Indian J. Hort. 70(3), September 2013: 328-332

Physico-chemical changes in litchi cultivar Rose Scented during fruit development and maturation

Aradhana Singh*, D.S. Mishra, Rajesh Kumar and Prabhat Kumar
Department of Horticulture, College of Agriculture, G. B. Pant University of Agriculture & Technology, Pantnagar, U.S. Nagar, Uttarakhand

ABSTRACT

Physico-chemical changes during fruit development of litchi (*Litchi chinensis* Sonn.) cultivar Rose Scented were studied. The initial fruit growth phase up to 40 days after full bloom (DAFB) is mainly contributed by peel and seed growth and the later growth phase until maturity is characterized by a rapid pulp growth. Fruit size, fruit weight, peel weight and specific gravity showed increasing trend while peel thickness showed declining trend with the advancement of age in litchi fruits. Pulp growth was not noticed until 40 DAFB and after appearance showed increasing trend. Incidence of cracking occurs after appearance of pulp during later growth period. Seed size and seed weight showed increase until appearance of pulp, then showed a declining trend. Fruit growth follows a simple sigmoid growth curve for majority of physical characters. Simultaneous occurrence of chlorophyll degradation and anthocyanin synthesis led to the development of red colour at maturity. Pulp pH, total soluble solids, total soluble solids to acid ratio and ascorbic acid increased, while titratable acidity decreased with advancement of maturity. Mineral contents like potassium, calcium and boron were also determined during fruit development period and the relative order of concentration at different growth stages was K > Ca > B. Harvesting at optimum maturity can be done during 66 to 70 DAFB.

Key words: *Litchi chinensis,* physico-chemical changes, development, maturity.

INTRODUCTION

The litchi (*Litchi chinensis* Sonn.), a popular member of the family Sapindaceae is an evergreen subtropical tree. Litchi is an unique fruit belongs to the group called 'drupe' characterized by thin, leathery pericarp, the edible part aril that is white, juicy, very aromatic and covers the single brown-black seed (Menzel and Simpson, 7). The litchi fruit has a unique structure, which has the aril as its edible part and major component at the mature stage. Hence, there are apparent needs and possibilities for making more thorough and detailed investigations by precisely examining and monitoring the growth and development not only of the fruit as a whole, but also of the different tissues appearing in a strict sequence (Huang and Xu, 3). The physico-chemical analysis of the constituents and their inter-relationships, biochemical events and role played by growth substances; mineral nutrition during the critical stages in the fruit development provide us an insight into the aspect of ontogeny of fruit described as maturation and ripening. Knowledge of stages of fruit development is essential to help in determining cultural practices (Grierson, 2). As litchi fruit is non-climacteric in nature the harvesting its at proper stage of maturity is desirable for maintaining the quality of the fruits and also the consumer acceptability. Therefore, the present investigation was carried out to study the physico-chemical changes taking place during fruit development and to determine the optimum harvesting date of litchi cultivar Rose Scented.

*Corresponding author's E-mail: aradhanasingh219@gmail.com

MATERIALS AND METHODS

The present investigation was conducted with 20-year-old trees of litchi cultivar Rose Scented at the Horticulture Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar (29°C N latitude and 79.3°C E longitude) during the period between January and June 2010. Eight healthy fruit bearing trees of uniform vigour and size, receiving uniform cultural practices were selected as replications for the purpose of investigation in Randomized Block Design. The fruit sampling was started 25 days after full-bloom and subsequent samplings done at 15 days interval for observations regarding the physico-chemical changes during the fruit growth period and at 2 days interval after attainment of proper colour and size for observations regarding the optimum harvesting date. Twenty fruits of uniform physiological stage were collected randomly from all the selected trees on each sampling date. Physical parameters like fruit length, fruit breadth, seed length, seed breadth and peel thickness were measured with the help of Vernier calipers and expressed as millimetre (mm) and

fruit weight, peel weight, seed weight and pulp weight were weighed on electronic weighing balance and expressed as gram (g). The data on volume of fruits was recorded by water displacement method and was expressed in terms of millilitre (ml). Specific gravity was determined by dividing the fruit weight with the volume of the fruit. Cracking per cent was determined by counting the number of cracked fruits among the total number of fruits.

Anthocyanin is extracted with ethanolic-hydrochloride (85:15) and the intensity of colour appeared is measured colorimetrically at 535 nm (Mazumdar and Mazumdar, 6). Chlorophyll was extracted with acetone (80%) and the intensity of colour appeared was measured colorimetrically at 645 and 663 nm (Ranganna, 11). pH of the pulp was recorded using digital pH meter. Total soluble solids (^{0}Brix) were recorded at room temperature by using digital hand refractometer. Titratable acidity was calculated by titrating the fruit pulp extract with 0.1 N NaOH using phenolphthalein indicator; ascorbic acid content of the juice was estimated by reduction of 2, 6-dichlorophenol indophenol (dye) by ascorbic acid; and mineral contents like K, Ca and B were determined according to procedure described by Ranganna (11). A total soluble solids to acid ratio was also calculated.

RESULTS AND DISCUSSION

The results pertaining to the changes in physical growth parameters of the litchi fruits during the development period are presented in Fig. 1. The fruit size (length and breadth) of developing fruits has been found to increase with the increase in age of the fruits. Increase in size of fruits from date of full bloom until 40 days was primarily due to the growth of the pericarp and seed, because until that time, the formation of the aril was incipient, whereas, the increase in size during later stages was mainly attributed to aril growth. These results are in consonance with that of Gaur and Bajpai (1), and Mahajan and Dhillon (7) in litchi cultivars. The fruit weight also showed an increasing trend with the increasing developmental period. The increase in weight of the litchi fruit appears to be due to occurrence of cell division in the early stages and cell enlargement in later stage of fruit growth (Gaur and Bajpai, 1). The fruit volume showed a stable increase throughout the growth period and the increase could be attributed to the increase in size and weight of the

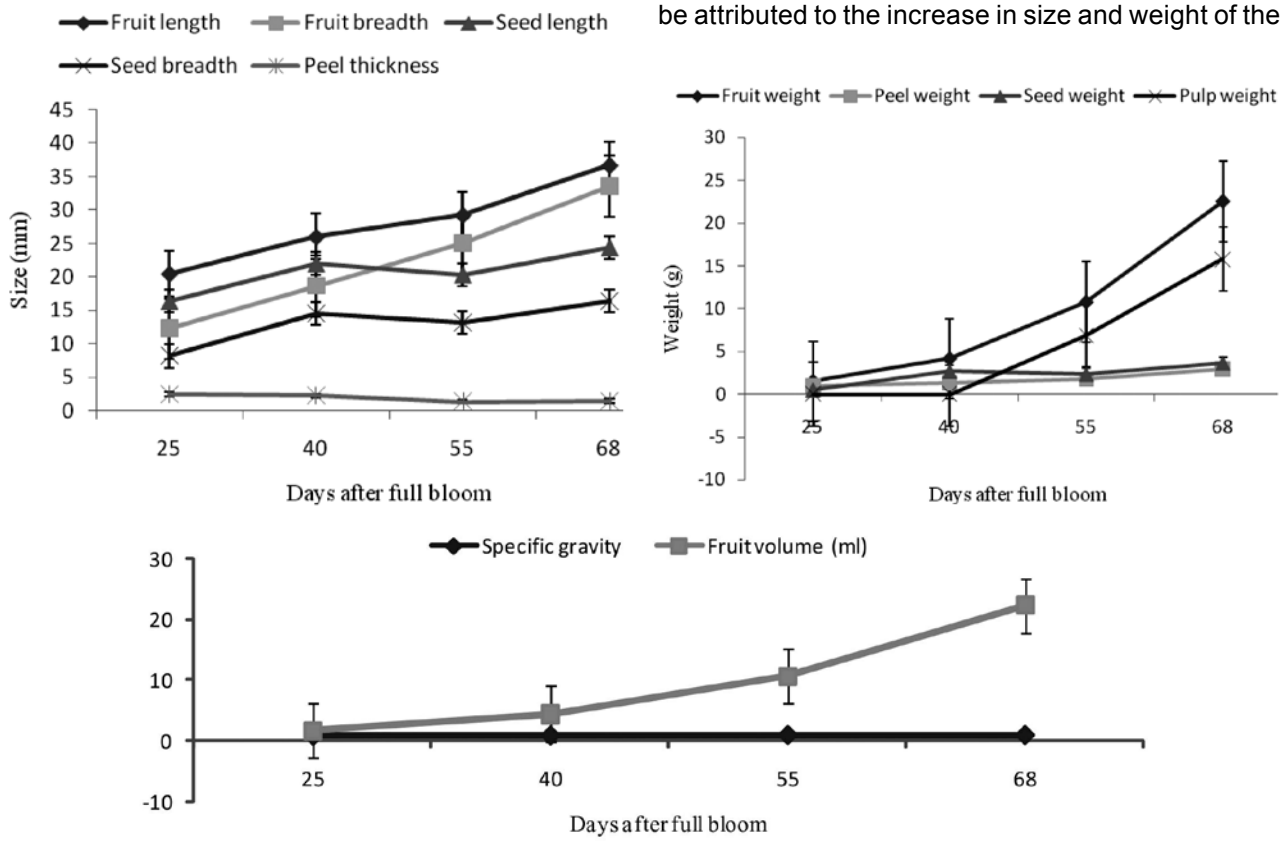

Fig. 1. Graphs showing the changes in physical growth parameters of litchi fruit during the development period [The vertical bars indicates the standard error (n = 8)].

fruit. The results obtained were in agreement with those obtained by Paull *et al*. (9). The specific gravity of fruits increases gradually throughout growth period and stabilized near maturity (Sharma and Ray, 12). Similar results were found in the present investigation and it was noticed that the regular increase in specific gravity denotes rapid increase in weight as compared to volume of the fruit. There was a gradual increase in peel weight until harvest as reported earlier by Gaur and Bajpai (1), and Huang and Xu (3) and this increase is due to the increase in size and weight of fruit during growth which is accompanied with peel growth. The peel thickness reduced from 25 days after full-bloom to 55 days after full-bloom and showed a slight increase afterwards until harvest (68 days after full-bloom). The progressive thinning of the litchi peel might be due to the rapid pericarp expansion due to the aril growth (Underhill and Critchley, 13). Pulp growth was not noticed up to the 40 days after full-bloom and after appearance increased gradually thereafter with advancement of age. This finding was in conformity with Mahajan and Dhillon (5). The seed weight and seed size (length and breadth) were found to increase up to 40 days after full bloom, decreased during the period between 40 to 55 days after full-bloom and finally increased slightly thereafter. The seed weight increased during early growth period but became static or even declined as the fruits approached harvest maturity (Pereira and Mitra, 10). Paull *et al*. (9) observed that in the fruits with normal seed, the seed reached maximum size at the same time as the whole fruit. Cracking was noticed on 55 days after full bloom and thereafter. It was observed that it occurs during the final stage of fruit growth when the aril develops and exerts pressure on the pericarp which is no longer actively growing. Growth pattern curve for the majority of physical characters like fruit length and breadth, fruit weight, fruit volume, specific gravity and peel weight followed single sigmoid growth curve. The shape of the curve, duration and expression of each growth period varies according to cultivar and environmental conditions (Huang and Xu, 3; Paull *et al*., 9). The perusal of data presented in Table 1 revealed that fruit length, fruit breadth, shape index, fruit weight, fruit volume and specific gravity stabilized after 66 days after full bloom while TSS to acid ratio stabilized after 68 days after full bloom. ^{0}Brix to acid ratio of the pulp was well correlated to mean eating quality (Underhill and Wong, 14). Hence, Rose Scented can be harvested at optimum maturity during 66 to 70 days after full bloom.

Variation with respect to chemical composition of litchi fruit during development period is presented in Fig. 2. Anthocyanin pigments were first detected on 40 days after full bloom and it continued to increase afterwards until harvest as reported earlier by Underhill and Critchley (13). Chlorophyll content was found to increase up to 40 days after full bloom, and then showed declining trend until harvest (68 days after full bloom) as reported earlier by Wang *et al*. (15). As the maturation of the fruit progresses, apparent changes in peel colour are brought about by the degradation of chlorophyll and concomitant biosynthesis of either anthocyanins. It was noted that pH increased while titratable acidity declined from pulp appearance until harvest. The increase in pH of litchi fruits is due to the decline of titratable acidity during the fruit growth. The decrease in acidity content during fruit growth might be due to use of organic acid as a respiratory substrate during ripening (Paull *et al*., 9). Total soluble solids were found to show increasing trend from pulp appearance to attainment of harvest maturity. Increase in total soluble solids during the growth period may be possibly on account of hydrolysis of polysaccharides in the fruits. Total soluble solids to acid ratio followed similar trend as of total soluble solids (Paull *et al*., 9). The increase in total soluble solids to acid ratio was due to soluble solids accumulation and decrease in organic acid content. Ascorbic acid content showed a significant increase with maturity. The increase in ascorbic acid content might be associated with rapid increase in sugars at the same time, as the fruits synthesize ascorbic acid from hexose sugar (Gaur and Bajpai, 1).

Table 1. Determination of optimum maturity date of litchi fruits in cultivar Rose Scented.

Days after full bloom	Fruit length (mm)	Fruit breadth (mm)	Shape index	Fruit weight (g)	Fruit volume (ml)	Specific gravity	TSS (°Brix)	TSS: acid ratio
64	36.74	33.59	1.09	22.42	21.96	1.02	18.54	23.34
66	36.75	33.59	1.10	22.50	22.07	1.02	18.61	23.40
68	36.75	33.59	1.10	22.55	22.23	1.02	18.69	23.44
70	36.75	33.59	1.10	22.55	22.23	1.02	18.69	23.44
CD at 5%	2.17	1.99	0.12	1.79	1.40	0.16	0.74	1.40

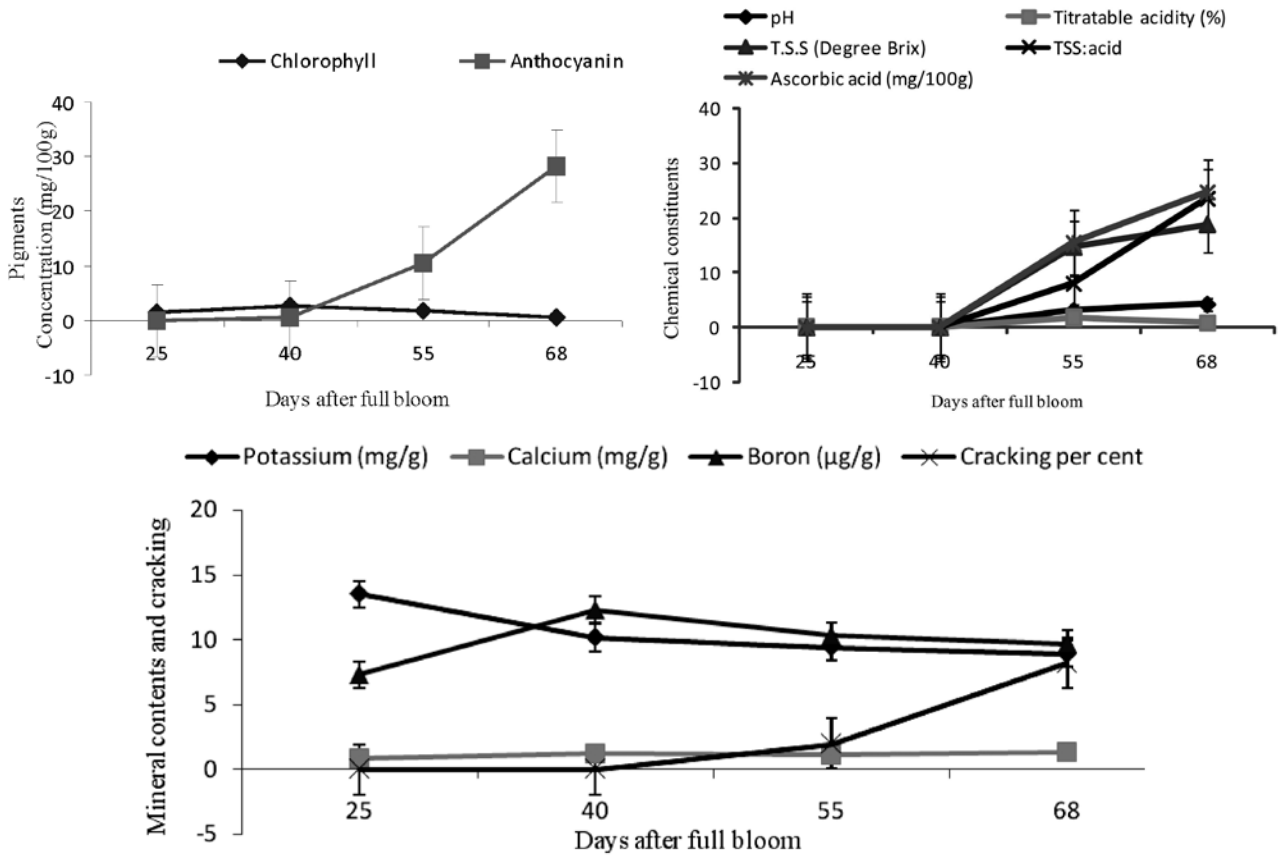

Fig. 2. Graphs showing the changes in chemical composition of litchi fruit during the development period [The vertical bars indicates the standard error (n = 8)].

The potassium content was found to decrease during fruit growth until harvest and calcium content was noted to increase up to 40 days after full bloom, decreasing during the period between 40 to 55 days after full bloom and increasing thereafter until harvest. Paull *et al*. (9) opined that potassium uptake ceased when the fruit attained full size, while calcium slowly continued to move into the fruit till full size was reached. Boron content increased up to 40 days after full bloom and then showed decreasing trend up to harvest until 68 days after full bloom. It was observed that both Ca and B concentration in fruit peel declined just before the aril growth started and might have contributed in the cracking incidence. Li *et al*. (4) recorded that the boron and calcium contents in the pericarp of uncracked fruits were significantly higher than those of the cracked fruits. The relative order for minerals content in the fruit at different growth stages was: potassium > calcium > boron. Similar observations were made by Menzel *et al*. (8).

REFERENCES

1. Gaur, G.S. and Bajpai, P.N. 1978. Some aspects of developmental physiology of the litchi fruit. *Indian J. Hort.* **35**: 173-77.

2. Grierson, W. 1995. Fruit development, maturation, and ripening. **In**: *Handbook of Plant and Crop Physiology*, Pessarakli, M. (Ed.), New York, Marcel Dekker, pp. 419-35.

3. Huang, H. and Xu, J. 1983. The developmental patterns of fruit tissues and their correlative relationships in *Litchi chinensis* Sonn. *Scientia Hort.* **19**: 335-42.

4. Li, J.G., Huang, H.B., Li, J.G. and Huang, H.B. 1995. Physico-chemical properties and peel morphology in relation to fruit-cracking susceptibility in litchi fruit. *J. South China Agri. Univ.* **16**: 84-89.

5. Mahajan, B.V.C. and Dhillon, B.S. 2002. Developmental pattern and maturity standards for litchi (*Litchi chinensis* Sonn.) cultivar Calcuttia. *J. Appl. Hort.* **4**: 47-48.

6. Mazumdar, B.C. and Mazumdar, K. 2003. *Methods on Physico-Chemical Analysis of Fruits*. Daya Publishing House, New Delhi, pp. 137-38.

7. Menzel, C.M. and Simpson, D.R. 1994. Lychee. **In**: *Handbook of Environmental Physiology of Fruit Crops*, Schaffer, B. and Andersen, P.C. (Ed.), Boca Raton, CRC, **2**: 123-45.

8. Menzel, C.M., Carseldine, M.L. and Simpson, D.R. 1988. The effect of fruiting status on nutrient composition of litchi (*Litchi chinensis* Sonn.) during the flowering and fruiting season. *J. Hort. Sci.* **63**: 547-56.

9. Paull, R.E., Chem, J.J., Deputy, J., Huang, H., Cheng, G. and Gao, F. 1984. Litchi growth and compositional changes during fruit development. *J. American Soc. Hort. Sci.* **109**: 817-21.

10. Pereira, L.S. and Mitra, S.K. 2004. Studies on fruit growth and development of litchi cultivars Bombai, China, Deshi and Early Large Red. *Hort. J.* **17**: 115-24.

11. Ranganna, S. 1986. *Handbook of Analysis and Quality Control of Fruit and Vegetable Products.* Tata McGraw Hill Pub. Co. Ltd., New Delhi.

12. Sharma, S.B. and Ray, P.K. 1987. Flowering and fruiting behaviour of some litchi cultivars. *Haryana J. Hort. Sci.* **16**: 168-74.

13. Underhill, S.J.R. and Critchley, C. 1992. The physiology and anatomy of lychee (*Litchi chinensis* Sonn.) pericarp during fruit development. *J. Hort. Sci.* **68**: 327-35.

14. Underhill, S.J.R. and Wong, L.S. 1990. A maturity standard for lychee (*Litchi chinensis* Sonn.). *Acta Hort.* **16**: 245-51.

15. Wang, H.C., Huang, X.M. and Huang, H.B. 2002. A study of the causative factors retarding pigmentation in the fruit of 'Feizixiao' litchi. *Acta Hort. Sinica*, **29**: 408-12.

Received: October, 2011; Revised: December, 2012; Accepted: February, 2013