruit showed about 13.87 per cent losses in weight while storage in plastic wired tray showed about 15.29 per cent loss in weight. The rate of physiological weight loss in litchi fruit harvested from different locations but stored under identical ambient conditions varied between 26.98 per cent (Kumar, 1994) and 43.08 per cent (Dutt, 1988) after 8 days of storage. Water loss is dependent on relative humidity in the ambient air and also is the browning. At 60 per cent R.H. the water loss from the pericarp of the fruit after 3 days of storage was up to more than 50 per cent, while it was only 19 per cent at 90 per cent RH for the same duration (Jiang and Fu, 1999). The weight loss of litchi increased with the length of the storage period, recording maximum PLW of 17.05 and 17.16 per cent on the 9th day of storage in 'Muzzafarpur' and 'Calcuttia', respectively (Neog and Saikia, 2007). Pandey (2003) observed 3.97 per cent weight loss in acid treated sample of the sulphur fumigated fruit and maximum weight loss of 6.2 per cent with control at the end of 84 hours of ambient storage and 38.68 per cent weight loss at 6 ± 2^{0}C storage temperature at the end of 15 days of storage period.

ii) Browning

Litchi fruit have a brilliant red pericarp upon harvest that turns brown during shipping and storage (Rattanapanone *et al*., 2007). Browning index has been used widely to determine browning in pericarp of litchi (Caro and Joas, 2005; Singh, 2011). Litchi pericarp browning index increases with storage time (Zheng and Tian, 2006). Anthocyanins are hydrolysed by anthocyanase to anthocyanidins and polyphenol oxidase or peroxidase oxidizes the anthocyanidins to ortho quinines, and hence results in browning (Sun *et al*., 2006). Micro-cracking is also responsible for pericarp browning (Huang *et al*., 2004). The factors contributing to litchi micro-cracks are dessication, SO_2 fumigation, improper handling, expanding aril and drought during fruit development which leads to loss of pericarp extensibility, which enhanced pericarp browning (Huang *et al*., 2005). The pH of pericarp cells is increased due to desiccation or water loss, which can stimulate the activity of the PPO and POD. Cellular compartmentation is disrupted during storage due to desiccation and senescence. Browning takes place when the phenolic substrate and the enzyme come in contact. Anthocyanins are hydrolysed by anthocyanase to anthocyanidins and PPO or POD oxidises the anthocyanidins to *o*-quinones and hence, results in browning (Sun *et al*., 2006). Micro-cracking is also one of the causes of pericarp browning (Huang *et al.,* 2004). The micro-cracks were observed prior to harvest which intensified during storage.

iii) Spoilage

Postharvest decay is one of the major causes of fruit spoilage in the postharvest fruit chain. A wide range of fungi can cause decay of litchi fruit (Zhang and Quantick, 1997). Relatively high temperatures in the field during harvesting, in transit or in the pack house, can render litchi fruit more susceptible to chilling injury and contribute to the development of disease. The combination of high temperature and relative humidity factors favours the growth of postharvest pathogens. Unhygienic pack houses and cool storage conditions where rotten fruit is not regularly removed, contribute to product contamination. This was particularly found towards the end of the export chain with litchi fruit (Jacobs and Korsten, 2004).

iv) Changes total soluble solids (TSS) content

The litchi fruit of cv. Rose Scented stored under ambient conditions showed an increasing trend in TSS for a few days

followed by a declining trend afterwards (Kumar, 2000). Pandey (2003) reported an increasing trend in TSS up to 6th day of storage and thereafter, a continuous declining trend up to 15 days of storage. The changes in TSS content were of lower degree in treated samples as compared to control during the entire storage period at 6 ± 2^0C temperature. The TSS content decreased from 17.2 per cent to 15.6 per cent in control after 15 days.

Chakraborty and Banik (2003) reported that maximum amount of T.S.S. was recorded on 8th day of storage when fruits were dipped in dilute HCl solution for 2 minutes following sulphur dioxide fumigation at ambient storage condition. Ray *et al*. (2004) reported faster rate of increase of TSS at ambient temperature than at low temperature (4°). Under the control, TSS increased from 20.12 per cent from first day to 23.05 per cent on 13th day and then declined to 33.63 per cent on 33rd day. TSS in fruits treated with sulphur @ 60g S/100Kg fruits increased from 20.20 per cent to 21.35 per cent at low storage temperature and then decreased to 17.42 per cent on the last day of storage.

v) Changes in acidity content

Mahajan *et al.* (2003) reported a linear decline in acidity of fruits during storage. The acidity remains unaltered as a result of different treatments. The acidity per cent decreased in control from 0.45 to 0.29 per cent at the end of 21 day storage period at 2°C storage temperature. Chakraborty and Banik (2003) reported declining trend in fruit acidity per cent throughout the storage period of 8 days irrespective of treatment, including control. The maximum amount of acidity (0.67 %) was recorded with litchi fruits which were fumigated and dipped in dilute HCl for 2 minutes and packed in perforated polypropylene bags subsequently. Pandey (2003) recorded a declining trend in acidity with the advancement of storage duration with all the treatments. The acidity content decreased from 0.65 per cent in fresh fruits to 0.19 per cent at the end of 15 days storage period.

vi) Changes in ascorbic acid content

Reduction in ascorbic acid during storage under ambient conditions was reported in litchi by Upreti (1988) in which ascorbic acid content decreased from 24.1 mg/100g to 0.07 mg/100g fruit pulp during 8th day of storage. Paul and Chen (1987) reported that the major post-harvest change was in ascorbic acid, which declined to half of the initial value at harvest in 4 days, irrespective of the storage method and temperature.

4. METHODS FOR REDUCING POSTHARVEST LOSSES AND TO INCREASE SHELF -LIFE

As stated above the shelf- life of litchi fruit under the prevailing condition is very short. Therefore, several methods have been attempted to slow down the rate of post-harvest losses and to increase the shelf life of litchi (Ray, 1998).

i) Edible coating

An edible film is defined as a thin layer, which can be consumed, coated on a fruit or placed as a barrier between the fruit and the surrounding environment. These films can mechanically protect fruits, prevent the contamination from microorganism, prevent the quality loss of fruits due to mass transfer (*e.g.* moisture, gases, flavours etc.). Coatings are a particular form of films that are directly applied to the surface of fruits. Edible films and coatings are produced from edible biopolymers and food grade additives. The edible films are classified into three categories taking into account the nature of their components: hydrocolloids (containing proteins, polysaccharides or alginates), lipids (constituted by fatty acids, acylglycerols or waxes) and composites (made by combining substances from the two categories) (Baldwin *et al*., 1995).

There are several advantages associated with edible coating like, they may be eaten by the consumer along with food, their use could reduce the waste and solve the solid disposal problem, they could enhance the organoleptic, mechanical or nutritional properties of fruit, they can reduce the cost by utilizing by products e.g., whey (Guilbert, 1986).

5. MATERIAL USE FOR EDIBLE COATING

Various materials can be used for edible coating for enhancing the storage life of fruits. Hydrocolloids are the polymers are of vegetable, animal, microbial or synthetic origin that generally contains many hydroxyl groups and may be polyelectrolytes (for example alginate, carrageenan, carboxy methyl cellulose, gum arabic, pectin and xanthan gum). Nowadays, they are widely used as film forming solution to perform and control the texture, flavour, and shelf-life of foods (Williams *et al*., 2000). Agar is a hydrocolloid consisting of a mixture of agarose and agaropectin that have the ability to form reversible gels simply by cooling a hot aqueous solution. Agar gel melts on heating and reset on cooling. Despite of its biodegradability and its enormous gelling power, agar has been few used as edible film due to a poor aging (Armisen *et al*., 2000). Aliginate is an indigestible biomaterial produced by brown seaweeds (phaeophyceae, mainly laminaria) therefore it may also be viewed as a source of dietary fibre. Films prepared by alignate exhibit poor water resistance because of their hydrophilic nature (Kester and Fennema, 1986) Cellulose derivatives are polysaccharides composed of linear chains of β (1-4) glucosidic units with methyl, hydroxypropyl or carboxy substituents. Only four cellulose derivatives form are used for edible coatings or films, Hydroxy propyl cellulose (HPC), Hydroxy propyl methyl cellulose (HPMC), Carboxy methyl cellulose (CMC) or Methyl cellulose (MC). Cellulose derivatives exhibit thermo gelation therefore when suspensions are heated they form a gel whereas they return to originally consistency when cooled (Murray, 2000). The films cast from aqueous solutions of MC, HPMC, HPC, and CMC tend to have moderate strength, are resistant to oils and fats,

and are flexible, transparent, flavourless, colourless, tasteless, water soluble and moderate barriers to oxygen (Kester and Fennema, 1986). Plasticizers are the substances that decrease activation energy for diffusion of gases and vapours through the film and can decrease elasticity and cohesion. Commonly used plasticizers in film systems are monosaccharide's (glucose), disaccharides (sucrose), oligosaccharides, polyols (sorbitol, glycerol, mannitol, glycerol derivatives and polyethylene glycols), and certain lipids and derivatives (phospholipids, fatty acids, surfactants, etc.). Lipids or waxes may interfere with polymer chain to chain interaction and/or provide flexible domains within the leading to reduction of film strength and increase of film flexibility in whey proteins.

ii) Scavengers

A scavenger is a chemical substance added to a mixture in order to remove or absorb either inactive impurities or unwanted reaction products by removing or absorbing one or more of the chemicals it interacts. Different scavengers are (potassium permanganate, activated charcoal, Pyrogallol, Oxycap, Pure Seal, Darex, Oxyguard etc.) to be used for scavenging the gases during storage of fruits. Ethylene is a natural plant hormone produced by metabolism in most fruits, initiates and accelerates the ripening of fruit and causes fruits and vegetables to deteriorate. This unavoidable process is a major problem, since in almost all applications non compatible fruits and vegetables (*i.e*., ethylene emitters and ethylene-sensitive items) are stored and/or shipped in the same container. Accordingly, one of the simplest ways was used to remove ethylene from the atmosphere that involves absorption and then oxidation to produce CO_2 and H_2O upon reaction with potassium permanganate ($KMnO_4$).

6. CONCLUSION

As lychee fruit mature, the concentrations of sugars, principally those of sucrose, glucose and fructose increase while the concentrations of organic acids, predominantly malic acid decrease. Fruit quality declines after harvest as concentrations of ascorbic acid, phenols, sugars and organic acids decrease during storage. Browning that occurs during the first few days after harvest is usually caused by dehydration of the pericarp. Postharvest treatment including edible coating and add of scavengers reduces water loss and slow the rate of browning. The future development of integrated post-harvest technology for the enhancing shelf life of litchi likely to focus on disease and quality control involving in fungicides dip, heat treatments and temperature management.

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